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## Editorial office

AGRIS on-line Papers in Economics and Informatics
Department of Economics of FEM CULS Prague
Kamýcká 129, 165 00 Praha-Suchdol
Czech Republic
Phone: +420 224 382 056
E-mail: agrisonline(at)pef.czu.cz

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# Factors Affecting Consumers' Dairy Products Preferences

Sina Ahmadi Kaliji[1], Seyed Mojtaba Mojaverian[1], Hamid Amirnejad[1], Maurizio Canavari[2]

[1] Sari Agricultural Sciences and Natural Resources University, Iran

[2] Alma Mater Studiorum University of Bologna, Italy

## Abstract

Choice models represent a valid approach for the analysis of consumers' preferences as these models offer an opportunity to investigate many aspects that influence consumer behaviour. This study with the purpose of investigating consumers' preferences and their affecting factors were conducted by using the nested logit model in Sari, Iran in 2018. The results revealed that yoghurt, milk and cheese had the most preferences among the dairy products and consumers had more tendencies towards using low fat than full-fat dairy products. The results of factors affecting dairy products choice indicated that price and family cost decreased the probability of products being chosen, and age, education and attention to exercise variables increased this probability. Marketing mixed variables (4p) also had a significant effect on the choice of dairy products.

## Keywords

Consumer preferences, nested logit model, marketing mix, dairy products.

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## Introduction

Effective and efficient management of the relationship with customers is one of the most important issues for marketers (Barone et al., 2000). The marketing strategy aims to identify and meet consumer preferences, which drive consumer purchasing decisions. Preferences complement the characteristics and needs of consumers in explaining their behaviour (Spacey, 2016). Marketing managers can increase the competitiveness of their company and guarantee its long-term survival by understanding consumer behaviour towards differentiated and high-quality products (Hanaysha, 2018; Canavari et al., 2010).

Choice models are applied to understand the decision-making process of individuals Alternative theoretical models, such as utility maximisation, are used in econometrics, marketing, socio metrics and other fields. (CIE, 2001). Discrete choice models represent a valid approach for the analysis of consumers' preferences as these models offer the opportunity to investigate many aspects that influence consumer behaviour, especially if applied in the field of food marketing research (Louviere et al., 2000). Some discrete choice models have been specified for particular purposes. The multinomial logit model is considered the workhorse of discrete choice models, although its assumptions are quite restrictive. The nested logit model introduces a partial relaxation on assumptions that limit other logit models. In nested logit models, similar alternatives are grouped together into different nests and then arranged in order of rank (Ben-Akiva and Lerman, 1985; Train, 2009). In a nested logit model, the distribution of error components of the choice alternatives could be different. The pattern of classified alternatives into nests with respect to their similarities and tree structure is different from a stochastic valuation of alternatives within the scope of a decision tree (Hensher et al., 2005).

In this study the factors that affect consumers' choice and preferences are analyzed by using a nested logit model. The case study focuses on dairy products. Dairy is one of the most important products of livestock and it can affect people's health (Rahnama and Rajabpour, 2017). Recommendations for consumption of dairy products are 2 to 3 servings or cups of milk or other dairy products per day (Weaver, 2014). Energy, proteins, calcium, vitamins, cholesterol, riboflavin, carbohydrate and other useful nutrients are provided by dairy products (Dror and Allen, 2014). Milk products come from a variety of sources.

A survey of global milk production has shown that about 81 per cent of the world's milk comes from cows.

In 2017 India, China and Turkey were the leading producing countries in Asia, while Iran ranked seventh. Dairy product consumption in Iran reveals that the trend is positive (FAO, 2017). The study is based on data collected in Sari, the most highly populated city ine Mazandaran province, in the north of Iran. The Northern areas of Iran are interesting because they have the highest production of dairy products (Beldman et al., 2017). While dairy production is growing, previous studies indicate a decreasing trend in milk consumption in Iran (Beldman et al., 2017).

Consumer buying behaviour of dairy products is becoming an attractive topic for researchers (Samoggia, 2016; Haas et al., 2016). In the literature, consumers' buying behaviour is considered to be closely linked to individual preferences. However, in some studies, also demographic characteristics are shown to affect consumer preference for dairy products (Shokrvash et al., 2015).

In a recent study, Yayar (2012) applied a multinomial logit model to investigate consumer preferences for packed and unpacked fluid milk in Turkish households. Education level of households, number of children, income and household size positively affected the consumption of packed milk. Allen and Goddard (2012) surveyed individual preferences for milk and yoghurt with specific attributes using Ordered Probit regressions. Results showed that purchasing and consumption intentions of milk and yoghurt products are predictable by using some aspects of the Health Belief model and general nutrition knowledge. Investigation of consumption patterns of dairy products by Bousbia et al. (2017) revealed that, regardless of the type of household, pasteurised milk and yoghurt have the biggest share in dairy product purchases. Geographical location, number of children per household, price and monthly income were important factors driving milk consumption in this province.

Bhanu et al. (2017) studied consumers' preferences for dairy products in Trivandrum city (India) and revealed that almost all the households in the sample, irrespective of income level, preferred whole fluid milk. Among the dairy products, curd was preferred by all the sample households. Ice-cream was the second most preferred dairy product, followed by ghee, butter, paneer and cheese. The reasons for preferring whole milk were taste, satisfaction, quality, availability, low price and bulkiness. Assan (2017) found that in Eastern Cape province, South Africa, consumption patterns of milk and its processed products are influenced by the households' demographic characteristics, such as household size and composition, gender and marital status. Furthermore, income turned out to be more important than the household location for milk products consumption, since its consumption will increase according to income level.

## Materials and methods

This research considered consumers' preferences under the Nested Logit model. This model groups similar alternatives into nests and creates a hierarchical structure for decision (Ben-Akiva and Lerman, 1985). Let c denote a dairy product and be the probability that product c is chosen by someone who decides to purchase a type of dairy product (denote t). This probability is influenced by a number of factors, or independent variables. The consumer demographic characteristics considered in the questionnaire are age, gender, household size, education (based on 7 levels of education degrees), occupational status (based on 6 levels). We also considered economic, attitudinal, and behavioural characteristics, such as average of monthly family costs of living (based on 5 levels) as disposable income, importance level of exercise for consumers (5 levels based on a semantic scale), awareness about importance of dairy products (3 levels), their dairy products brand preferences (rated with scores from 1 to 9), their sensitivity to dairy products price. Finally, in this study we also considered whether the 4 marketing mix elements affect their brand choice. The marketing mix is most commonly implemented through the so-called 4 P's of marketing: **P**rice, **P**roduct, **P**lace and **P**romotion. Price is about dairy products value, Product as quality, packing, etc., Place as access to shopping and Promotion as brand reputation, loyalty and advertising. In our model, these four variables are measured as dummy variables (0 or 1), where the value is 0 if the element, according to respondents, does not affect consumer preference and 1 if it does affect it.

Under the usual multinomial logit model, the choice of dairy products (c) conditional on the type of products is (Danaher and Dagger, 2012):

$$P_{c|t} = \frac{e^{\beta_c x_c}}{1 + \sum_{i=1}^{C} e^{\beta_{c_i} x_{ci}}} \quad (1)$$

where $c$ ranges from 1 to 16, which is the indicator of the main suggested dairy products in the last level of the tree (such as low-fat and full-fat yoghurt, natural and lactic cheese, see Figure 1). In the nested logit structure we used, the probability of choosing any of these products is given by (Danaher and Dagger, 2012):

$$P_t = \frac{e^{\beta_c x_c + \eta I_t}}{1 + e^{\beta_c x_c + \eta I_v}} \quad (2)$$

where $I_v$ is the expected maximum utility (known as the inclusive value) that a person derives from purchasing types of dairy products that are defined as (Ben-Akiva and Lerman, 1985):

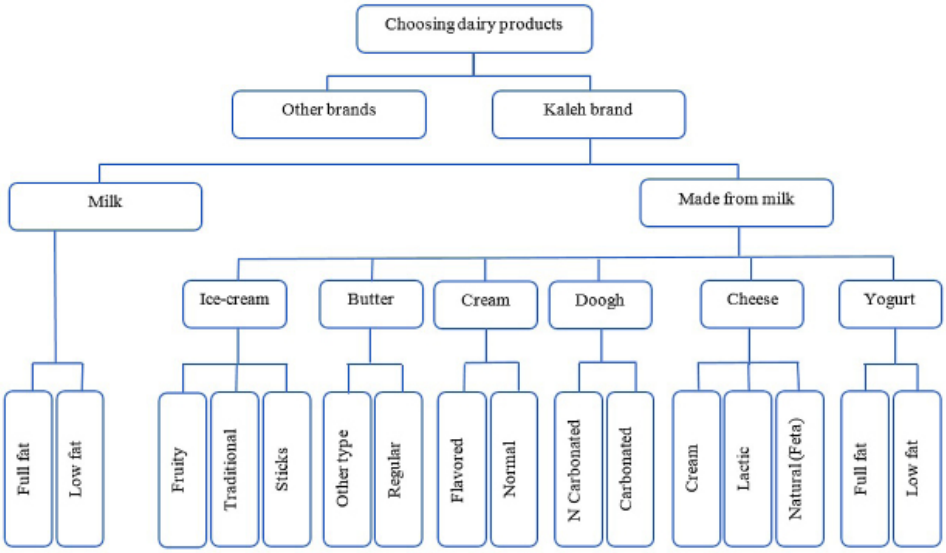
$$I_v = \log(1 + \sum_{i=1}^{C} e^{\beta_{ci} X_{ci}}) \quad (3)$$

This parameter is a dissimilarity parameter. It can be considered as a measure of the dissimilarity of alternatives or nests. McFadden (1980) showed that the nested logit model is consistent with the random utility maximisation. Borsch-Supan (1990) revisited the compatibility of the nested logit model with the utility maximisation principle and showed that the nested logit model can still be compatible with a random utility-based choice model for dissimilarity parameters greater than one (Davis et al., 2014) (Table 1).

| Independent variables | | Describes |
|---|---|---|
| Age | | Years |
| Gender | | male=1 and female=0 |
| Family size | | Count |
| Education | | 1-Illiterate, 2-Before diploma, 3-Diploma, 4-Associate, 5-Bachelor, 6-Master, 7-Doctoral |
| Occupational status | | 1-Unemployed, 2-Academic student, 3-free job, 4-Farmer, 5-Employee and 6-Other |
| family costs | | 1-less than 500 thousand Tomans* (T), 2-Between 500 thousand to 1 million T, 3- Between 1 to 2 million T, 4-Between 2 to 3 million T and 5-More than 3 million T |
| Exercise importance | | Very low=1, Low=2, moderate=3, high=4, very high=5 |
| People awareness about dairy products | | Low=1, moderate=2, high=3 |
| Brand preferences | | Rating score from 1 to 9 |
| Products price | | 10 Rials (Tomans) |
| 4P variables | Product | Affected=1 and not affected=0 |
| | Price | Affected=1 and not affected=0 |
| | Place | Affected=1 and not affected=0 |
| | Promotion | Affected=1 and not affected=0 |

Source: own processing

Table 1: Description of the independent variables used in this study.




Source: own processing

Figure 1: Suggested Nested Logit tree for the dairy products considered in this study.

The data was collected using a face to face survey administered in winter 2018 in Sari, Iran. To define the sampling method, we used a Cochran's sample size Formula and the simple random sampling method.About 30 pre-test questionnaires were collected to estimate the sample variance, and the calculated variance was 0.179. Based on this value and the Cochran formula, the sample size has been set to 275. To estimate the nested logit model we used the NLOGIT (5) software.

## Results and discussion

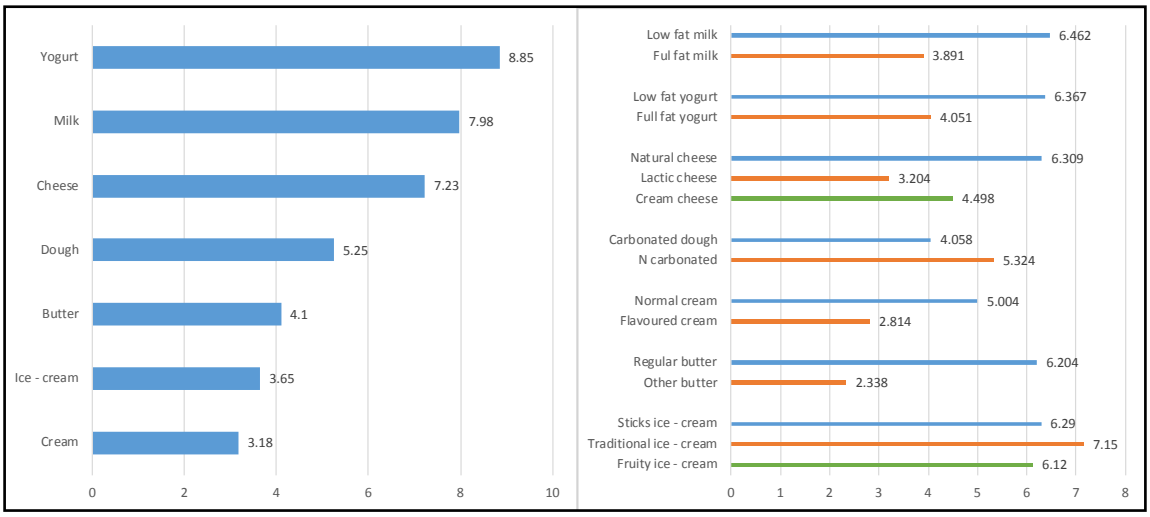
The descriptive statistics shown in Table 2 reveal that the people's average age in the group was about 42 years old. The minimum and maximum of respondents were 20 and 70 years old, respectively. There were more men than women. The average family size was around 3 persons, and the most was 7 persons. The result of education level showed that most respondents had a bachelor degree and government jobs. Family life cost between 1 to 2 million Tomans[1] were the most frequent. Other results indicated that respondents had an average tendency to exercise and their awareness of the importance of dairy products was low. The Kaleh company brand had maximum preferences among other dairy producers' brands. The data about the relevance of marketing mix variables showed that the stated relevance of "product" (that is, questions about quality, packaging, freshness and differentiating with other products) and "price" had more effect on people's choice than the stated relevance of the "place" and "promotion" 4p elements. Survey results of people's dairy preferences revealed that yoghurt, milk and cheese were the most preferred among other dairy products. Comparing low fat and full-fat products showed that, in the case of milk and yoghurt, consumers tend to use low-fat products. Average preferences for low fat and full-fat milk were 6.46 and 3.89, respectively, while preferences for low fat and full-fat yoghurt were 6.37 and 4.05, respectively (Figure 2).

| Independent variables | Min | Max | Average | Percent of total |
|---|---|---|---|---|
| **Age** | 20 | 70 | 42.396 | |
| **Gender** | 0 | 1 | | |
| Male | | | | 57 |
| Female | | | | 43 |
| **Family size** | 1 | 7 | 3.294 | |
| **Education** | 1 | 7 | | |
| Illiterate | | | | 1.5 |
| Before the diploma | | | | 9 |
| Diploma | | | | 23 |
| Associate | | | | 18 |
| Bachelor | | | | 29 |
| Master | | | | 12 |
| Doctoral | | | | 7.5 |
| **Occupational status** | 1 | 5 | | |
| Unemployed | | | | 5 |
| Academic student | | | | 10 |
| Non-government | | | | 32 |
| Farmer | | | | 14 |
| Employee (govern.) | | | | 39 |
| **Family costs** | 1 | 5 | | |
| < 500 thousand Tomans | | | | 9 |
| 0.5 - 1 million T | | | | 24 |
| 1 - 2 million T | | | | 33 |
| 2 - 3 million T | | | | 23 |
| > 3 million T | | | | 11 |
| **Willingness to exercise** | 1 | 5 | | |
| Very low | | | | 10 |
| Low | | | | 24 |
| Moderate | | | | 40 |
| High | | | | 21 |
| Very high | | | | 5 |
| **People awareness** | 1 | 3 | | |
| Low | | | | 64 |
| Moderate | | | | 21 |
| High | | | | 15 |
| **Brand preferences** | 1 | 9 | | |
| Low (1-3) | | | | 13 |
| Moderate (4-6) | | | | 40 |

Source: research findings

Table 2: Descriptive Statistics of the variables used in the model.

[1] Toman= 10 Rials




Source: research findings

Figure 2: Dairy product preferences (1 to 10, 1= very low).

Table 3 shows the estimated results of the model and enabled identification of some of the factors affecting people's preferences. The results indicate that a higher price decreased the probability of choosing dairy products and a 1-unit increase of this variable decreased this probability by 0.31 percentage points. Bhanu et al. (2017), Assan (2017) and Bousbia et al. (2017) also indicated that increasing price negatively affects consumers' preferences for the alternative. Results also show that for every product age, family size, education, exercise and the 4p product variable are statistically significant and increased the probability of choosing milk. The age variable is the most affecting factor. High family living costs decreases the choice probability for low-fat yoghurt, while age and education level variables increase this probability. In other words, according to our results, old people tend to choose low-fat yoghurt more than young people.

Meanwhile, the result for full-fat yoghurt showed that factors such as gender had a negative and significant effect on consumers' choice. It showed that men had a lower tendency than women to choose full-fat yoghurt. The preferences for the Kaleh brand, product and price (as for 4p) variables had positive and significant effects on full-fat yoghurt choice. The "Price" variable, as one of the marketing mix variables, had the most substantial effect on this probability, with a coefficient of 0.43 percentage points. Among the variables that affected the choice of cheese, the family living cost variable decreased the choice probability of natural and lactic cheese, and variables such as gender and price (4p) decreased the probability of cream cheese choice. Family size and price (4p) increased the probability of choosing natural cheese. Kaleh brand preference increased choosing of lactic cheese and promotion variable (4p) increased choosing of cream cheese. The results for the Doogh product reveal that age, family size, education and product (4p) variables increased choosing probability, while family size had the most effect on this probability. The "gender" variable increased choosing probability for normal cream and family cost and price (4p) variables decreased this probability. The "cost" variable by 0.70 percentage points had the most effect on this probability. In the case of butter products, age, education level, price (4p) variables increased choosing probability of regular butter, and that age variables had the most effect on this. Factors such as gender and family living costs decreased, Kaleh, brand preference and price (4p) increased choosing probability for ice-cream on sticks. In the case of traditional ice-cream, four factors of promotion, education, price and place increased choosing probability.

Results of the estimation of the inclusive value coefficients are illustrated in Table 4. These coefficients are known as dissimilarity parameters, and they can be considered as a measure of the dissimilarity of alternatives or nests. Results indicated that **all of the coefficients were significant and nests were independent.** It confirms our nested structure based on Figure 1.

| Products | Variables | Coefficient | Standard deviation | Z | Marginal effect (percent) |
|---|---|---|---|---|---|
| Total products | Price | -1.417*** | 0.593 | -2.39 | -0.308 |
| Low fat milk | Age | 5.655*** | 2.077 | 2.72 | 1.230 |
| | Family size | 1.254*** | 0.323 | 3.88 | 0.273 |
| | Education | 0.482** | 0.247 | 1.96 | 0.105 |
| | Exercise | -1.226*** | 0.247 | -4.97 | -0.267 |
| | Product (4p) | 1.326* | 0.789 | 1.68 | 0.288 |
| Yogurt low fat | Age | 1.261*** | 0.512 | 2.47 | 0.274 |
| | Education | 0.927* | 0.55 | 1.69 | 0.202 |
| | Cost | -1.244* | 0.715 | -1.74 | -0.271 |
| Yogurt full fat | Gender | -4.249* | 2.365 | -1.80 | -0.924 |
| | Brand | 1.620* | 0.881 | 1.84 | 0.352 |
| | Product (4p) | 1.768* | 1.004 | 1.76 | 0.384 |
| | Price (4p) | 1.965** | 0.918 | 2.14 | 0.427 |
| Natural cheese | Cost | 4.812*** | 1.549 | 3.11 | 1.047 |
| | Family size | 5.111*** | 1.762 | 2.90 | 1.112 |
| | Price (4p) | 2.052** | 0.989 | 2.07 | 0.446 |
| Lactic cheese | Cost | -3.664*** | 1.005 | -3.64 | -0.797 |
| | Brand | 1.729*** | 0.518 | 3.34 | 0.376 |
| Cream cheese | Gender | -1.431*** | 0.555 | -2.58 | -0.311 |
| | Price (4p) | -4.061*** | 1.276 | 3.18 | -0.883 |
| | Promotion (4p) | 1.746** | 0.884 | 1.97 | 0.380 |
| N-carbonated doogh | Age | 0.456*** | 0.201 | 2.27 | 0.099 |
| | Family size | 3.132** | 1.448 | 2.16 | 0.681 |
| | Education | 0.792* | 0.462 | 1.72 | 0.172 |
| | Product (4p) | 2.165** | 1.027 | 2.11 | 0.471 |
| Normal cream | Gender | 0.965** | 0.505 | 1.91 | 0.21 |
| | Cost | -3.212*** | 1.436 | -2.24 | -0.699 |
| | Price (4p) | -1.846** | 0.884 | -2.09 | -0.401 |
| Regular butter | Age | 4.062* | 2.284 | 1.78 | 0.883 |
| | Education | 2.644*** | 0.786 | 3.36 | 0.575 |
| | Product (4p) | -1.433* | 0.764 | -1.87 | -0.312 |
| | Price (4p) | 0.751* | 0.414 | 1.81 | 0.163 |
| Other butter | Gender | 4.026* | 2.264 | 1.78 | 0.876 |
| Sticks ice-cream | Gender | -6.408* | 3.784 | -1.69 | -1.394 |
| | Cost | -0.782* | 0.428 | -1.83 | -0.170 |
| | Brand | 1.335* | 0.260 | 5.12 | 0.290 |
| | Price (4p) | 0.246*** | 0.076 | 3.26 | 0.053 |
| Traditional ice-cream | Family size | 2.413*** | 1.003 | 2.40 | 0.525 |
| | Education | 1.753*** | 0.768 | 2.28 | 0.381 |
| | Price (4p) | 0.761*** | 0.347 | 2.19 | 0.165 |
| | Place (4p) | 2.009* | 1.138 | 1.77 | 0.437 |
| Fruity ice-cream | Family size | 7.043* | 4.032 | 1.75 | 1.532 |
| | Price (4p) | -3.075*** | 1.246 | -2.47 | -0.669 |

Note: ***, ** and * indicate significant at the 1%, 5% and 10% significance level, respectively.
McFadden Pseudo $R^2$ =0.58, Chi squared = 7.44, Log likelihood function= -26.31

Source: research findings

Table 3: Nested logit model estimation results.

| | Nest | Coefficient | Standard deviation | Z statistics |
|---|---|---|---|---|
| Second level | Yogurt | 0.852*** | 0.261 | 3.26 |
| | Cheese | 0.678*** | 0.279 | 2.43 |
| | Doogh | 0.468** | 0.242 | 1.93 |
| | Cream | 0.497*** | 0.224 | 2.22 |
| | Butter | 0.503* | 0.279 | 1.80 |
| | Ice-cream | 0.566* | 0.324 | 1.75 |
| Third level | Milk products | 1.428* | 0.870 | 1.64 |
| | Milk final consumption | 0.712** | 0.368 | 1.94 |
| Fourth level | Company brand | 2.154*** | 0.923 | 2.33 |
| | Other brand | 1.514*** | 0.722 | 2.10 |

Note: ***, ** and * indicate significant at the 1%, 5% and 10% significance level, respectively.
Source: research findings

Table 4: Estimation results of inclusive value coefficient.

## Conclusion

To understand the decision-making process of an individual or stated preferences made in a particular context or contexts, we can use choice models. This study estimated factors that affect consumers' dairy products choice and preferences in Sari, a city in the north of Iran, by using a nested logit model as a choice model. The result of consumers' dairy preferences indicated that yoghurt, milk and cheese had the most preferences among other dairy products and consumers' tended to use low-fat products. The estimation results of affecting factors on consumers' preferences showed that price variable decreased the probability of this choice. Bhanu et al. (2017), Assan (2017) and Bousbia et al. (2017) also indicated that the price variable may be a negative factor, affecting consumers' preferences. This variable had the same effect on dairy consumption in all the cities in Iran (Chizari et al., 2015).

The analysis of factors affecting consumers' preferences showed that, among demographic variables, consumers' age, gender, family size, education level and life cost all had a significant effect on their choice and preferences. Increasing age changed preference for choosing low-fat yoghurt, n-carbonated doogh, regular butter and low-fat milk. This effect could be related to life cost and health concerns. The number of family members affected consumers' preferences when choosing five products of low-fat milk, natural cheese, n-carbonated doogh, traditional and fruity ice-cream. Increasing numbers of children in the household changed their preferences to using other types of ice-cream. The development of education level affected choosing low-fat yogurt and milk. Actually, higher level of education led to preference for low fat products. Because of the positive correlation between education and the importance of the exercise variable, persons who did more exercise, preferred to choose low fat milk. Living cost had the most effect on choosing natural cheese. This means that' preferences change towards buying lower price cheese. Mousavi et al. (2016) revealed that these variables had the same effect on preferences of dairy consumers in Tabriz (north-west of Iran) and Shiraz (south of Iran). Brand names of dairy products were one of the important effective factors on willingness to consume some dairy products. In our case study, the Kaleh brand preference increased the probability of choosing lactic cheese and promotion (4p) increased choosing of cream cheese. Findings of a previous study in Karbasi and Aghasafari (2017) in Mashhad (north-east of Iran) revealed that the brand of dairy products increased consumption of dairy products. The history and experience of the dairy brand also increased this preference in Tehran and in the North cities of Iran (Mahdavi et al., 2013). The 4p marketing mix show that product (4p) had the greatest effect on choosing n-carbonated doogh brand and price had the most effect on choosing cream cheese brand., especially in the dairy market By using these results Marketing managers can improve their products based on consumers' preferences.

*Corresponding authors*
*Seyed Mojtaba Mojaverian, Associate Professor of Agricultural Economics*
*Sari Agricultural Sciences and Natural Resources University*
*9th km of Farah Abad Road, Sari, IRAN*
*Email: mmojaverian@yahoo.com*

*Hamid Amirnejad, Associate Professor of Agricultural Economics*
*Sari Agricultural Sciences and Natural Resources University*
*9th km of Farah Abad Road, Sari, IRAN*
*Email: hamidamirnejad@yahoo.com*

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# Spatial Price Transmission and Trade in the European Dairy Sector

Zoltán Bakucs[1,2], Zsófia Benedek[1], Imre Fertő[1,3]

[1] Institute of Economics, Centre for Economic and Regional Studies of the Hungarian Academy of Sciences, Budapest, Hungary

[2] Corvinus University of Budapest, Hungary

[3] Kaposvár University, Hungary

## Abstract

There exists a large literature on spatial price transmission in agro-food sectors, but research on milk sector is relatively limited. In addition, we cannot generalize the results of these studies due to their diversity in terms of methodology, periods and countries. The aim of the paper is precisely to generalize, or at least broaden the evidence on horizontal price transmission in European Union dairy market. We employ two stages approach. First, we test whether Law of One Price exists among European Union member states. Second, we try to explain our findings based on gravity model framework in a binary choice setting. Our results are in line with theoretical expectations: the volume of milk traded and Eurozone membership positively, the geographical distance negatively affects the probability of perfect price transmission. In addition, we show that horizontal price transmission is dependent on political group variables (New Member States versus Old Member States).

## Keywords

Spatial price transmission, EU milk market, trade.

JEL code: F14, F15, Q11, Q17

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## Introduction

Research on the spatial price transmission and integration is often used to test the efficiency of agricultural markets. On a spatially integrated market, price information should freely and fully be transmitted between trading partners. Not surprisingly, one of the most important targets of the European Union's (EU) Common Agricultural Policy (CAP) is to facilitate the spatial integration of agricultural markets within the individual member states as well as at the whole EU level by enhancing price discovery mechanisms.

Horizontal and vertical price transmission papers are abundant: an August 2016 AgEcon Search (**http://ageconsearch.umn.edu**) on 'price transmission' term results 546, on 'Law of One Price' 115, on 'market integration' 1837, and finally, on 'price integration' 1087 papers. Whilst some of the search results above are surely redundant, the numbers emphasise the popularity of these topics. The analysis of price transmission is and has been an econometrician's playground. Without completeness, some of the ground-breaking methodologies such as threshold cointegration, smooth transition and some Markov switching models were developed and tested using this framework, (see e.g. Enders, 2010). Most of these studies focus on single country-multi region cases (e.g. Brosig et al., 2011), country pairs (e.g. Bakucs et al., 2015) or multi-country framework (e.g. Emmanouilides and Fousekis, 2015). Recently, the 2007-2008 and 2010-2011 price spikes generated a renewed interest in spatial price integration (e.g. Goetz and von Cramon-Taubadel, 2008; Esposti and Listorti, 2013).

Assessing whether markets are integrated, whether the Law of One Price holds, or whether price transmission is symmetric or indeed asymmetric are themselves interesting research questions, since price transmission theory provides detailed theoretical explanations (see e.g. the discussion in Bakucs et al. 2014). In the light of this

abundance, the lack of empirical research uncovering the determinants of price transmission is perhaps even more striking. 16 years ago, in a seminal paper Peltzman (2000) called for the reconciliation of price transmission theory and empirical analysis, yet not much has been done since.

The weak connection between price transmission theory and empirical papers is mainly because the classical price transmission methodology employs time series econometrics thus it was developed using only price data, not allowing the inclusion of further covariates as determinants of price transmission. More recent techniques may directly or indirectly account for non-price variable effects as well, but encounter data availability problems. As Stephens et al. (2012) rightly argue, 'lack of available complementary price, trade flow and transaction cost data has hampered the analysts' ability to test empirically whether or not trade flows are the main mechanisms behind spatial equilibrium patterns' (p. 454). There are however several possible solutions to the problem of joint analysis of horizontal price transmission/ market integration and its determinants.

A possibility to indirectly incorporate trade (or trade costs) into price transmission analysis is the application of non-linear threshold price transmission models which allow adjustment asymmetries (e.g. Enders and Siklos, 2001) or indirectly account for unobserved transaction costs and define regimes with varying adjustment and short-run parameters (e.g. Hansen and Seo, 2002). Perhaps the most intuitive of this model class is the Gonzalo and Pitarakis (2006) procedure, which is capable of directly defining price transmission regimes (including regime dependent long-run relationships) dependent on an exogenous stationary variable (e.g. trade, market share, etc.). Empirical examples of the latter include Goetz and Cramon-Taubadel (2008) for German apple market or more recently, Bakucs et al. (2015) estimating trade volume dependent Slovenian and Hungarian wheat market integration models.

Second, given the wealth of price transmission papers, the use of meta-regression techniques in order to test second stage explanatory variables is a method at hand. This has been done for both vertical (e.g. Greb et al., 2012; Bakucs et al., 2014) and horizontal (e.g. Kouyaté and Cramon – Taubadel, 2016) price transmission. Besides the often not directly comparable methodologies, the publication bias might be a serious issue when first stage data originates from published research. As an example, Greb et al. (2012) find that cointegration occurs in 79% of all analysed commodity markets originating from published research, yet this ratio halves to 43% when the integration of similar commodity markets was directly assessed using FAO's GIEWS dataset.

In this paper we propose a new, systemic approach - which overcomes the comparability and publication bias issues discussed above - to analyze the changes in the dairy market during the previous decade from a market integration and efficiency perspective. (Following Barrett (2001), Holst and von Cramon-Taubadel (2013) discuss the distinction between market efficiency as result of price equilibrium in geographically distinct regions, and market integration as result of physical trade flows. In practice however, most importantly because of the lack of comparable frequency trade data, these terms are often used interchangeably.) First, we estimate all possible long-run cointegrating models between milk price pairs. We then apply discrete-choice models to assess the role of trade and other variables originating from gravity models affecting market integration. To the best of our knowledge, this approach has not been applied in empirical research. It is important to observe that none of the papers reviewed in this section focus on milk price integration. It is not obvious why this CAP regulated sector was neglected by empirical researchers.

## Materials and methods

### Spatial integration of EU raw milk markets

#### Law of One Price

Markets that pass price information quickly and fully, are considered to be perfectly integrated and commonly assumed to be efficient. Tomek and Robinson (2003) define the two axioms of the international price differences theory (For a detailed discussion on the methodological issues and generally the empirics of horizontal market integration see the excellent review paper of Listorti and Esposti (2012)):

- The price difference in any two international markets involved in trade with each other equals the transfer (or transaction) costs.
- The price difference between any two international markets not involved in trade with each other is smaller than the transfer costs.

Consider two spatially different markets and denote the time varying prices of the same commodity

as P1t and P2t respectively. The two markets are considered integrated, if prices corrected with transportation and other handling costs K, are equalized:

$$P_{1t} = P_{2t} + K \quad (1)$$

Trade between the two markets occurs only if $|P_{1t} - P_{2t}| > K_t$. (There are however some examples of existing trade despite negative arbitrage, explained e.g. by the need of keeping trade channels open or maintaining market share.) To put it other way, the arbitrage ensures that prices of the same good traded in spatially separate international markets equalize. In the literature, this is called the Law of One Price, LOP. Empirical literature usually tests the validity of the LOP with prices expressed in logarithms, allowing the interpretation of coefficients as elasticities of transmission:

$$lnP_{1t} = ln\beta_0 + \beta_1 lnP_{2t} + \varepsilon_t \quad (2)$$

According to the strong version of LOP, prices move perfectly together in time. Using the coefficients of equation (2), the necessary conditions are $\beta_0 = 0$, and $\beta_1 = 1$. In practice, however, the strong version of LOP only occurs very rarely, therefore a weak version of LOP was also defined. (Throughout the empirical analysis we use the weak version of LOP. Constant free cointegrating relationships are rather restrictive assumption resulting (amongst other issues) to over rejection of $\beta_1 = 1$ null hipothesis.) This states, that only the price ratio is constant, the actual price level is different due to transportation and other handling or transfer costs. Applying the notation of equation (2), the necessary restrictions $\beta_0 \neq 0$ and $\beta_1 = 1$, i.e. 1% price change in market 2 results in a 1% change in market price 1.

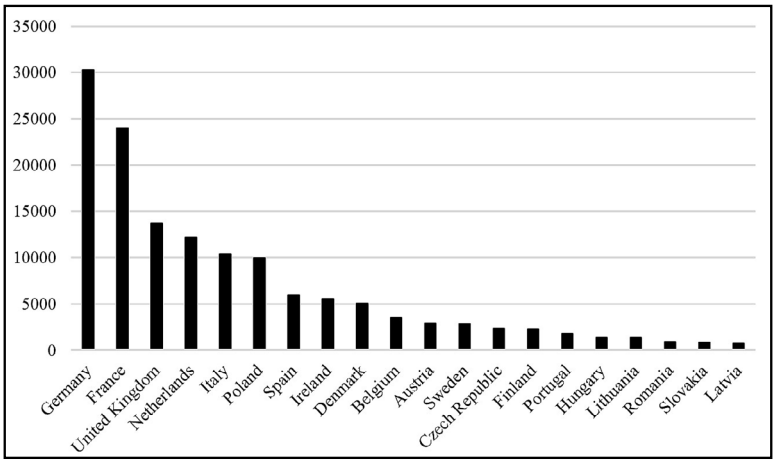
## Methodology and empirical strategy

Given the time series nature of milk price data, stationarity and integration properties within well specified Vector Autoregressive models are assessed first, applying the usual unit root tests for the logged price data and their first difference. Pairwise Engle and Granger type cointegration tests are employed next, followed by the estimation of bivariate cointegrating regressions (Engle and Granger, 1987). The (weaker) LOP hypothesis is tested for cointegrating price pairs only, within a Fully Modified OLS (FMOLS) framework developed by Phillips and Hansen (1990), which employs a semiparametric correction to assure unbiasedness and to allow the use of standard Wald and Chi-square tests. Using a 5% significance level we code the result of Chi-square restriction $\beta_1 = 1$ (eq. 2) into a binary variable taking the value 1 if the LOP holds, and 0 otherwise. Throughout the estimations, to account for residual serial correlation, the Akaike criterion is used for lag length selection. The Maximum Likelihood estimator of parametric discrete-choice models is only consistent and asymptotically efficient if distributional assumptions are valid. A number of semiparametric discrete-choice models were developed (see De Luca, 2008 for more details on this model class) to overcome estimator inconsistency in the presence of unknown error distributions. In this paper we apply the the semi-nonparametric discrete-choice model of Gallant and Nychka (1987).

## Data

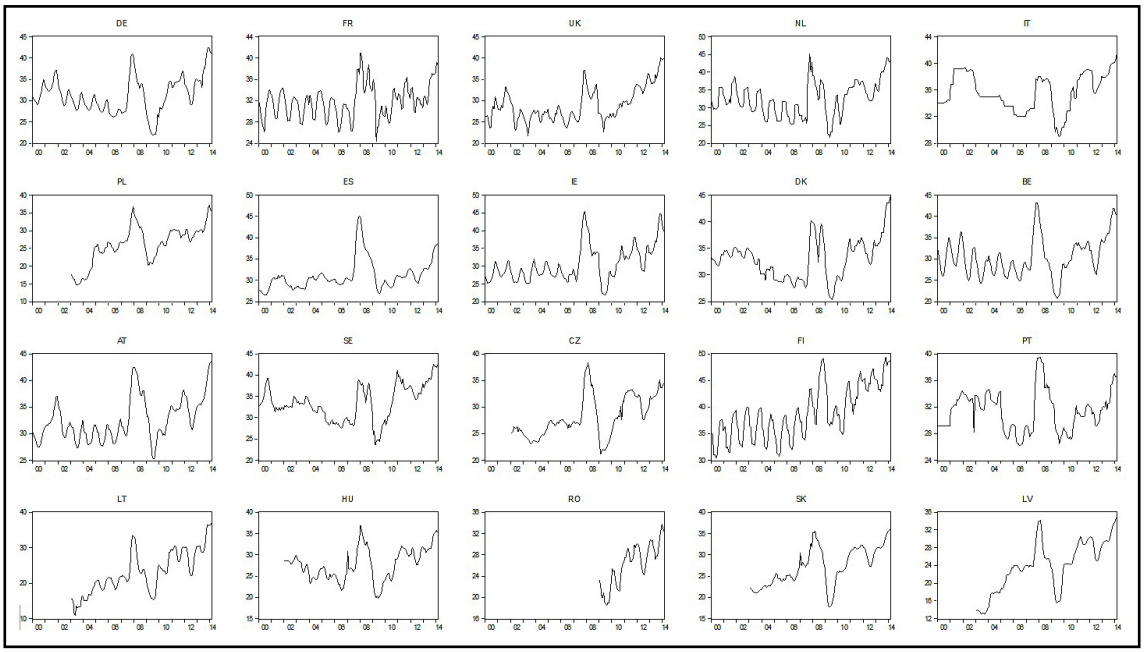
It is hard to overestimate the importance of EU dairy sector. It is the second source of animal protein; the yearly average consumption in the European Union (EU) is equivalent to approximately 300 kg milk (Westhoek et al., 2011). Although dairy products of many EU member states are competitive on global markets (Bojnec and Fertő, 2014), intra-EU milk trade is also significant (EDA, 2014). Enlargement, policy reforms and trade liberalization are considered the most important drivers of the changes in the dairy sector; but the joint impact of these changes is rarely analysed, especially at the EU level (Bouamra-Mechemache et al., 2008). Raw milk – the subject of this research - is a homogenous (and thus directly comparable) product that has not gone through any transformation except cooling. Monthly cow's raw milk price series from 2000 January until 2014 February were obtained from the European Commission's milk market observatory (**http://ec.europa.eu/agriculture/milk-market-observatory/**). Following an initial data consistency analysis, the following 20 out of the possible 27 member states were included in the analysis (in descending milk production order): Germany, France, United Kingdom, Netherlands, Italy, Poland, Spain, Ireland, Denmark, Belgium, Austria, Sweden, Czech Republic, Finland, Portugal, Hungary, Lithuania, Romania, Slovakia and Latvia. Together these countries account for 97.9% of EU27 2013 cow's milk production in 2013 (see Figure 1).

Figure 2 presents the individual country specific milk prices. Old Member States (OMS) series are composed of 170 observations, while New Member States (NMS) time series are ranging between 62 (Romania) and 146 observations (Czech Republic




Source: Own calculations, EUROSTAT data

Figure 1: Raw milk production in 2013 (1000 tons).




Source: own calculations

Figure 2: Raw milk prices in member states (EUR/100kg).

and Hungary). The 2007-2008 spikes followed by the 2012 price increase are clearly visible on graphs; however the inclusion of structural break dummy in test equations did not prove significant or did not alter results.

In spirit of market integration models we apply logarithm export volume as a prime candidate for second stage explanatory variables. Gravity models emphasise the role of trade cost explaining trade flows. Thus, we employ standard trade cost variables (logarithm) distance between trading partners' capitals, measured in kilometres, the existence of common border, and Euro dummy as a common currency. Moreover, we control regional/political division of European Union using different dummy variables:

- *lnexport(q)*: is a log of export value (volume) from country 2 to country 1 (using the notation of eq. 2) in 1000 dollars (tons) (source: World Integrated Trade Solution, or WITS, **http://wits.worldbank.org**);
- *lndist*: is the log of distance measured in kilometres between trading partners' capital cities used as proxy for transaction costs;
- *border*: dummy, takes value 1 if the two countries share a common border
- *Euro:* dummy, takes value 1 if both countries are members of Eurozone and zero otherwise.

- *OMS*: dummy, takes value 1 if both countries are old member states and zero otherwise;
- *NMS*: dummy, takes value 1 if both countries are new member states and zero otherwise;
- *NMSOMS*: dummy, takes value 1 if the reporter country is new member state and the partner country is old member states and zero otherwise.

## Results and discussion

The large number of unit root tests with varying deterministic specifications are not included in this paper, yet available upon request. In our single equation estimation and testing framework, each country in a price pair is considered both as a dependent and as an independent variable. Thus, using the logarithm of the 20 member state prices depicted in Figure 2, a total of 380 price pairs (k(k-1), where k = 20, the member of countries considered in this paper) were tested for cointegration and 135 (35%) proved to be cointegrated. Pairwise cointegration tests were run in the Engle and Granger framework (Engle and Granger, 1987). The weak LOP restriction ($\beta_1 = 1$) could not be rejected in 63 cases, that is 16.5% of all possible price pairs and 46% of cointegrating price pairs. Next, a LOP binary variable is created that contains 63 entries of unity for country pairs where the restriction holds, and 72 entries of zeros totalling 135 observations. To ensure consistency, we estimated four models (M1-M4): with and without border dummy and with both log trade value and quantity. The upper part of Table 1 presents the estimation output of the semi-nonparametric discrete-choice model (SNP) of Gallant and Nychka (1987), the lower part displays the number of observations, log likelihood, Wald test of all zero coefficients, Akaike information criteria and most importantly, the p-value of the chi2 test of Probit model against SNP model. (SNP procedure is implemented in STATA package, see De Luca (2008).) Note, the number of observations decreased from 135 to 108, since not all cointegrating price pairs are actually involved in physical trade.

Our primary interest here are not the magnitude, but rather the sign of coefficients. Very robust results were obtained: trade value and quantity parameters are significant beyond .001, as is the trade cost (log distance) coefficient. In line with our a priori expectations, trade cost negatively affects market integration, whilst increasing trade activity boosts integration. Country group dummies except NMS are significant at 5%, and have consistent signs, suggesting that price transmission is more complete if both the exporter and importer countries are Old Member States (positive coefficient of OMS). The positive coefficient of NMSOMS dummy (i.e. the reporting exporter country is a NMS trading with an OMS) suggests stronger integration, perhaps possible to interpret as NMS are following OMS price signals. This seems plausible, since besides orienting towards the core of EU countries, (except Poland, 6th largest producer) New Member States are generally smaller both in terms of population and milk production. The positive coefficient on the Euro dummy emphasizes that membership in the Eurozone results in more profound milk market integration.

| | M1 | M2 | M3 | M4 |
|---|---|---|---|---|
| Lnexport | .184*** | .179* | | |
| Lnexportq | | | .156*** | .150*** |
| Lndist | -.716*** | -.363*** | -.786*** | -.536*** |
| Border | -1.373 | | -1.284 | |
| Euro | 1.232* | .985** | 1.101* | .932** |
| OMS | .940* | .663* | .906* | .746* |
| NMS | .086 | -.708 | -.086 | -.960 |
| NMSOMS | 1.599* | 1.688 | 1.307* | 1.249* |
| cons (fixed) | 3.164 | .782 | 2.752 | .463 |
| N | 108 | 108 | 108 | 108 |
| ll | -58.85 | -60.22 | -58.9 | -60.08 |
| Wald $chi^2$ | 674.8 | 73.36 | 529.95 | 119.37 |
| AIC | 139.71 | 140.45 | 139.81 | 138.16 |
| P (Probit against snp) | 0.029 | 0.018 | 0.02 | 0.003 |

Source: own calculations, * p<0.05; ** p<0.01; *** p<0.001

Table 1: Determinants of LOP on the European raw milk market.

Albeit focusing on the correction coefficient (speed of adjustment) and not on LOP, our results show strong similarities with the findings of Holst and von Cramon-Taubadel (2013) on the European pork market, i.e. faster transmission (stronger integration) between OMS, Eurozone members if trade-costs are low (proxied by common border in the referred paper).

By estimating the LOP restriction to all possible country pairs in the first stage, we implicitly assumed that price information might flow even without physical trade. Traditionally (horizontal) price transmission and market integration is considered trade driven. There is however evidence that error correction between price margins, and thus market equilibrium happens both with and without trade if distinct markets monitor each other's prices. Stephens et al. (2012) use tomato prices with actual trade-flow and trade-cost data to estimate a Hansen (2003) type fully flexible error correction model allowing for separate trade and non-trade regimes. Although the authors expected that during no-trade periods prices are not adjusting towards the long-run equilibrium, empirical analysis proved cointegrated prices and adjustment in both regimes, implying multiple spatial equilibria (with and without actual trade flows). Similar conclusion, i.e. 'physical trade is not a necessary condition for price transmission' was reached by Holst and von Cramon-Taubadel (2013, p. 20.) with respect to horizontal integration of European pork markets. Although from a completely different perspective and methodology, it supports our finding of cointegration, i.e. equilibria for some country pairs not actually engaged in physical trade. More, in this paper we also found a fair number of country pairs where the LOP holds, yet are not engaged in trade.

To sum up, our paper uses a completely different methodology to reach the conclusion of Kouyaté and Cramon-Taubadel (2016 pp. 269): 'for those who criticize PT analysis as lacking an adequate theoretical basis, these results might provide some reassurance that empirical PT studies are on the whole producing consistent and plausible results.' A key issue of our paper is the relatively low number of occurrence of pairwise cointegration on the milk market. Whilst Holst and von Cramon-Taubadel (2013) rejected the null of no cointegration in 103 cases of the possible 105 (98%). (We are aware that the referred paper employs a different approach, i.e. system cointegration with one cointegrationg vector versus our single equation approach considering each partner both as dependent and independent variable, yet the difference between frequency of no-cointegration rejection on pork and milk markets is striking.) Our analysis resulted in a much lower rejection rate (35%). Does this finding point to lower degree of market integration of milk (defined here at its least restrictive form, co-movement of prices), compared to pork markets? It might as well just be so, when one considers the rather different way raw milk and pork markets are organised in space. Whilst transport of live pigs to slaughterhouses and processor plants from a given region occurs at given (larger) intervals and at lower unit costs, raw milk collection by processors is an (almost) daily business (depending on local cooling facilities) limiting spatially the radius processors can reach. Thus it is likely that prices are formed around milk collecting hubs, not necessarily within national borders. Consequently, national prices (at least within the EU) might not be fully representative for all of the given country's geographic regions. The availability of EU-wide regional prices would almost certainly change results.

## Conclusions

We assess the horizontal integration of raw milk markets in 20 EU member states accounting for roughly 98% of milk production in the EU for a period covering the past 13 years. Results suggest the cointegration of milk prices is less prominent than that of other agricultural sectors. More, the pairwise LOP only holds in 16.5% of all possible cases, raising questions with respect to the efficiency of markets, and perhaps applicability of national price data. Second stage analysis emphasised the positive role trade volume plays in strengthening market integration, although results (in line with other recent papers) highlighted that physical trade in not a necessary precondition of integration and market equilibria. It appears that OMS and Eurozone member states are better integrated compared to NMS, yet there is some evidence for inter-regional relationships (OMS, NMS) accelerating integration.

*Corresponding authors*
*Zsófia Benedek, PhD.*
*Institute of Economics, Centre for Economic and Regional Studies of the Hungarian Academy of Sciences*
*Tóth Kálmán u. 4., 1097 Budapest, Hungary*
*Phone: +36 305 071 019, Email: benedek.zsofia@krtk.mta.hu*

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# Development of Methods Acquiring Real Time Very High Resolution Agricultural Spatial Information Using Unmanned Aerial Vehicle

Basuti Bolo, Dimane Mpoeleng, Irina Zlotnikova

Botswana International University of Science and Technology, Palapye, Botswana

## Abstract

There is a need for high resolution spatial information to provide quality agricultural spatial information for better monitoring and management of farm activities to increase production and sustainable agricultural economic development. The Unmanned Aerial Vehicles are able to capture very high resolution spatial data that can be transformed into useful geospatial information, databases and digital maps. However, Unmanned Aerial Vehicle methods of acquiring spatial data are yet to be developed. The objective of this study was to develop methods of acquiring real time high resolution agricultural spatial data using Unmanned Aerial Vehicle. A qualitative case study research approach, and data collection method were used to achieve the objective. A ground truth data was carried out to eliminate errors. Unmanned Aerial Vehicle data acquisition system and data processing methods were developed. These methods could be used for better farm management and reduce the cost of inputs like fertilizers.

## Keywords

UAV, agricultural data, data acquisition, very high resolution data..

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## Introduction

This study aimed at developing methods of acquiring real time very high resolution agricultural spatial data using Unmanned Aerial Vehicle (UAV) to manage farm activities. Farm management when done properly could increase production and profit, and lead to an increase in agricultural economic production. The real time high resolution data and spatial information on agricultural farming is a need for agricultural land management, development and sustainable crop production. Imagery allows for observation of individual plants and patterns over the landscapes (Franklin et al., 2014; Laliberte et al., 2006). The high demands of very high resolution spatial data are advancing thus leading to the discovery of the new platforms. A new platform of the spatial data acquisition is based on Unmanned Aerial Vehicle (UAV). This new platform can provide real time very high resolution spatial data. UAV is one of the powerful equipment that can be used to obtain the earth surface images from any altitude (Tahar, 2012). High quality data can be later be transformed and used for obtaining geospatial information. Unmanned Aerial Vehicles (UAVs) have shown to be capable for agricultural Remote sensing data collection (Xiang and Tian, 2011). The agricultural spatial data had been typically captured by the manned mission known as satellites. Satellites had some limitations on providing high resolution data, and the imagery are of adequate spatial and temporal resolution.

### Importance of UAV in provision of spatial data and information

Unmanned Aerial Vehicles (UAVs) play a role complementary to that of satellites and conventionally piloted aircraft (Cano et al., 2017). Although satellites are useful for global and regional data acquisition, they are limited in their ability to provide data of adequate spatial and temporal resolution (Cano at el., 2017). UAV overcome limitations of satellites by providing a flow of real time data and allowing timely information (Liaghat and Balasundram, 2010). UAV provide real time, more high quality imagery data as compared to satellite imagery data (Zinkie and Flener, 2013), (Antle et al., 2015). UAV fly in low altitude, without cloud interference and can take higher resolution pictures (Zinkie

and Flener, 2013), (Yano et al., 2016). UAV uses the combination of simple digital photographic cameras with spectral filters designed to provide multi-spectral images in the visible and infra-red domains (Kahan, 2007). UAV provides the real time aerial photographs and information, and can produce both high and low resolution data on both small and large spatial coverage. UAV can monitor crops and unreachable areas any time anywhere. UAV bridges the gap in scale and resolution between ground observations and imagery acquired from manned aircraft and satellite sensors (Oltmanns et al., 2012). It also reduces the gap between fieldwork and low resolution data acquisition.

However the use of UAV application in agriculture is not common. There is insufficient information and methods on how to acquire the data and transform it into a useful information. This study developed methods on how to capture high resolution spatial agricultural data of a ploughed farm using UAV. The data captured was in a form of images.The methods for calculating the spatial resolutions were developed based on the images captured by an UAV.

This study used UAV to fill the gap on provision of high resolution quality spatial data and developed methods of acquiring real time very high resolution agricultural spatial data. The data acquisition system, methods of capturing the data and calculation of spatial resolution were developed and can be used by other researchers as a reference. The captured data and developed methods could be used to manage agricultural farm activities for better management and to increase production.

### General background

Unmanned Aerial Vehicle (UAV) based agricultural Remote sensing systems have been developed by several researchers (Herwitz et al., 2004). UAV had been used in many industries such as in forestry, surveying and mapping, disasters and risks management and agriculture. This study focused on how the UAV technology had been used in agriculture. This section presents an account of the existing studies on the use of the UAV technology in agriculture. (Peña et al., 2013) identified weeds between the lines of a corn crop using the images captured by an UAV multispectral camera. (Greenwood et al., 2016) used Remote sensing images to obtain the data of the orange fleshed sweet potato fields in Tanzania. Quality images were produced to accurately discriminate land use methods. The Lima CIP team (Allen, 2016) used the images to monitor crop stress. In India the UAV technology was used in crop insurance by the Kisan Pilot Programme (Garg, 2016). (Nigon et al., 2015) evaluated the ability of hyperspectral remote sensing to predict nitrogen stress in potatoes (Solanum tuberosum) during two growing seasons (2010 and 2011). The spectral data were evaluated using ground based measurements of leaf nitrogen concentration. These researches had provided a basic use of UAV in agricuture. There is insufficient methods and tools of capturing managing and transforming UAV data into a useful geospatial information. This study aimed at developing advanced UAV methods of data capture of a very high resolution data for monitoring and managing agricultural farm activities and the surrounding environment.

### General and specific objectives

The general objective of this study was to develop methods of acquiring real time very high resolution agricultural spatial data using Unmanned Aerial Vehicle (UAV).

The specific objectives of the study were as follows:

1. To identify methods and techniques of spatial data acquisition of real time very high resolution agricultural spatial data and information using UAV
2. To develop data acquisition methods to obtain real time very high resolution agricultural spatial data.

## Materials and methods

The methods used to identify the technologies of spatial data acquisition of real time very high resolution was through literature from the past research. Two broad types of platforms can be used for the acquisition of aerial images (Zinke and Flener, 2013), the aircraft and the Unmanned Aerial Vehicles (UAV). The aircraft are expensive and not easy to control because they are manned vehicles. The UAVs are easy to pilot and can fly at very low altitudes, enabling them to deliver very high resolution imagery at relatively low cost (Zinke and Flener, 2013). This study used the easy piloted Unmanned Aerial Vehicle to achieve the objectives.

A qualitative case study research approach was used to achieve the main objective. Qualitative research is a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem (Creswell, 2004). In this study, the exploration and understanding

was on the Unmanned Aerial Vehicle (UAV) for the development of methods of acquiring spatial data to process and transform it into useful geospatial information. The research approach involved questions and procedures; data collection and making interpretations of the meaning of the data (Creswell, 2004). These could be used to develop methods of UAV data acquisition and process. Qualitative methods rely on text and image data, had unique steps in data analysis, and draw on diverse designs (Creswell, 2004). This study relied on the agricultural information based on the text, and the Unmanned Aerial Vehicle (UAV) multi-spectral imagery to develop data acquisition and process methods.

Two farms were used to collect the agricultural farm activities qualitative spatial data. The data collected was used to developed methods of managing and transform the spatial data into useful geospatial information. The study used a DJI Phantom 4 quad-copter drone with a payload of a 12 pixel camera, focal length (20mm) with an inbuilt of both Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS) to collect the primary data. GPS and GLONASS when used together provide very high positioning accuracy real time data. UAV can be manually or autonomously controlled (Chao et al., 2010). The selection of manual or autonomous mode depends on the purpose of research. Manual control requires an operator to operate UAV during flight mission while autonomous requires ground crew station and operator to launch and land the UAV (Tahar, 2012). Manual control allows altitude to be changed easily and it reacts to real time information quickly. Autonomous is automatic and it is not easy to change altitude, it has to be reset again. In this study the data was captured mannual by a Unmanned Aerial Vehicle (UAV).

The spatial data was captured under a low altitude of five to 120 m above the ground on the studied objects or features. The data captured were unprocessed true colour digital images produced in a multi-spectral three bands (Red, Blue and Green) format. The images were shown in visual colours representing the colour seen by human eye.

After data collection, the data had to be verified for accuracy. This was done through the ground truth data approach. A ground truth data was carried out to eliminate errors. Ground truth the data involved checking to ensure that the collected data are the representative of what exist on the ground. This was done by surveying the data and the ground. These data was used to develop methods of UAV data aquisition. After the data had been captured, the spatial resolution was calculated in order to calculate the ratio (scale) of the images to the ground.

The spatial resolution is important for features identification and data analysis. The calculation of spatial resolution of UAV data had been considered to be complicated due to many factors involved (Propella, 2018). The UAV spatial resolution is referred to as Ground Spatial/Sample Distance (GSD) in aerial photography (Propella, 2018). The spatial resolution is the distance between two consecutive pixel centers measured on the ground.

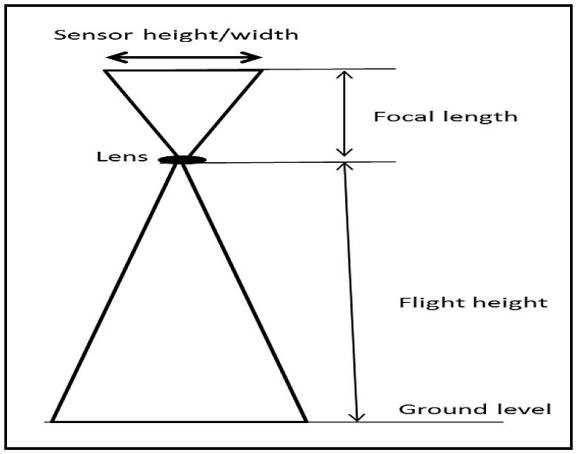
The spatial resolution of the UAV spatial data (imagery) was determined by a combination of several factors such as sensor dimensions, aspect ratio, camera focal length and the height of the camera above the ground of the area where data (image) was being taken. The number of pixels on the sensor in the X (horizontal) and Y (vertical) was obtained from the properties of an image taken by UAV camera. The horizontal and the vertical fields of view or a camera were found in the manufacturer's specifications for the camera/lens. The spatial resolution was determined by the number of pixels in the sensor array and the field of view of the camera. The UAV spatial resolution was calculated using GSD calculator and by manually method .

In this study a GSD calculator developed by the Propeller was used to calculate the resolution. When calculating the UAV spatial resolution the followings camera parameters are needed; the image width (pixel), image height (pixel), sensor width (mm), sensor height (mm), focal length (mm) and the flight height (m). Another option is to use customize procedures where the parameters of the drone have to be entered manually. In this case, the parameters of the camera and the flight height must be known to produce accurate results.

The resolution is determined by the height or the focal length of the camera to produce quality data and information. The bigger spatial resolution value represents the lower spatial resolution of the data (image) with less visible details. The smaller spatial resolution value represents the higher spatial resolution of the data (image) with more visible details. A spatial resolution of 5 cm means that one pixel in the image represents linearly 5 cm on the ground (5*5 = 25 square

centimeters). A spatial resolution of 5 m means that one pixel in the image represents linearly 5 m on the ground (5*5 = 25 square meters).

The spatial resolution was also calculated manually based on the flight height, the sensor height, the image height, the focal length, the sensor width and the image width as shown in Figure 1.




Source: Tellidis and Levin (2014), Propeller (2018)

Figure 1: Graphic representation of parameters for calculating the spatial.

The calculation was based on this manual GSD calculation formula.

$$GSDh = \frac{Flight\ Height * Sensor\ Height}{Focal\ Length * Image\ Height}$$

$$GSDw = \frac{Flight\ Height * Sensor\ Width}{Focal\ Length * Image\ Width}$$

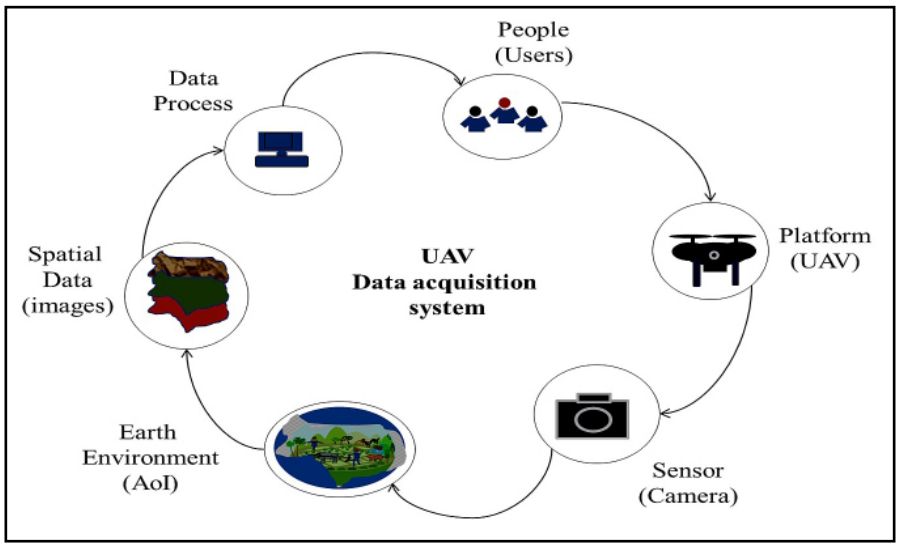
The diagram in Figure 1 is the general geometric of all aerial photographs. The parameters that were used were for the data (images) that were captured in this study.

## Results and discussion

The results of this study are the methods of acquiring spatial agricultural data and information using Unmanned Aerial Vehicle (UAV). The process of methods of data acquisition of UAV is complex. Several steps have to be considered to achieve better results. This study developed an UAV data acquisition system (Figure 2) composed of six components. The system is based on the main methods of data acquisition developed during the study.

The main components for the UAV data acquisition are the people, the platform, the sensor, the earth environment (Area of Interest (AoI)), spatial data and the data process. These components are needed to acquire and provide data, and process it into useful information.

The people are the users of data and also those that operate the UAV. The motivation for data acquisition is the need by farmers, decision makers, researchers and other users. Platform is the UAV is the platform carries the payload (sensors). The sensor (camera) takes the image of the objects of interest (features on the ground) such as ploughed areas and crops. The earth environment is where the agricultural activities take




Source: own processing

Figure 2: UAV based data acquisition system.

place. The spatial information is needed for planning purposes therefore the data is the main output of UAV data acquisition. UAV collect raw data. These data need to be processed and transformed into useful information of agriculture presented in maps for visualization. The data processing includes the methods and software. They are used to convert data into geospatial information.

The acquisition and methods comprising the data processing component of the system on Figure 2 are considered in more detail in the next two subsections, namely 1 and 2.

## 1. Procedures of data acquisition and processing

The study identified two main procedures of data acquisition by UAV. The first procedure was developing preparation plan which included the site plan, the image acquisition plan and the flight preparation plan. The second procedure was the survey of the area of interest. Both procedures had to be completed before starting the process of data capture.

### 1.1 Development of the preparation plan

The preparation plan is needed in order to plan for the flight mission and to decide on how the data be captured. The site plan involved identification of the sites where to locate the operation of the flight. The image acquisition plan explained how the image would be captured. The flight preparation plan set parameters for the constant flying height and overlapping.

### 1.2 Study area survey

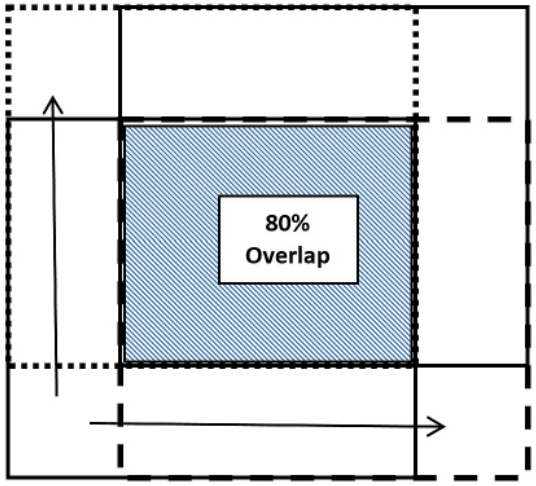
A survey of the study area was needed before UAV data acquisition. This was done to identify obstacles in the study area such as power lines, large trees and sensitive areas that could interact with the UAV. Those undesirable interactions might lead to distortion of the information and less accuracy.

## 2. Capturing UAV spatial data

An Unmanned Aerial Vehicle (UAV) was able to produce a significant amount of spatial data in a form of image scenes. The exact number of image scene depended on the size of the camera, area of interest and the height to cover the entire study area. An overlapping of images was needed to minimize the side distortions occurred when the images were being captured.

### 2.1 Image overlapping

An Unmanned Aerial Vehicle (UAV) produces many image scenes depending on the size of the camera, area of interest and the limited height to cover the entire area being studied. An overlapping of images is needed to minimize the side distortions occurred when the image is being captured. In this study an overlap of 80% forward and back, as shown in Figure 3 was done in order to avoid distortions from the edges.



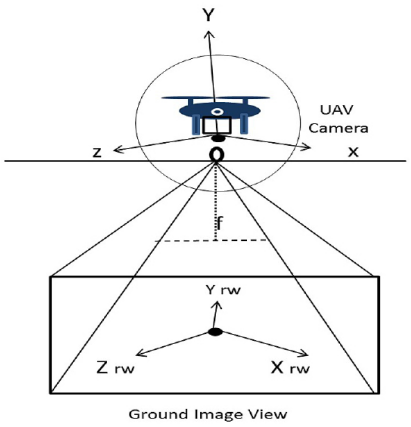

Source: own processing

Figure 3: Image overlap of 80% forward and lateral sides.

An overlapping of 80% was done also to produce a precise spatial data and information results during a transformation when the data is assigned the real world coordinates. This minimizes the error of geo-referencing of the data and data transformation error that is controlled by the quality of spatial data. In order to perform the process of image overlapping, the speed of the UAV and the altitude is balanced when capturing the images.

### 2.2 The methods of spatial data capture by an UAV

The spatial farm activities data was captured using an Unmanned Aerial Vehicle (UAV) under the manual flight control. The process is represented schematically in Figure 4. The optical axis of the camera was set perpendicular to the ground in order to capture vertical (Nadir) imagery type as shown in Figure 4. During the data capture the field of view in the real world coordinates (rw) with planar dimensions (X rw, Y rw) is mapped to the camera sensor elements (X, Y).

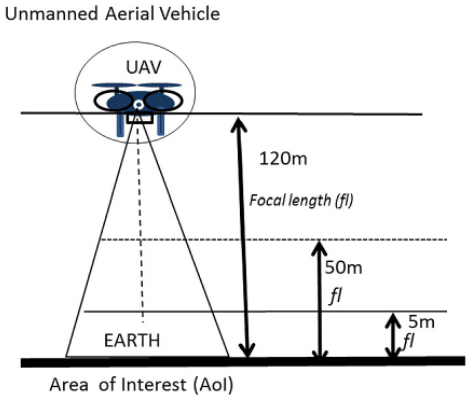



Source: own processing

Figure 4: Agricultural spatial data capture by an UAV.

All the images captured by the UAV were geo-referenced to the real world coordinates. The coordinates were located at the center or focal point of the camera on the ground when the image was being captured in a vertical system.

The images were captured at different heights above the ground as shown in Figure 5, to capture views of areas of interest and to get detailed information about the farm and crop grown.




Source: own processing

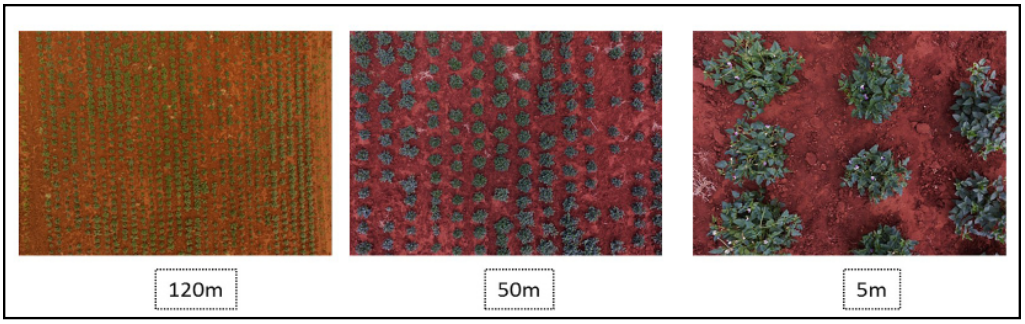
Figure 5: UAV data capture in different height.

The higher height produced large ground coverage with fewer details and low resolution. The lower height produced smaller ground coverage with more details and higher resolution. The captured images were taken at the height of 120m, 50m and five meters above the ground (Figure 6). This was done to get a clear picture about the condition of crops grown.

Capturing RGB multi-spectral images at three different heights provided a clear picture of the farm activities (crops grown and how they were planted). The crops were those of beans planted in rows. The images were captured one month after the crops were planted. Using UAV, the images can be captured anytime, anywhere at certain intervals for monitoring and assessing the growth, health, and crop variability.

The images captured by an UAV, each image had a metadata (image information) attached to it. The metadata is the documentation of data. The quality of the data can easily be identified using the metatadata. The metadata stores the data quality components. The metadata included: (1) Global Positioning System (GPS) reference coordinate (X, Y) that identified the position of the image on the ground, (2) altitude (Z), (3) image bands – Red (R), Green (G) and Blue (B), (4) focal length, (5) resolution (in pixels), and (6) the date of capture. Both the data and metadata were needed for the spatial data transformation, management and sharing. The metadata of the images in Figure 5 are presented in Table 1.

The metadata is needed in the processing of data, transformation and analysis of data. Based on the images captured by an UAV, pixel size is needed when processing data using rasterization analysis. The latitude and the longitude is needed when transforming the data and georeferencing the data into a real world. The altitude is the height above sea-level. It represents the elevation or slope on the ground.




Source: own processing

Figure 6: RGB multi-spectral images showing bean crops at different heights.

| Image | Multispectral | Size (pixel) | GPS Latitute | GPS Altitute | Altitute |
|---|---|---|---|---|---|
| 120m | RGB | 4000x3000 | -22:45:29.523 | 12:53.1 | 948.705m |
| 50m | RGB | 4000x3000 | -22:45:29.537 | 12:53.1 | 934.305m |
| 5m | RGB | 4000x3000 | -22:45:29.531 | 12:53.1 | 921.505m |

Source: own processing

Table 1: Metadata of UAV images.

## 3. Spatial resolution of UAV data

In this study the spatial resolution of the images were calculated using the Ground Spatial Distance (GSD) calculator and the results are shown in Table 2.

| Image Flight height | Spatial resolution | Rounded-off |
|---|---|---|
| 120m | 4.63 cm/px | 5 cm/px |
| 50m | 1.93 cm/px | 2 cm/px |
| 5m | 0.19 cm/px | 0.2 cm/px |

Source: own processing

Table 2: GSD calculator spatial resolution results.

The results presented in Table 1 show the resolution of the image with a flight height of 120m 4.63cm/px, image with flight height of 50m (1.93 cm/px) and the image with a flight height of 5m (0.19 cm/px).

The spatial resolution was also calculated manually based on the flight height, the sensor height, the image height, the focal length, the sensor width and the image width. The parameters that were used were for the data (images) that were captured in this study. The calculation was based on the manual GSD calculation formula below:

$$GSDh = \frac{Flight\ Height * Sensor\ Height}{Focal\ Length * Image\ Height}$$

$$GSDw = \frac{Flight\ Height * Sensor\ Width}{Focal\ Length * Image\ Width}$$

To calculate the spatial resolution (GSD) for 120 m above the ground using manual calculation and the camera parameters in Table 3.

| Item | Parameters |
|---|---|
| Image Width | 3000 pixel |
| Image height | 4000 pixel |
| Sensor Width | 6.17 mm |
| Sensor Height | 4.55 mm |
| Focal length | 4 mm |

Source: own processing

Table 3: Camera parameters.

Before starting the calculations, the values of the measurements must be converted into cm. The calculation for 120m flight height was as follows;

$$GSDh = \frac{12000 * 0.455}{0.4 * 4000} = 3.41cm/pixel$$

$$GSDw = \frac{12000 * 0.617}{0.4 * 3000} = 6.17cm/pixel$$

The worst case scenario in this case was the one that was used because the projected pixels onto the ground are not perfectly square. Therefore when spatial resolution is being calculated, the greatest (worst) is the one used (Propeller, 2018). The spatial resolution was 6.17cm/pixel.

There was difference between the spatial resolutions of manual calculated and the one calculated by GSD calculator. The resolution calculated by a GSD calculator for a flight height of 120m in this study was 4.63 cm/pixel while the one calculated manually was 6.17cm/pixel. There was a difference of 1.17 cm/pixel. Based on the resolution calculated mannally, where the worst scenario was being considered, the results could be improved by combinng the two results (GSDh + GSDw), averaging them and taking the average as the final resolution result. Thus;

$(GSD_h + GSD_w) / 2$

(3.41cm/pixel + 6.17 cm/pixel)/2

= **4.79cm/pixel**

The average results were close to the one calculated by a GSD calculator which was **4.63 cm/pixel.** Therefore the manual calculated method can be improved by adding the two results (GSDh + GSDw) then taking the average as the final result to improve accuracy.

## Conclusion

The study has achieved the objectives and proved the application of Unmanned Aerial Vehicle (UAV) technologies in managing farm geographic spatial information. The study has shown the effectiveness

of the UAV in managing agricultural crop farm activities. The study availed precise geospatial information system methods and information needed by farmers and the government to plan and forecast agricultural crop production. The researchers could use it as a reference, and advanced the methods and data acquisition system that have been developed.

During the study when capturing agricultural information, the study identified six main components of UAV data acquisition and developed an UAV data acquisition system. The system was used to collect and store UAV raw data. The system can also be improved by advancing it with other data processing tools and methods for other use. This study has improved the UAV methods of data acquisition and processing. These methods can be used to produced precise agricultural geospatial information frameworks.

The spatial data that was collected at different heights of 120m, 50m, and 5m using DJI Phantom 4 with 12 pixels had proved the capability of an UAV that it can be adjusted to any height during data collection any time.

The UAV techniques have proved to fill the gap between other aerial and satellite techniques with accuracies and high resolutions of a centimeter, that had been also identified by other researchers such as (Oltmanns et al, 2012), (Zinke and Flener, 2013). The data collected in this study was used to calculate the spatial resolution of the images which proved to be high at cm/pixel as follows; a flight height of 120m above the ground, the spatial resolution was 4.63 cm/pixel), flight height of 50m was 1.93 cm/pixel and, a flight height of 5m was 0.19 cm/pixel.

From the literature methods for calculating the spatial resolution of UAV were identified and used to calculate the spatial resolution of the spatial data that was captured in this study. The methods were used in order to test their effectiveness and use them as a reference. The methods that were used and found to be effect are the GSD Propeller calculator and the Manual GSD calculation formula (Propeller, 2018).

The study has availed methods of acquiring real time very high resolution agricultural spatial data using Unmanned Aerial Vehicle (UAV). The methods that were developed and identified in this study can be used to capture the high resolution spatial data for the agricultural crop production. These data can be used to manage farm activities and reduce costs.

*Corresponding authors*
*Basuti Bolo*
*Botswana International University of Science and Technology*
*Private Bag 16, Palapye, Botswana*
*Phone: +267- 72415845, Fax: +267-493 1002, Email: Basutibolo@gmail.com*
*Orcid. No. 0000-0003-1723-5108*

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# Robotic Internal Audit – Control Methods in the Selected Company

Marcela Hradecká

Department of Accounting and Finances, Faculty of Economics, University of South Bohemia in Czech Budejovice, Czech Republic

## Abstract

Simultaneously with the gradual introduction of automation and robotics industry 4.0., it is necessary to apply and use control methods of internal audit. Robotics and automation now provide us with far greater scope for applying internal audit control methods. Especially in manufacturing and agriculturals businesses is data interoperability important to streamline the production process and save operating costs. With proper application of checkpoints at risk points, hard data can be retrieved to prevent losses or fraud .

Using internal audit control methods, it is possible in real time to gain an overview of the company's situation and to contribute to better decision making by the management or the owners of the company. The article focuses on the implementation of robotic internal audit in the process of industrial beer production. The main goal is to elaborate own methodology for management of production or agricultural company within informatics and accounting to reduce high production and operating expenses.

## Keywords

Internal audit, fraud, IoT, Industry 4.0, manufacturing company, agricultural businesses, accounting, interoperability.

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## Introduction

The company management is the very sophisticated system (Kavan, 2002) of methods that is applied by top management, eventually by owners and investors as the effective instrument for the company strategy, planning and operating savings in the production process. The fraud management also has its irreplaceable place in the modern system of the company management and in its top management. The task of the fraud management is the elimination of all losses caused by failure of the human factor using robotization, automation and especially digitisation.

Managers monitor these processes and take measures based on obtained data through the robotic internal audit[1] that lead to a reduction of losses in the company[2]. This problem is addressed also by agricultural businesses that produce commodities for the food industry.

Automation and progressively robotization of agriculture and food industry began in the 20th century. The strategic idea was to eliminate hard (Grimstad et al., 2015) and physically demanding human work, especially during harvests. Robotic machines and systems have also penetrated into the field of automated robotic milking, stable cleaning (Kabeš, 2015), fruit harvesting, vine, etc. An important aspect is the compliance of robotic systems with the requirements of farm management. In particular, these include the reduction of operating expenses, human labor saving, time saving and return on invested capital. Agriculture robotization is closely linked to robotics introduced in the food industry. In some areas, the cultivation of agricultural commodities is intertwined with food industry. A brewery can be mentioned as an example. The cultivation of malting barley, which is the main raw material in beer production, is fully included in agricultural activity. Another intermediate step is malting for malt production. Malting can perform farms as part of their activity, as well as breweries that are included in the food sector.

[1] Internal audit can be understood as internal control procedures used to secure assets and ensure the accuracy and reliability of accounting data. Danos et al. (1992).

[2] Risk management in a business includes three basic rules that allow risks to be eliminated. 1. Don't risk more than you can lose. 2. Consider probabilities. 3. Don't risk much for little. Smejkal and Rais (2013).

The main problem of managing an agricultural or food enterprise today is the many actions, both manual and administrative, carried out by employees with different human factors. The operations are carried out in accordance with the company's internal guidelines, but without control links to the enterprise information system. There may be opportunities for fraud during the process of purchasing inputs into production and during the production process itself. Control activities are performed only on the basis of current monthly financial statements when the management of a company can only say that the production of a given product was loss-making and it is difficult to decipher why the cost of production was so high.

Literature research on robotic internal audit as methods of control for the prevention of fraud in accounting and production have not been found by the author in her research. Generally Robotic Process Automation (RPA) deal auditors in their article PwC (RPA Robotic Process Automation, 2017). They present the possibilities of using software robots in processing receivables, entering data between applications, copying, etc. Another company that generally deals with Robotic process automation (RPA) is KPMG (RPA Internal Audit and Robotic Process Automation, 2018). The company's auditors state that RPAs will help identify opportunities for the integration of automated assets and thus influence business processes and functions. Authors Dovenport and Raphael (2018) also dealt with automated audit processes. In this article, they provide options for replacing manual audits with automated processes.

Main goals:

1. Detection of risk spots at various stages of production to identify fraud opportunities
2. Review the manufacturing process to reduce production and operating costs
3. Implementation of Robotic Internal Audit IT application to ensure interoperability of production data and enterprise information system

For the application of control methods of the robotic internal audit[3] was selected production company, whose object of activity is the beer production and its bottling into PET bottles.

In a selected food enterprise, detection was carried out an existing process[4] procedures. Based on the conclusions of this analysis, was presented to the management of the company a detailed report on the status of processes in the enterprise.

In particular, this report states that the current technology for brewing beer is unsatisfactory, namely for wear and tear, that is, production losses such as leakage of some equipment, high energy and water consumption, non-ecological, as well as obsolescence from the perspective of IT technology. Individual devices are controlled only by the start and stop buttons or manually. The production equipment does not communicate with the superior information system at all. It is not possible to obtain any important data from the existing technology for operational and strategic management decisions.

Based on the conclusions and recommendations of this detailed report, the owners of this manufacturing company decided to purchase modern technology that meets requirements of the 4.0 industry. One of the reason for the purchase of this technology, is to eliminate all opportunities and possibilities of frauds that provably occur at all production companies with the object of beer industry activity in the Czech Republic that use the technology with a large portion of human work.

## Materials and methods

- Description of new technology for beer production - scheme
- Risk point analysis in term of fraud – scheme
- Design and implement control devices in the enterprise process system
- Proposal for implementation of supportive control methods
- A proposal for the implementation of a robotic internal audit software application by a IT engineer (project team member) to ensure interoperability
- Comparison of original and new technology data
- Induction of operating and production cost savings
- Evaluation of targets

At the stage of processing procedures and proposals, the author based her work on the literature review. The first two methods, description and analysis of the new technology material extracted

[3] Římovská (2001) states that internal audit helps the company achieve its goals and introduces a systematic approach to assessing and improving the effectiveness of risk management, management and control processes.

[4] Risk management focuses mainly on monitoring activities (risk detection) and subsequent prevention of fraud and theft. (Korecký and Trkovský, 2011).

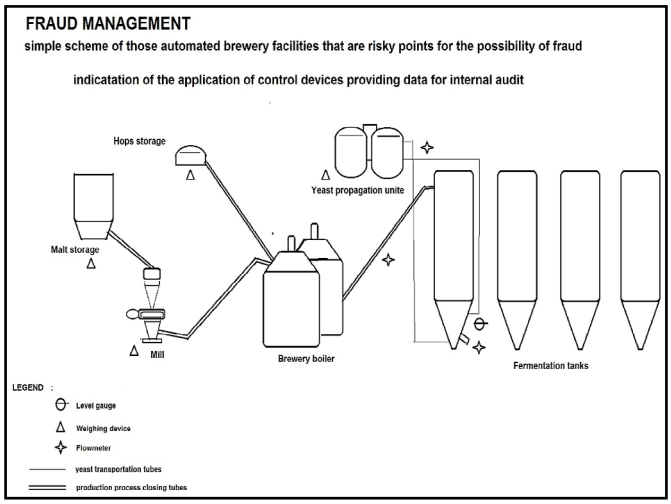
from a foreign internship was used. As part of a collaboration with Marco Bortolan, the author designed a system of checkpoints and control devices indicated in the scheme. (Figure 1).

## Control and supporting methods applied for individual phases of the production process.

The activity of fraud management starts during planning of the purchase of production commodities using anti-corruption procedures for the selection of suppliers. These procedures are supported by information technologies. Deliveries of individual commodities to the warehouse precede the dispatch of labels to suppliers. The label includes the following data: the commodity name, commodity trademark, weight of the commodity with packaging, commodity net weight, expiration time of the commodity, number of the stock item, barcode. Then the supplier physically accepts it into the warehouse and hands over the accompanying documents required by the legislation and documents required by the company's procedure, as well as registers the commodity as a warehouse item by reading the barcode on a reader located at a single entry into the warehouse. In the initial phase of production, i.e. in bins, the individual commodities are re-stamped by reading the barcode. The bins are multiples of the weight of the commodity packaging and are provided with a weighting system. The next brewing process is already fully automated and works without human factor intervention, only based on a recipe stored in the central counter. The production phase after beer brewing continues by placing the beer in the matured tanks for the ripening process. The further production phase is bottling of beer into PET bottles. The process of beer bottling into PET bottles is carried out using an intelligent, fully automatic batch line consisting of individual machines and devices that operate as one synchronous unit ending with a palletizer. The production process ends with the result that the boiled ripe beer is bottled in PET bottles. The bottles are labelled, packed in a group pack, placed on a euro pallet wrapped in a foil wrapping and provided with a barcode label. The whole euro pallet is then placed in the warehouse by reading the barcode on the label.

## Supporting methods

Supporting methods serve as complementary methods to the robotic internal audit. The supporting methods used in this selected company are: camera system, attendance system, physical security, physical control activity by documentary and material worker according to responsibility, monitoring the observance of work activities by the responsible persons. Among the support activities, the selection of employees can be included when recruiting staff by the human resources department. The camera system in the selected company monitors in real time all events where the risk of fraud is increased. The camera system monitors the surroundings of the production company as well as the interior production facilities. The specific risk points are: commodities take-over activities to the warehouse, dispatch of commodities from the warehouse of raw materials, the storage of the finished products in the warehouse. Records and archived data from camera systems are used by internal audit for secondary analysis when discrepancies




Source: www. marcobortolan.it, own processing

Figure 1: Automatic devices of the brewery.

in values of the company system are detected. This means finding out the different values reported by the commodity purchase department, commodity stocks and financial accounting. This supporting method prevents the thefts of entry commodities and finished products and thefts can be detected at a given moment. Another closely related supporting method is the physical security. Its intention is the psychological stimulus "I will be caught in the act." That means to discourage the temptation to alienate the property or commodities owned by the company. The attendance system as the supporting method fulfils a number of supporting tasks. The attendance for wage purposes is the most important one. The attendance system provides a periodic report of the number of worked hours, both regular and overtime. Another important task is an overview of persons who are situated in a production facility in a given time period. This means finding out that there are also non-shift workers in the production facility. For internal audit purposes, the attendance system provides data to analyse the production efficiency, respectively a share (combining) of functions, because the modern and fully automatic beer brewing plant with the fully automatic beer bottling line into PET bottles allows this sharing. The periodic physical and document control as the internal audit supporting method enables to physically check the status of entry commodities or finished products with accompanying documents on the purchase of material commodities. For example, a check of delivery notes, shipping notes, invoices with warehouse receipts and release orders or check of -ups of stacked material commodities with data from labels issued by the purchase department. Data from the results of physical and documentary checks are very valuable for internal audit purposes. Together with other supporting methods, they help to prevent thefts and frauds of entry commodities when purchasing commodities or stealing finished products from the warehouse.

Monitoring of observance of work activities is one of the other supporting activities. It is done by a responsible worker and its aim is a psychological incentive for workers to move only at their workplace. This supporting method helps to discourage the temptation to alienate the property of the company and at the same time helps to keep the production process flowing within the work shift. So there is no production downtime such as failure to add labels, closing caps, packaging foils, etc. The optional supporting method is the selection of employees by the human resource department. Every company should consider behavioural influences in the selection procedures for new job positions in the company. Job candidates are interviewed in multiple-stage selection procedures and in many cases with psychological tests, for example a BMTI personal test (Myers Brigs, 1980). This test can reveal the tendencies of individual types of personality to mistakes, such as distraction, but also the tendency to thefts and frauds.

The robotic internal audit control methods are a set of financial and non-financial values and information obtained through reported data from information systems[5] in the real time as well as from data stored in the data storage "data warehouse"[6]. The control methods used in this selected company are: binding internal strategic purchasing procedure, measuring of quantities, binding procedure of the sales department. The first mentioned method - binding internal strategic purchasing procedure especially includes these obligations: a selection of suppliers from as many potential candidates as possible. Registered candidates must be inspected for their creditworthiness and stability in order to avoid bankruptcy of the supplier during any cooperation. To communicate with suppliers, you only need to use e-mail company correspondence. The personal contact with the supplier is only possible after a meeting planned in advance and with the participation of at least two persons. After each negotiation with the supplier, a record of this meeting is made, with which all participated parties are acquainted. This record is required to be stored on the intranet and made available to internal audit workers. The telephone communication is inadmissible at the conclusion of the contract. Every supplier must respect the binding strategic purchasing procedure and fulfil the obligations that arise for him /her as a supplier. These obligations also include the provision of the supplied commodity with labels issued by the purchase department of the production company. This control method leads to the prevention of the corrupt environment when purchasing input commodities. The most important control methods include the measurement of quantities.

[5] Král et al. (2008) states that every decision is original and its information support is specific. The decision-making information system is more demanding than just providing the basis for comparing the reality with the desired state.

[6] Pospíšilová et al. (2008) states that data warehouses are a suitable superstructure for transformation systems, through which information can be easily obtained for summary data analysis and for uncovering hidden connections.

The technical devices for measuring of quantities used in this production company are: barcode scanners, technological scales, level gauges and flowmeters. The barcode scanners measure a number of commodity packages of a given weight stored in the commodity warehouse. The quantity of the commodity is thus automatically recorded on the commodity storage card of the economic system of the company. For purposes of the internal audit, the barcode scanners provide the data on the stacked quantity of the commodity for the control comparisons of stocks between the warehouse and financial accounting. In case of inconsistencies, the secondary data and records from camera (CCTV) systems shall be used. This control method prevents the theft of input commodities. Further technical devices are technological scales. These devices measure a weight of the commodity in bins and further a raw material modified by milling in the mill. For purposes of the internal audit, the control technological scales provide data on the quantity of the commodity taken out from the warehouse and placed into the bin in front of the mill for the control comparations of stocks between the warehouse, bin before the mill and financial accounting. In case of inconsistencies, secondary data and records from camera (CCTV) systems are used. This control method prevents the thefts of input commodities. The importance of placing the technological weighing scales under the mill is to control the amount of input raw material treated by milling into the beer brewing process according to a calculated recipe. The technological weighing scales are further placed under the hop bin for the check of the amount of input raw material to the production according to a calculated recipe. For internal audit purposes, these technological weighing scales placed under the mill room and hop bin provide data for the check of compliance with production calculations and determination of variations on the given batch. In the case of yeast propagators, the technological weighing scales fulfil the control safety function to prevent the theft of the very valuable input commodity. Other closely related devices with technological weighing scales are flowmeters located on the yeast propagator and on the pipeline between the brewing plant and fermenting tanks. This device measures the amount of liters of brewed beer pumped from the brewing plant into the fermenting tanks and the amount of added yeast from the yeast propagator. For internal audit purposes, these flowmeters provide data for checking of compliance with production calculations and determining of deviations in the fermentation process. Level gauges measure the level of beer in the fermenting tanks. For internal audit purposes, they provide data on the amount of beer placed in tanks. The level gauges as control devices placed on the fermenting tanks fulfil a safety function to prevent beer and yeast thefts. In the beer production process, this place is considered to be the most critical in terms of fraud management. The next phase of a fully automated production plant is beer bottling into PET bottles.

In order to efficiently perform the bottling line as a set of machines and equipment aggregated into one automated functional system, we serve a wide range of control devices for the proper performance of individual bottling line operations (bottling, closing, labelling, packing). These measuring devices provide data for the amount of filled beer into PET bottles for internal audit purposes. The filling device is able to provide data on the number of well-filled bottles, the number of filled bottles per unit of time, the number of bottles not filled. The labelling device provides data on labelled bottles and not on unlabeled bottles. The packing unit provides data on the number of packed bottles in the group pack. The palletizer provides data on the number of individual packages placed on the pallet. Reported data from the filling line for internal audit purposes serves to compare the number of bottles coming out from the bottling device and coming out from the labelling device. Another function of these control devices is also the safety aspect to avoid thefts of bottled beer. In case of discrepancies, secondary data from the camera system can be used. Packages placed on the pallet are labelled with a barcode label. At the goods warehouse entry, the pallets are registered into the company's economic system by scanning of the bar code with the scanner. The benefits of the barcode scanner control method are described in the previous paragraphs. The last control method is the binding internal procedure of the sales department. It particularly includes the following duties: monitoring of the compliance with the pricing policy for clients at all levels, observance of the anticorruption internal company policy. All extra discounts and non-standard sales conditions provided to customers must be discussed and approved in advance by an authorized manager, most often by a financial director. Employees of the Sales Department are banned from all business activities, and every year they submit

schedules of assets (property returns) according to the procedure with which they were acquainted with the entry into employment.

### Internal audit - robotic system

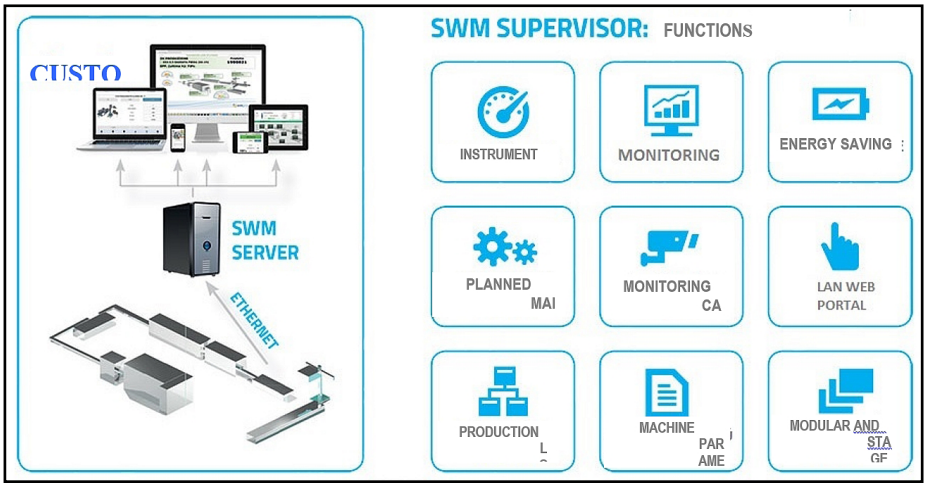
More and more company managers are interested in promoted robotic software that automates manual processes, makes employees work more effectively and provides the time to focus on methods, how to increase revenues and reduce costs. The Departments of Internal Audits in the Czech business environment are in the early stages of understanding how the robotics can support the automation of the company's internal processes. In fact, only about 10% of companies and their audit teams plan to use automated and robotic processes in this year. Approximately 80% of companies do not plan to use RPA at all (RPA Robotic Process Automation, (2017).

It is necessary to note that the present managers of the Internal Audit Departments have not done much in the field of service sharing. They show their interest in information about robotic internal audits, but they still have a lack of professional knowledge and experience needed for implementation of this project into the production company process.

What is the robotic software?

The robotic software is basically what separates it from other forms of automation. This means that it is not intended for any process or activity. The robotic software is flexible and can be almost used by any rule-based activity. It reminds of human interaction with IT systems. Unlike a human factor, the robotic software can run rules-based steps for a fraction of the time a person needs to do this. RPA is the software that can record multiple steps among more systems (Figure 2).

Multi-step recording between multiple systems is important for program data interchange, such as OPCUA, OPC, MODBUS / TCP, PROFINET, AJAX, SOAP. Internet Object Technology "IoT" - 4.0 industry allows the collection and integration of the operational data of all machinery present in the production company into a single control platform that provides continuous monitoring of the production company's efficiency level performance in a real-time environment and allows the remote access to all decentralized locations in case of inconsistencies or problems. In this way, it is possible to obtain real-time information, either from an aggregated point of view of the entire production line of the company (production volume, average production time, consumption, waste and stock) or from the viewpoint of each individual machine. An example of such a software application is the corporation SMI Group's new application for automation and control “SWM Supervisor“ (IFI Intelligent factory of 4.0 industry, 2018). The "SMI“ application was developed according to principles of Industry 4.0 and IoT (Internet of Things – called in informatics as the network of physical devices, appliances and other devices that are equipped with electronics, software, sensors, moving parts or network connectivity to enable these devices to interconnect and exchange data). IoT allows you to combine typical functions of collecting and monitoring the production data from a series of machines that simplify the device control,




Source: www.smi.it

Figure 2: Intelligent factory of 4.0 industry.

increase its productivity, safety and reduce operating costs, ensuring the excellent return on investment. The SWM Supervisor is based on a modular, open and flexible "company" web portal that can be customized to any application area and is available at several levels to meet the needs of all data collection and surveillance. Thanks to this innovative SMI system, it is easy to identify the main causes of downtime of the bottling or packing line, to improve the overall line efficiency and to reduce the time required for machine maintenance on the production line and format changes. It is also possible to obtain a structured report for performing of analyses with various functions, such as backgrounds for the internal audit.

### Own contribution

- Presenting the management of the business corporation, for what purpose and in what way it is possible to use the extracted data from the software application in real time.
- Development of author´s own proposal of RPA implementation methodology and own participation in RPA implementation.

The collection of these valuable data shall also serve as prevention against thefts, which the food production companies in the Czech Republic are constantly facing. It especially concerns attractive foodstuffs such as alcohol, beer, chocolate, etc. By collecting and distributing of information sent through various intelligent devices located in the production line and connected to the network it is possible to easily manage and transfer data through the web so they can be shared instantly with people, systems and other IT applications, both on the Internet and on the company intranet. By integrating the SWM Supervisor with the SMI Group, together with the software of robotic and automated storage of finished products, comprehensive data on needed quantities can be obtained from the beginning of the production process up to the expedition in the production factory. These valuable data lead to financial savings, better and more efficient decision-making and, last but not least, to prevent unintentional and criminal losses. So this avoids frauds in accounting and distortions of profit. For each production or farm, it is necessary to create a specific software application within the RPA project according to the client's requirements so that he can respond to the situation immediately.

### Comparison of energy consumption old and new technology

By comparing the energy requirements of old and new brewing technology, the author came to the conclusion that the new technology is up to 46.5% more economical (Table 1).

| Old equipment | KW | New equipment | KW |
|---|---|---|---|
| Brewhouse | 40 | Brewhouse | 24 |
| Yeast propagator | 8 | Yeast propagator | 3 |
| Ice water tank | 35 | Ice water tank | 24 |
| Hot water tank | 9 | Hot water tank | 6 |
| Steam generator | 4 | Steam generator | 2,5 |
| Fermantation tanks | 10 | Fermantation tanks | 8 |
| Open maturation room | 40 | Maturation tanks | 8 |
| Mill | 10 | Mill | 8 |
| Total | 156 | Total | 83.5 |

Source: author´s processing

Table1: Beer processing technology.

By comparing the energy intensity of old and new beer bottling technology to PET bottles, the author concluded that the new technology is 27.48% more economical (Table 2).

| Old equipment | KW | New equipment | KW |
|---|---|---|---|
| Depaletisation | 15 | Depaletisation | 10 |
| Filling block | 19 | Filling block | 15 |
| Dryer | 30 | Dryer | 14 |
| Pastorisation unit | 50 | Pastorisation unit | 30 |
| Conveyors | 30 | Conveyors | 28 |
| Packaging machine | 60 | Packaging machine | 55 |
| Paletisation unite | 10 | Paletisation unite | 5 |
| Stretchwrapper | 8 | Stretchwrapper | 4 |
| Total | 222 | Total | 161 |

Source: author´s processing

Table 2: Beer bottling.

### Comparison of personal employment of technology operations old and new technology

By comparing the personnel intensity of old and new beer technology, the author came to the conclusion that the new technology requires 6 employees less than old technology (Table 3).

| Old equipment | No. empl | New equipment | No. empl |
|---|---|---|---|
| Brewhouse | 2 | Brewhouse | 1 |
| Yeast propagator | 1 | Yeast propagator | 0 |
| Ice water tank | 1 | Ice water tank | 0 |
| Hot water tank | 0 | Hot water tank | 0 |
| Steam generator | 0 | Steam generator | 0 |
| Fermantation tanks | 0 | Fermantation tanks | 0 |
| Open maturation room | 1 | Maturation tanks | 0 |
| Mill | 2 | Mill | 0 |
| Total | 7 | Total | 1 |

Source: author´s processing

Table 3: Beer production.

By comparing the personnel demands of the old and the new technology of beer bottling, the author came to the conclusion that the new technology requires 7 employees than old technology (Table 4).

| Old equipment | No. empl | New equipment | No. empl |
|---|---|---|---|
| Depaletisation | 1 | Depaletisation | 0 |
| Filling block | 1 | Filling block | 2 |
| Dryer | 0 | Dryer | 0 |
| Pastorisation unit | 1 | Pastorisation unit | 0 |
| Conveyors | 0 | Conveyors | 0 |
| Packaging machine | 1 | Packaging machine | 0 |
| Paletisation unite | 4 | Paletisation unite | 0 |
| Stretchwrapper | 1 | Stretchwrapper | 0 |
| Total | 9 | Total | 2 |

Source: author´s processing

Table 4: Beer bottling.

By comparing the other personnel demands of the old and the new technology, the author came to the conclusion that the new technology requires less staffing of 12 employees (Table 5).

| Old equipment | No. empl | New equipment | No. empl |
|---|---|---|---|
| Maintenance | 2 | Maintenance | 0 |
| Technician | 2 | Technician | 0 |
| Brewmaster | 1 | Brewmaster | 1 |
| Process engineer | 2 | Process engineer | 1 |
| Warehouseman products | 1 | Warehouseman products | 1 |
| Row material warehouse | 2 | Row material warehouse | 1 |
| Maintenance manager | 1 | Maintenance manager | 0 |
| Administration | 2 | Administration | 2 |
| Economic departement | 2 | Economic departement | 1 |
| Gate-keeper | 4 | Gate-keeper | 0 |
| Building management | 0 | Building management | 1 |
| Manipulation worker | 0 | Manipulation worker | 1 |
| Purchase department | 2 | Purchase department | 0 |
| Total | 21 | Total | 9 |

Source: author´s processing

Table 5: Other professions.

## Additional important comparation

By comparing the efficiency of old and new technology of production and bottling of beer, the author came to the conclusion that the new technology shows substantial savings in production and operating costs (Table 6).

| Indicators | Old equipment | New equipment |
|---|---|---|
| Water consumption | 6 l/ 1 liter beer | 3 l/ 1 liter beer |
| Loss in production carelessness | 15 % | 2 % |
| Loss in production intentional (Fraud) | 30 %! | 1 % |
| Constant deviation of beer quality | 10 % | 0.40 % |
| Frauds elimination | 20 % | 97 % |
| Work productivity possibility control | 30 % | 90 % |

Source: author´s processing

Table 6: Economic indicators.

## Comparison of annual energy savings and wage costs in thousands of CZK

Table 7 compares savings on selected cost items. The presented result shows considerable annual savings in production, which will significantly reduce the price of beer while maintaining its quality. I made a comparison of cost savings in a selected beer production company on selected annual reporting data and on the basis of extracted data from the original technology analysis and new technologies presented in Tables 1 to 5.

| Position | Old technology in ths. CZK | New technology in ths. CZK | New technology savings in ths. CZK |
|---|---|---|---|
| Energy | 37 990 | 24 623 | 13 367 |
| Personal expenses | 14 087 | 5 122 | 8 965 |

Source: author´s processing

Table 7: Selected data of real beer production enterprise.

## Robotic internal audit in the context of the agriculturals businesses

The current trend in agriculture is to increase farmers' productivity by using automated systems Yang et al, 2018; Comba et al., 2010), robotic machines (Akbarzadeh et al., 2013; Richards et al., 2015) (transport vehicles) (Sorensen et al., 2004), guided and navigated GPS (Ball et al., 2015), robotic milking systems, robotic fruit harvesting machines, vines, etc.

The global food chain is facing population growth, climate change, water loss in nature, as well as political pressures. Robotics, automatic systems, and digital technology help to transformation of agriculture and food industry. Research in this area helps to plan, coordinate, manipulate and interoperate

between robots and the human control factor (Trianni et al, 2018). The global agri-food industry could be transformed by the implementation of robotics and digital advanced industrial systems 4.0 (Barth et al, 2014). These sophisticated systems can attract qualified IT professionals.

Manufacturing and agriculturals are closely interconnected. Agriculturals businesses produce commodities that are essential for food production as well as beer production. It is therefore necessary for agriculturals businesses to produce a commodity at a price that is competitive on the market. An important aspect is therefore the reduction of production and sales costs. Robotic internal audit can also be applied to agriculturals businesses. The theme of internal audit in the conditions of the agriculturals businesses, was dealt with by an author, Římovská (2001), in an article in Agris magazine. It focused on risk analysis and management. This means the consistency of documents with the real state of the agriculturals businesses. She found that only 20% of farms have managed risk management. Another author, who was dealt in internal auditing in agriculturals businesses, is Čapek[7], who, in his presentation under the aegis of the European Agricultural Fund for Rural Development, devoted himself to regular procedures and procedures in the framework of a regular internal audit. One of the nonconformities referred to by the author in the internal audit is insufficiently secured crossings between the zones, low frequency of waste handling, unsecured sanitation, lack of integrity control, poorly stored raw materials and products, unsystematic maintenance of machinery and machines needed for production. All of these findings can be identified as the cause of technological and other production losses. There is losses in storage as well as possible failure of human factor - fraud. All of these aspects are closely linked to accounting that may be distorted by these losses and the financial statements do not faithfully reflect the state of the assets and liabilities in contravention of accounting and tax regulations.

## Results and discussion

### Evaluation of the main objectives

Detecting risk spots in the enterprise management process and in production process to identify fraud opportunities is a prerequisite for streamlining production and savings in the cost area. The calculation of production and causally related operating costs is closely related to financial accounting, which may be distorted by the embellishment of beer production results. In the Czech Republic, financial accounting is very closely linked to the tax base and other taxes. If a robotic internal audit is not implemented and implemented in manufacturing plants, which can detect fraud in both production, and accounting in real time, there may also be losses in income tax, VAT and excise duty.

Comparing of the value of the old technology where is not applied internal audit and new automated technology where is robotic internal audit included is clear that strategic investment of corporation to new production technology for foods or to agriculturals technology save significant production costs and in particular financial resources for faster return of investment. Corporate management obtain all information and values of productivity and efficiency of beer production from robotic internal audit in real time. A new fully automated technology can be clasified as anti-fraud technology, that the performance of the automated process of production and beer bottling minimizes human factor failure. If fraud occurs in the manufacturing process, corporate management obtain all information about this case in real time, not than after the current monthly financial statement.

### Discussion

Fraud management can also be applied in a modern farm management system. Its function is to eliminate all losses caused by human factor failure and technological losses, using robotization of internal audit. Every upgrading and innovation within the business requires the development of strategic plans, including a plan for new modern investments that allow the installation of control devices to prevent losses on the agriculturals enterprises. An integral part of fraud management is an information business system that allows sharing and reporting data to a data warehouse for further fraud management. The application of robotic internal audit is specific for each production and farming enterprise, but for some production and production processes, similar control measuring devices can be applied. For example, barcode readers, process scales, level gauges, flowmeters, ect.

The main objective of the Czech Republic's Rural Development Program, approved by the European Commission, is the restoration and improvement

[7] Čapek, T. (year is not listed) Available: www.uniconsulting.cz/download/ucebnitext/Interni_auditor_kvality_potravinarstvi.pdf [Accessed 30 Oct. 2018].

of agricultural dependent ecosystems, in particular agro-environmental measures, and investment in competitiveness and innovation of agricultural enterprises. The Ministry of Agriculture of the Czech Republic has earmarked EUR 3.5 billion for this program from European and national sources. Therefore, there is time to create strategic plans for the modernization of the farm management system with the support of robotization, automation and digitization.

## Conclusion

The article is focused on the implementation of robotic internal audit in the process of industrial beer production. The main objective of the RPA implementation is to streamline production, reduce production and operating costs in production and prevent fraud opportunities in the manufacturing plant.

On the basis of the comparison of the energy and personnel demands of the old and new technology of production and bottling of beer into PET bottles, performed in tables 1 to 7, significant cost savings have been demonstrated. In the energy sector, the saving is 46.5% in the wine and 27.48% in the bottling line, which represents an annual saving of 13,367 thousand. CZK. Savings in the area of personnel and wages are less than 6 employees less, and 7 employees less on serving the bottling line other staff by 12 employees less, which represents an annual saving of CZK 8,965 thousand.

The importance of robotic internal audit can be described as the elimination of theft of input commodities, semi-finished products and finished products and then eliminating the losses caused by corruption in the purchasing and sales departments. A fully automated production produces a more efficient of production, saves human resources and minimizes wastefulness. Another advantage of this automation and robotic is the reduction of the product production price and thus the acceleration of the return on investment.

Analyses and outputs from the robotic internal audit enable the efficient cash flow planning of operational and investment character, more stable and credible dividend policy, as well as effective planning of the value growth of the production enterprise.

Automation and robotization of industry 4.0 in manufacturing, agricultural and industrial enterprises, along with the modification of Czech accounting regulations, can move the Czech Republic in the ranking of ranking by several ranks higher.

*Corresponding authors*
*Ing. Marcela Hradecká*
*Department of Accounting and Finances, Faculty of Economics*
*University of South Bohemia, Studentská 13, 370 05, České Budějovice, Czech Republic*
*Phone: +420 602 346 483, E-mail: hradecka@mh-dane.cz*

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# Time Series Models: Development Trends of Foodstuffs Consumption in CR Considering Healthy Eating

Jana Köppelová, Libuše Svatošová

Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

## Abstract

The agrarian sector can be understood in several ways, according to the integration of the agrarian sector into national economic structures. Understanding the agrarian sector in its complex relation to the sectors that represent the final consumption of already processed agricultural products - food (not agricultural raw materials) represents agribusiness. Among other issues, food consumption is affected by the newest nutrition trends and opinions on healthy eating and food safety. The paper´s aim is an indication of development tendencies in the consumption of some selected food types and subsequent construction of a short-term forecast, considering food quality and healthy eating. Some of the prognostic procedures based on time series extrapolation have been applied in this paper. Time series analysis is therefore the starting basis for assessment of the selected foodstuffs consumption developmental tendencies and a subsequent short-term forecasts construction.The results demonstrate unambiguously that, the time series analysis methods can be applied with success in finding development tendencies of the food consumption indicators studied. Application of the adaptive models in particular, can bring good quality outcomes in this field. Anyway, it is not possible to reach an unambiguous conclusion concerning the assessment whether the consumption of some selected food types is in line with nutritional recommendations. In some cases it is, in some it is not.

## Keywords

Extrapolation, time series models, forecast, agribusiness, food consumption in the CR, healthy eating, nutrition recommendations.

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## Introduction

Another possibility of understanding the agrarian sector is the agri-food sector, which serves primarily to ensure the nutrition of the population and is part of the agribusiness. The economic stability of the agri-food sector is due to a guaranteed level of demand, but is significantly affected by emergencies such as crop failure or fear of health risks from the consumption of certain foods, as well as regulatory intervention by the EU. The agri-food sector remains one of the most stable sectors of the Czech economy. However, the sector's most pressing challenge today is the lack of permanent but also seasonal labor. The food market as a whole has been exceptionally stable, in principle it is subject to crisis or conjunctural influences only insignificantly. On the other hand, it is strongly oriented towards the end customer - the individual consumer. The foodstuffs consumption problem directly concerns everyone of us. Statisticians have followed various CR food consumption indicators for almost a hundred years already. Data from the food consumption field on the domestic market have been collected by the Czech Statistical Office (ČSÚ) since 1948 already, applying the Family Accounts Statistics. This way the Office has continuous time series available from this field. Without quantitative information knowledge one cannot perform decision making practically, regardless the field of interest. Quantitative information knowledge makes the increase possible of accuracy of the forecasts constructed, or the indication of changes in the nutrition trends or eating habits, too. The eating habits level is different in every country since it is affected by many factors such as, e.g., demography, habits of the population, or level of economics or farm production. Study of the differences in eating among the adults

with differing socio-economic status (SES) and trends in time, was the object of study by Hulshof et al. (2003).

Procházková et al. (2016) have recalled an important fact concerning the reduction of arable land area which can lead to growing worries as to the food self-sufficiency secured. The low food self-sufficiency can then affect negatively both the stability of prices and food security, being often discussed recently. Restrictions on agricultural production can then have negative impacts not only from the consumers viewpoint (higher prices of imported foodstuffs, worse quality etc.), but from the ecological and environmental aspects, too, and all in all, they affect negatively the development of the countryside. And in the case of livestock production in particular, the food self-sufficiency lags behind the needs in the Czech Republic. The total farm production value in 2017 made it about 133 billion CZK, out of which the livestock production was about 51.4 billion CZK and the crop production then about 73.7 billion CZK. Meat consumption in the CR is around 80 kg per person in the long run. The most popular meat in the CR is pork meat which is consumed by an average Czech the most. Poultry meat consumption is on increase in the long run, too, it is the second most popular meat here. However, meat production in Czechia is relatively steadily declining even despite the increasing subsidies and livestock production support. Náglová and Horáková (2016) dealt with the meat industry, too, in their work.

Food consumption is, among other things, one of the basic needs of a human being. Its analysis is possible from many points of view. The global food consumption, not omitting global food demand and supply, was the object of attention by Smutka et al. (2009). Kearney (2010) in his work dealt with capturing of the trends and food consumption forecast up to 2050, both all the world over and in various regions. He dealt with the principal factors mostly influencing the food consumption trends observed. Great shifts in the field of catering have recently been observed all the world over. Human health is one of the reasons of these changes at both the global and regional levels. Human health is one of the key factors facilitating the transition to „healthy nutrition". High level of obesity, cardiovascular diseases and cancer belong among the most frequent aftermath of unhealthy eating. Therefore, food policies of the future have to take the farming sector, human health and the environment into account.

The opinions concerning healthy eating and the newest trends in food consumption influence the final consumption significantly. Healthy eating currently is the object of interest of many scientific works very often. Olsen and Tuu (2017) in their work dealt with a comparison of the healthy eating value and self-indulgence. Healthy eating is very fashionable. Healthy food is aimed in particular at body weight regulation, nevertheless, a big and fast weight loss is not its purpose. The aim of healthy eating is maintenance of a stable body weight, gradual and permanent weight loss in the case of need, but mainly the elimination of health risks resulting from inappropriate modern diet and bad eating habits. The purpose is a style of life, the aim of which is vitality, stronger health and psychic serenity. It can be reached by the consumption of tasty and quality food, balanced nutrient intake, enough minerals and vitamins and optimal habits. However, healthy eating is actually practised by a fraction of the population only and still less of these actually know how the healthy eating is to look. In the today´s hurried time it is unfortunately quite common to eat in the fast food. When you say „fast food", everyone can certainly imagine a big hamburger with crips, a hot dog or oversweetened lemonades. To prepare such food improper technologies are practised, mainly frying in burned oil. This type of refreshment represents mostly an excessive supply of hidden energy in the form of sugars, animal fats, salt and cholesterol to our body, what has a very negative impact upon our health. Šrádl and Mikhalkina (2014) examined the extent of changes in consumer preferences as connected with the arrival of supranational oligopoly chains including the fast food restaurants in the CR. The fast food refreshment became a prominent feature of children´s eating in the United States in particular, and it has kept appearing still more often all the world over. The aim of the Bowman et al. (2004) study was to verify the effect of fast food refreshment upon the dietary factors connected with the obesity risk. Obesity represents a socio-economic problem. A reason of a different approach to more healthy eating may be the household´s income. The efficient strategy for public health is a comprehensive political approach taking into account the behavioural nutrition and the foodstuffs choice economics (Drewnowski and Darmon, 2005). McCrory et al. (1999) in their work examined the connect- ions between meal consumption

frequency in the restaurants and the body fat volume in the adults.

The gravity centre of this paper is laid in capturing and assessment of the basic development trends in consumption of some selected food sorts. The development trends found are put in connection with factors offering an assumption of their capacity to influence the consumption (information on the product composition or healthy nutrition views), what should lead to a more precise forecast. The expected consumption estimates of separate food types can offer an important information both from the economic and marketing viewpoints. In the field of food consumption forecasting various model procedures have been applied, of which the time series analysis techniques start being applied more often currently. The reason, in particular, are the undemanding conditions concerning input data, since there are the techniques based on time series model extrapolation and on the course of values over time only (Kába, 1997). Thanks to undemanding conditions for the input data these offer a simpler alternative for the forecasting as compared with forecasting using the econometric models, applied by Dozorova and Ulmanova (2015). The analyses done have shown that, the adaptive time series models in particular, and the application of these, can offer a comparatively good quality forecast (Svatošová and Köppelová, 2017). The adaptive time series analysis models will be applied in this study, too, in order to assess the development trends in food consumption and to perform the subsequent consumption forecasts for the close future.

It must not be forgotten that food consumption, as one part of agribusiness, is very sensitive to any negative information regarding individual food products. It is particularly sensitive to information based on negative findings of the State Control Authority and Sanitary and Veterinary Authority. The Czech market is also negatively reflected in cases of so-called double quality food across the EU.

## Materials and methods

The source of data applied in the empirical analysis is the Czech Statistical Office (ČSÚ). The data have been collected in time series with annual frequency. Based on the ČSÚ survey a total of 33 annual time series concerning the basic food types consumption have been analyzed, with the 1989-2017 reference period.

The following foodstuff groups have been included in the processing:

- cereals and bakery products (6 items – cereals total, durable pastry, pasta, rice, bread, wheat bread)
- meat in terms of carcass weight (5 items – meat total, beef, pork, poultry, fish)
- milk, milk products, cheese and eggs (3 items – milk and milk products total, cow milk, cheeses)
- fats and oils (4 items – fats and oils total, butter, lard, edible vegetable fats and oils)
- sugar, sweets and confectionery (3 items – sugar total, confectionery, chocolate)
- non-alcoholic beverages (3 items – mineral waters, soda waters, lemonades)
- vegetables, pulses, potatoes (6 items – vegetables total, tomatoes, potatoes, lettuce, spinach, legumes)
- fruits in terms of fresh (3 items – fruits total, southern zone fruits, moderate zone fruits).

For effective implementation the SAS statistical software has been used, the Time Series Forecasting System (TSFS) specifically. The study is presuming the adaptive models application in particular, since these take aging of the data in account and usually offer a higher quality forecast. The SAS system offers a very wide scale of adaptive models, both from the exponential smoothing models group and from the Box-Jenkins methodology based models group. Applying a lot of diagnostic tests based on the study of the time series properties (Arlt and Arltová, 2009), the SAS is then in the position to design the perfectly suitable forecasting models. In quality assessment of the forecasts designed the Mean Absolute Percent Error (MAPE) measure and the relative forecast error rp have been applied, subsequently the mean relative forecast error, the two of these defined by the following relations:

$$M.A.P.E. = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{y_t - y_t'}{y_t}\right| \quad (1)$$

$$rp = \frac{|y'_t - y_t|}{y_t} \bullet 100 \quad (2)$$

kde $y_t$ eventually y't (t = 1, 2, …, $n$) are the real, eventually smoothed (theoretical) values of the given time series and n represents the number of observations in the series. Also the testing parts of the time series studied have been applied, where the pseudoforecast was established always for three years. For every year of the estimate

the relative error of the forecast has been obtained and subsequently the mean relative error for the whole three-year period has been calculated, in order to obtain a final assessment of the forecast quality. A research into the properties of various measures serving in assessment of the time series models quality - inclusive of the MAPE - was performed by Mahmoud and Pegels (1990).

The MAPE measure has been applied, among other authors, also by Kalekar (2004) in the study of the exponential models quality in application of these on seasonal time series, or Ganquiong et al. (2010) in their study of farm products market prices short-term forecast.

As a starting point for the assessment of development trends in connection with the correct nutrition requests, a material by the Ministry of Health, titled Health 2020 has been used, from which the specific recommendations concerning healthy eating were drawn (Společnost pro výživu, 2018).

## Results and discussion

### 1. Time series models constructed and assessment of these

The TSFS model applied will automatically find the most suitable model both for description of the indicators studied development tendencies and for future development forecasting. The model quality has been assessed using the MAPE measure and for the forecast quality assessment the relative forecast error and the mean relative forecast error have been used.

The Table 1 summarizes the findings – the indicator studied and the best model chosen for it, incl. of the MAPE value obtained, representing

| Food | Model | *MAPE* value in % |
|---|---|---|
| Cerals - total | Linear Holt Exponential Smoothing | 3.11 |
| Long Pastry | Log Linear Trend | 5.07 |
| Pasta | Log Linear Holt Exponential Smoothing | 6.65 |
| Rice | Log Linear Trend | 5.65 |
| Bread | Linear Holt Exponential Smoothing | 2.7 |
| Bread of wheat | Damped Trend Exponential Smoothing | 4.01 |
| Meat - total | Log Simple Exponential Smoothing | 2.17 |
| Beef | Log Linear Holt Exponential Smoothing | 5.89 |
| Porc | Damped Trend Exponential Smoothing | 2.18 |
| Poultrymeat | Damped Trend Exponential Smoothing | 3.56 |
| Fish | Linear Holt Exponential Smoothing | 6 |
| Milk and milk products | Damped Trend Exponential Smoothing | 3.12 |
| Cow´s milk | Log Simple Exponential Smoothing | 4.6 |
| Cheese | Damped Trend Exponential Smoothing | 4.36 |
| Fats and oils | Log Simple Exponential Smoothing | 1.25 |
| Butter | Log Simple Exponential Smoothing | 5.94 |
| Lard | Log Linear Holt Exponential Smoothing | 3.14 |
| Edible vegetable fats and oils | Simple Exponential Smoothing | 1.32 |
| Sugar - total | Linear Holt Exponential Smoothing | 4.57 |
| Sweets | Damped Trend Exponential Smoothing | 2.75 |
| Chocolate | Linear Holt Exponential Smoothing | 6.1 |
| Mineral water | Linear Holt Exponential Smoothing | 3.96 |
| Soda water | Log Damped Trend Exponential Smoothing | 4.86 |
| Lemonade | Damped Trend Exponential Smoothing | 2.13 |
| Vegetable | Linear Holt Exponential Smoothing | 3.1 |
| Tomatoes | Linear Holt Exponential Smoothing | 9.7 |
| Potatoes | Linear Trend | 2.14 |
| Lettuces | Log Damped Trend Exponential Smoothing | 16.2 |
| Spinach | Damped Trend Exponential Smoothing | 17.9 |
| Pulses | Damped Trend Exponential Smoothing | 4.6 |
| Fruit - total | Linear Holt Exponential Smoothing | 4.41 |
| Fruit of the mild belt | Log Damped Trend Exponential Smoothing | 3.7 |
| Subtropical and tropical fruit | Simple Exponential Smoothing | 6.8 |

Source: Own processing

Table 1: Overview of time series models applied with the MAPE values obtained.

the assessment criterion for the model quality assessment.

The results presented in Table 1 show that, in the position of the most suitable ones, the adaptive models are taking place actually, of these then the exponential smoothing models in the first place. Most often the Holt exponential smoothing model, the exponential smoothing model with damped linear trend and the simple exponential smoothing model took place. In several - not many - cases, the classical analytical model - linear trend model - succeded as the best one.

The mean absolute percent error (MAPE) value did not exceed 5 % in most models, what supports the high quality of the models. As long as the MAPE measure value fluctuates within an interval of not more than up to 10 %, the given model can still be taken as one of comparatively good quality. Higher than 10 % MAPE values happened in the models of spinach and lettuce consumption only.

The forecasts quality also can be valuated very positively. As an excellent one the quality of forecasts can be assessed where the relative forecast error and consequently the mean relative forecast error (3 years) did not exceed 5%.

Such low values of the measures mentioned have been achieved in 66.7% cases of the indicators studied from the food consumption field. In 27 % indicators the relative, or the mean relative forecast error value has been recorded within 5 % - 10 %. The forecasts obtained at such a level can be classified as very good. The results obtained are proving that, the food consumption forecasts for the one closest future period – coming out from the time series models constructed – can be taken as very probable ones.

The Table 2 is presenting the actual consumption

| Food | Consumption in 1989 | Consumption in 2017 | Forecast for 2018 | Relative error of forecast in % |
|---|---|---|---|---|
| Cerals - total | 156 | 143.5 | 141.0 | 1.59 |
| Long Pastry | 6.5 | 7.8 | 10.1 | 8.70 |
| Pasta | 3.1 | 7.8 | 8.0 | 4.14 |
| Rice | 3.96 | 6.5 | 5.7 | 8.35 |
| Bread | 56.8 | 39.2 | 37.2 | 2.80 |
| Bread of wheat | 33 | 50.4 | 45.3 | 8.05 |
| Meat - total | 97 | 80.3 | 79.3 | 2.63 |
| Beef | 30 | 8.4 | 7.0 | 6.74 |
| Porc | 49.9 | 42.3 | 41.0 | 3.06 |
| Poultrymeat | 13 | 27.3 | 27.7 | 4.25 |
| Fish | 6 | 5.4 | 5.8 | 0.19 |
| Milk and milk products | 259.6 | 246.5 | 247.2 | 0.96 |
| Cow´s milk | 94.3 | 61.2 | 64.0 | 2.88 |
| Cheese | 7.8 | 13.2 | 13.2 | 3.11 |
| Fats and oils | 28.8 | 27.1 | 27.0 | 0.74 |
| Butter | 9.4 | 5.0 | 5.5 | 3.73 |
| Lard | 6.8 | 4.0 | 4.2 | 1.48 |
| Edible vegetable fats and oils | 12.5 | 17.6 | 17.2 | 1.76 |
| Sugar - total | 39.8 | 34.9 | 32.6 | 4.55 |
| Sweets | 5.1 | 7.1 | 7.1 | 1.93 |
| Chocolate | 0.9 | 2.7 | 2.8 | 5.03 |
| Mineral water | 14.1 | 55.3 | 60.6 | 4.85 |
| Soda water | 10.9 | 30.2 | 30.2 | 8.16 |
| Lemonade | 45 | 89.3 | 85.2 | 2.55 |
| Vegetable | 68.7 | 88.2 | 86.4 | 2.38 |
| Tomatoes | 5.1 | 11.2 | 12.5 | 6.73 |
| Potatoes | 82.8 | 68.5 | 64.0 | 2.15 |
| Lettuces | 1.2 | 2.4 | 2.4 | 14.30 |
| Spinach | 0.1 | 1.2 | 1.3 | 14.60 |
| Pulses | 1.3 | 2.9 | 3.2 | 7.90 |
| Fruit - total | 70.5 | 82.0 | 83.9 | 2.11 |
| Fruit of the mild belt | 53.6 | 46.9 | 48.1 | 5.16 |
| Subtropical and tropical fruit | 16.9 | 35.1 | 33.5 | 2.28 |

Source: Own processing

Table 2: The constructed forecasts for 2018 incl. of relative forecast error values.

in the first and last periods studied (meaning the 1989 and 2017 years), the forecasts constructed using the time series models for 2018 and the relative forecast error for the assessment of the forecast given.

The consumption development of separate food sorts is going to be confronted subsequently with healthy eating requirements.

## 2. Development tendencies in the consumption of selected food types

This chapter is dealing with a description of the past development of selected food types since 1989 until 2017. Among the selected food types taken in account here belong cereals, meat, milk and milk products, oils and fats, sugars, fruit and vegetables. Graphical presentation has been employed here, too. Anyway, due to holding to the required study extent, only some selected indicators´ development has been presented graphically.

### 2.1. Cereals

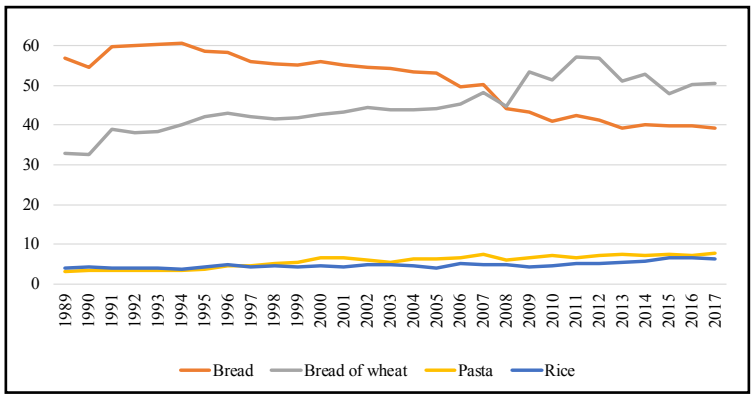
Cereals consumption in total recorded a more pronounced decline over the 1969-1999 years. Since 2000 the consumption of cereals has been maintained - with alternating fluctuations - about 140 kg per person per year. The forecast for the next year constructed using the Holt exponential smoothing model is assuming a consumption of 142 kg per person/year. The Figure 1 is showing the consumption development of selected types of cereals (bread, wheat pastry, pasta and rice) over 1989-2017. Concerning the flour products, from the healthy eating point of view it is recommended to consume whole wheat flour products instead of white flour products and to prefer at the same time pasta and rice in the menu, due to the low glycemic index of these. The consumption increase of pasta and rice is evident as shown in the Figure 1, which is in line with the healthy eating recommendations. Rice consumption is growing on average by 2% annually, pasta then by 3.4%. As far as pastry is concerned, consumption increase is coming here for wheat pastry, what of course is not in line with healthy eating. Considering the usual weight of one slice of bread and one bread roll or roll at 43 g, then the daily consumption takes it 3 bread rolls and 2.4 slices of bread.

Rice consumption, showing an increasing trend in the CR and recording a moderate increase worldwide, too (Kearney, 2010), is recommended, in particular from the cereals. Consumption of wheat worldwide has recorded a more significant growth, what has been supported by its increase of consumption in the CR, too, but this does not quite correspond to healthy nutrition.

### 2.2. Meat

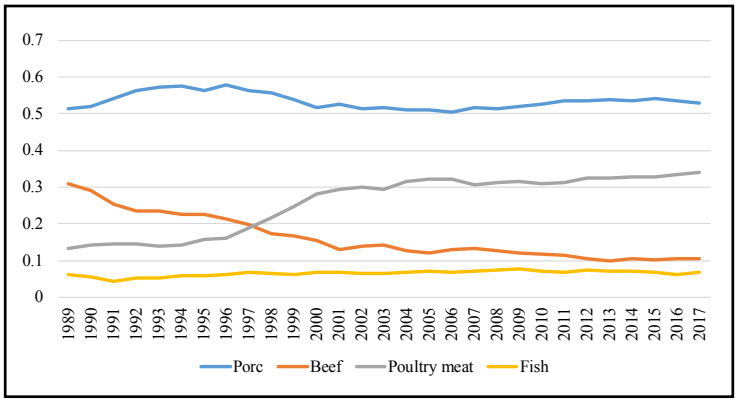
Consumption of meat in total recorded a significant decrease between the 1989 to 1993 years. By 16.2 kg per person/year actually. Over the recent years it has been fluctuating always about 80 kg per person/year what has been supposed, too, for use in the simple exponential smoothing model chosen as the most suitable one for the analysis and forecasting of future development of the given indicator.

Consumption development trends of the separate meat types differ mutually. As Figure 2 shows it, the consumption of meat and meat products also does not match too much with the nutrition recommendations. Concerning healthy nutrition, the recommendations offer fish and fish products consumption, rich in the omega-3 fatty acids and conversely, meat and meat products consumption with high contents of fat should be limited (pork and sausages in particular). However,




Source: Own processing, based on data from CzSO – Food consumption, 2018

Figure 1: Consumption development of bread, wheat pastry, pasta and rice over 1989 – 2017 (kg/person).




Source: Own processing, based on data from CzSO – Food consumption, 2018

Figure 2: Consumption development of separate types of meat over 1989 - 2017 (kg/person).

a slight decrease only has been recorded in pork consumption over the studied period. A more pronounced decrease has been recorded in beef and conversely, in poultry meat consumption a practically permanent growth has been monitored. Both of these trends have probably been affected by prices. It concerns both the beef consumption decrease and the poultry meat consumption growth when not even during the period of the bird flu occur-ence any consumption drop was recorded, thanks to a very low price of poultry meat. All in all, despite the nutrition recommendations, there was no change in the fish and fish products consumption.

As it concerns meat and meat products - despite the fact that meat is an important component of human diet and it is a part of most dishes in the developed countries, in many developing countries there are still the dominant sources of proteins from other than animal origin. A prominent increase of meat consumption in total is appearing worldwide, in Asia in particular. But the consumption of beef is stagnating worldwide, while in some regions - in the developing countries in particular - it has slightly increased, in others (North America, Europe) it has slightly decreased. Great Britain has had the lowest red meat consumption in Europe. In the CR has the beef consumption over several recent years remained at an approximately stable level. Conversely, an increase of poultry meat consumption has been recorded worldwide (Kearney, 2010), what corresponds to the outcomes of this work.

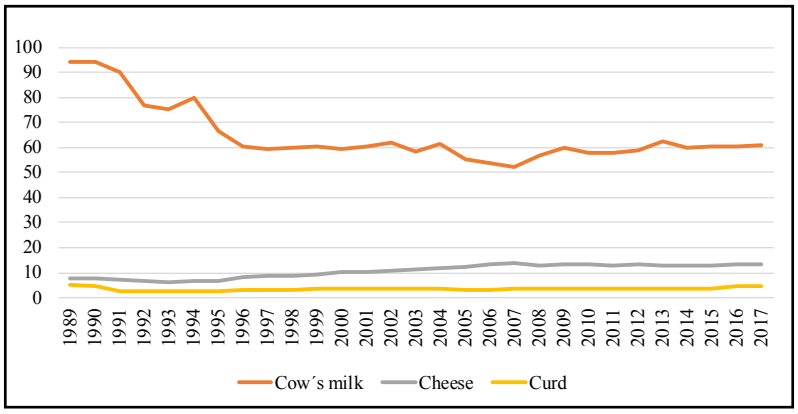
### 2.3. Milk and milk products

For the description of milk and milk products in total consumption development tendencies the exponential smoothing model with damped linear trend has been chosen as the most suitable one. The forecast constructed using it is presenting a slight increase taking in account the 240 kg per person/year consumption of milk and milk products over the 2011 to 2018 years. Since the beginning of the period observed, i.e. since 1989 up to 1997, a sharper decline happened (by 65 kg per person/year), an increasing trend was recorded within the 1998 - 2010 period on the contrary, up to 249 kg per person/year. From the healthy nutrition viewpoint it is recommended to include milk and milk products in the diet daily. The Figure 3 shows again, regretfully, the current milk and milk products consumption not to be much in line with the recommendations mentioned. Cow milk consumption is showing a declining trend over the period up to 2005. Since 2005 until 2007 the consumption maintained a level approximately 60 kg per person/year, what means 0.16 kg daily. But the cheese consumption in total over the period was growing and currently it represents a daily consumption of 0.036 kg per person. As curd is concerned, its consumption recorded the most significant drop in 1991. Since then it has slowly grown up to the value of 4.7 kg per person/year, which is the consumption much close to the same at the very beginning of the period studied.

Variable consumption trends have been recorded worldwide by the livestock origin products such as milk, butter and cheese, incl. of eggs and milk products; a slight increase in Europe recently, in the Eastern Europe in particular, and a slight decrease in North America on the contrary, and a sharper decrease in Oceania (Kearney, 2010).

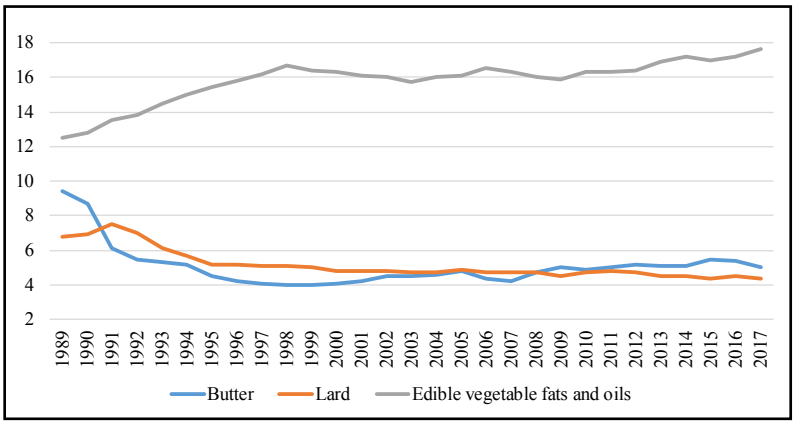
### 2.4. Oils and fats

Oils and fats consumption in total has recorded the greatest changes over the period under study (Figure 4). At the beginning of the period




Source: Own processing, based on data from CzSO – Food consumption, 2018

Figure 3: Consumption development of cow milk, cheese and curd over 1989 – 2017 (kg/person).




Source: Own processing, based on data from CzSO – Food consumption, 2018

Figure 4: Consumption development of butter, lard and edible vegetable fats and oils (kg/person).

- from 1989 till 1996 - the consumption was decreasing. Since this section it maintained a level of 25.5 kg per person/year up to 2009, when an increase appeared again. A slight increase of consumption is also assumed by the simple exponential smoothing model, chosen as the most suitable for the indicator studied analysis. The recommendations concerning healthy nutrition are based in the growth of vegetable oils intake and reduction of animal fats. Consumption of edible vegetable oils hence is in line with nutrition trends since the consumption has shown a long-term tendency of growth.

On the other hand, consumption of lard has recorded a permanent slight decrease. Worldwide trends have recorded a significant decrease in the animal fats consumption together with the growth of vegetable oil consumption (Kearney, 2010).

### 2.5. Sugars

One of the most basic and most emphatic recommendations concerning healthy nutrition is reduction of the consumption of sugars (in total). The recommended sugar consumption is about 60 g per person/day. It corresponds to an annual consumption of 22 kg per person, i.e. 63 % of the actual consumption 34.9 kg per person/year in the year 2017. The model chosen for the analysis of the given indicator development - the Holt exponential smoothing model - is assuming sugar consumption at 32.6 kg per person/year in 2018, what means a slight drop as compared with the previous year 2017. During the period under study is a decrease recorded in total, from a long-term viewpoint (with varying fluctuations), but a very slight decrease only.

### 2.6. Drinks

Out of the alcoholic drinks beer „is enjoying“ the highest consumption, its consumption is comparatively high, 146.9 l per person/year. However, over the past 12 years a decrease of this consumption has been observed, on average by 0.8 % annually, and an increase of wine consumption has appeared on the other hand,

by 1.5 % on average annually. The healthy nutrition tolerates a daily consumption up to 20 g of alcohol, which means 0.2 l of wine or 0.5 l beer, hence, considering that only the adults consume alcohol, this limit has been severely violated.

When a more detailed look at the drinks consumption is taken, it is apparent that, in the consumption of non-alcoholic drinks sweet lemonades consumption prevails, in spite of the decrease over the recent years. A forecast for the 2018 year, constructed using the best model chosen - the exponential smoothing model with damped linear trend - is awaiting a further decrease, from 89.3 l per person/year in 2017, down to 85.2 l per person/year. In 2017 it fell below the 90 litres per person/year limit, what was close to the consumption in 2002. The lowest consumption has been recorded concerning soda water, reaching less than 40 litres per person/year in 2011.

### 2.7. Fruit and vegetables

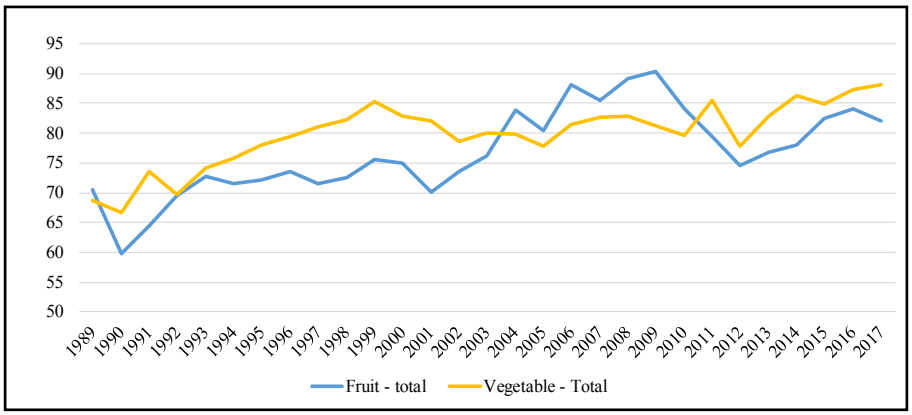
Fruit consumption has been even exceeded considering the healthy nutrition recommendations. The standard requires 60.2 kg per person/year consumption. The total consumption reached 82 kg per person/year value in 2017. The Holt exponential smoothing model having been constructed as the best one, has presumed a further increase of fruit consumption - actually 83.9 kg per person/year in 2018.

Consumption of vegetables, too, has recorded an increasing tendency (by 25 %) over all the period under study (Figure 5). However, when compared with the consumption recommended regarding healthy nutrition, the consumption of vegetables still is not sufficient. Regarding the healthy nutrition every one should consume about 350 g daily, which makes it the annual consumption of 128 kg per person/year, but in 2017 the consumption of vegetables made it 88.2 kg per person/year only. The forecast for 2018, based on the Holt exponential smoothing model, is still presuming a drop down to 86.4 kg per person/year value, regretfully.

As it concerns the fruit and vegetables intake, the combined intake of these worldwide markedly exceeds the levels recommended, by 500 g daily at least. Even this is from the healthy nutrition viewpoint still insufficient. While fruit and vegetables production has grown over the recent years, the insufficient consumption is remaining a problem worldwide. In order to increase the consumption level, it is needed to aim at the aspects of the market-supplier chains. This will help to make fruit and vegetables accessible to poor households, too, same as to ensure the access to markets to small producers (Kearney, 2010).

## Conclusion

Time series of the economic indicators frequently follow a very irregular course. Forecasting of their future development can be rather complicated in such cases. But the results of empirical analyses done have proved that, the adaptive time series models can be applied for the future food consumption forecasts with success. Hence it is possible to recommend these as an alternative or supplement to the complicated econometric models. First the quality of models constructed has been assessed in this study, using the MAPE measure, but of course the quality of forecasts, too, using the relative error of the forecast. Good quality results have been reached in both cases. The MAPE criterion value has not exceeded




Source: Own processing, based on data from CzSO – Food consumption, 2018

Figure 5: Consumption development of fruit and vegetables in total over 1989 - 2017 (litres per person/year).

5% in most cases, actually in 67% cases of all the indicators. Exactly the same frequ- ency has been reached in the relative forecast error values lower than 5%, which supports the high quality of the forecasts constructed.

But an assessment whether the food consumption development, inclusive of the forecast statements, correspond to the healthy nutrition principles recommended, is not so unambiguous in any case. For example, as to meat consumption, it is recommended to consume more fish, but the consumption of fish does not increase even in spite of all the recommendations. Even concerning cereals, in some cases consumption is not in line with nutrition recommendations - consumption of both wheat pastry and durable pastry increases. On the contrary, consumption of rice and pasta is consistent with the recommendations - it has an increasing tendency. Also milk and milk products consumption is corresponding to the healthy nutrition principles. Fruit and vegetables consumption is recording a growing tendency, but in case of vegetables the consumption still is not sufficient. Sugar consumption in total has a slightly declining tendency, what can be taken as a positive development, but we have to omit sugar contents in the non-alcoholic drinks; very high consumption of sweet lemonades has been recorded as compared with the mineral or soda waters.

Healthy nutrition recommendations have been taken into account to a degree, but in a comparatively large consumers group still the established traditional ways of eating predominate and moreover, food prices can influence the decisions concerning eating.

Demand for food, in 2018, focused on higher-quality products in connection with the growth of the final consumer's purchasing power. This is evidenced by regular analyzes carried out in the agrarian sector. However, wage growth in the Czech economy is expected to slow in the coming years, and so this trend may not be expected to continue. There is also a noticeable shift in demand and in consumption towards Czech products (national quality mark KLASA and domestic food products labeled Czech Foodstuff or Regional Foodstuff).

*Corresponding authors*
*Ing. Jana Köppelová*
*Department of Statistics, Faculty of Economics and Management, Czech University of Life Sciences Prague, Kamýcká 129, Prague, 165 00 Czech Republic*
*E-mail: koppelova@pef.czu.cz*

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# Adaptive Perception and Adaptation Responses to Weather Shocks: An Adaptation Deficit

Quang-Thanh Ngo[1], Hong-Ron Nguyen[2], Duc-Thuan Nguyen[2], Ngoc-Phuc Doan[2], Van-Thong Le[3], Thuy-Khanh Hong Thai[4]

[1] University of Economics and Law, Viet Nam National University Ho Chi Minh City (VNUHCM), Ho Chi Minh City, Vietnam

[2] University of Finance – Marketing (UFM), Ho Chi Minh City, Vietnam

[3] Center for Political Science (CPS), Viet Nam National University Ho Chi Minh City (VNUHCM), Vietnam

[4] Nguyen Tat Thanh University (NTTU), Ho Chi Minh City, Vietnam

## Abstract

This study examines the influence of adaptive perception on farmers' adaptive responses to climate change induced natural shocks in the Mekong River Delta (Viet Nam) from a data set of 329 farmers in 2017. Seemingly Unrelated Regression model is used and results show that, controlling for household and household head's characteristics, farm characteristics, institutional factor, infrastructure, climate conditions, and past climate experiences, adaptive perceptions are the most important factor of adaptive responses. With respect to policy implication, sources and quality of information can be of important consideration due to the potential influences on farmers' adaptive perception and their adaptation assessments. In addition, awareness on climate change and adaptation methods should be highlighted. Other policy options could also be suggested, such as: strengthening education level of farmers, and facilitating cheap technologies for farmers.

## Keywords

Climate change, weather shocks, private adaptive responses, adaptive perception, adaptation deficit, Mekong River Delta, Viet Nam.

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## Introduction

There is devastating consensus that climate change is leading to an increase in the level of environmental disasters (IPCC, 2012; IPCC, 2014; Field, 2014 among others). Adaptation and mitigation to climate change and extreme events have been implemented and advocated by many governments, scientific communities and international institutions (for example, World Bank, 2013). Along with this, the so-called 'adaptation deficit' (Barr et al., 2010; Brooks and Adger, 2005; Tol and Yohe, 2007) has emerged, playing an increasingly important role in responding to climate change. Adaptation deficit can be seen from both macro and micro levels. From macro level such as country, adaptation deficit is a situation in which a country experiences a lack of institutional, economic, and technological means to facilitate the adaptation process (Fankhauser and McDermott, 2014). From micro level such as individual, literature identifies a set of individual factors that can raise the vulnerability level such as gender, age, health, social status, ethnicity, and class (Adger et al., 2009; Smit and Pilifosova, 2003).

The Mekong River Delta, the major agricultural region of Viet Nam, is identified as significantly vulnerable to climate change (Yusuf and Francisco, 2010). Agricultural production remains the main source of livelihoods for most farmers in this area (Nguyen and Le, 2012; Le et al., 2014). Several Mekong River Delta related studies and reports by McSweeney et al. (2008), EU/MWH (2006), Nguyen (2007) and ADPC/GTZ (2003) clarify the trends of climate change in terms of higher temperature, salt water intrusion, eroded shorelines, exacerbated coastal flooding, rainfall

increasingly concentrated over fewer months in the rainy season, while the dry season will be more prolonged. This will lead to more frequent and intense floods and droughts simultaneously. In addition, tropical cyclone and typhoon occurrence are expected to alter and become more intense under a warmer climate as a result of higher sea-surface temperatures.

Since climate change have greater negative impacts on farm households (Yu, Zhu, Breisinger, and Hai, 2010), adaptation measures are therefore important to help farmers to better face extreme weather conditions and associated climatic variations (Adger et al., 2003; Kandlinkar and Risbey, 2000). A better understanding of current adaptation measures and their determinants is important to inform policy for future successful adaptation. Some related studies conducted in the last few years focus on farmers' past climate experiences (see for example, Niles et al., 2015; Le Dang et al., 2014; Geoff, 2014; Nicholas and Gina, 2012). Niles et al. (2015), using farmer survey data from New Zealand, show that limiting factors mediated the effect of past climate experiences on the adoption of adaptation strategies differently in two regions with water acting as a limiting factor in Hawke's Bay and water and temperature as a limiting factor in Marlborough. Le Dang et al. (2014) address the limited understanding of how rice farmers appraise their private adaptive measures and influential factors in the Mekong River Delta of Viet Nam. Authors find that belief in climate change, information and objective resources influence farmers' adaptation assessments. Geoff (2014) also stresses that farmers' climate change beliefs affect adaptation to climate change. Nicholas and Gina (2012) explore commercial farmers' perceptions of and responses to shifting climates in the Little Brak River area along South Africa's south coast and find that farmers' experience with shifting climates plays a large part in driving their adaptive decision-making.

Wolf and Moser (2011), on individuals 'role in climate change, distinguish between understanding (acquiring and employing factually correct knowledge of climate change), perception (views and interpretations based on beliefs and understanding), and engagement (a state of personal connection that encompasses cognitive, affective, and/or behavioural dimensions). In practice, it is possible that adaptation choices may not be in effect due to lacking of clear understanding of adaptation measures, or adaptation deficit exits between adaptive perception and adaptation choices. While several studies so far explore the influence of climate change understanding, perception, or engagement on adaptation behaviour, there is still a missing link between adaptive perception and adaptation behaviour in terms of empirical evidences. By adaptive perception, the current paper means the views and interpretations of adaptive measures based on beliefs and understanding.

The current study employs survey data at household level of 329 farmers in the Mekong River Delta of Viet Nam and the cluster specific fixed effect at household level with clustering standard error at commune level is employed for investigating the influence of farmers' adaptive perception on adaptation responses to climate change induced natural shocks. Results show that, controlling for household and household head's characteristics, farm characteristics, institutional factor, infrastructure, climate conditions, and past climate experiences, adaptive perception is the most important factor of adaptive responses

This paper contributes to the interdisciplinary development literature on climate change adaptation. A plenty of empirical studies have analysed the effects of many factors on climate change adaptation and some most recent developments can be named, such as climate change beliefs (Kuehne, 2014), farmers' perceptions of shifting climates (Wiid and Ziervogel, 2012), limiting factors within a farm system (water or temperature) (Niles et al., 2015), migration (Bazzi et al., 2016; McLeman and Smit, 2006), micro-credit (Fenton et al., 2017), diversification (Howden et al., 2007; Asfaw et al., 2018), gender (Bhattarai et al., 2015), forestry activities in supporting adaptation (Fisher et al., 2010), the role of local seed banks and seed markets (Maharjan and Maharjan, 2018; Nordhagen and Pascual, 2013), and microfinance, agricultural extension, and education (James, 2010).

Our paper makes contributions to the adaptation literature in a number of ways. We provide the first estimation of adaptive perception to adaptive responses to climate change induced natural shocks. As mentioned, earlier work on responses to climate change and/or weather shocks did not concern this issue, to our best knowledge. Therefore, findings from the influence of adaptive perception associated with adaptation choices can be useful inputs for policies to response to climate change and weather shocks. In addition, the current study examines the issue in the context of a large delta in a developing country. Thus, our findings may also provide important implications for other emerging and transition economies similar

to Viet Nam and/or regions from developing countries with conditions of natural resources familiar to the Mekong River Delta of Viet Nam.

The structure of the paper is as follows. The next section presents Materials and Methods. Section 3 is about empirical results and discussion. Conclusion and implications for policy are in Section 4.

## Materials and methods

### 1. Data sources and questionnaire

Long An, Ben Tre, Can Tho, Soc Trang, Kien Giang, and Ca Mau are the six provinces randomly selected from 13 provinces in the Mekong River Delta which are defined at different agro-ecological systems that is enable representation for the Mekong River Delta region. One district from each province and two communes from each district were randomly chosen. In total, there are 12 communes and commune centres in the survey. From the official household lists of the twelve communes, farm households were selected by simple random sampling.

The face-to-face structured interviews have been conducted in July of 2017. Four teams of 10 interviewers each had been involved in two intensive training sections, one before and one after the pre-test. The interviewers visited 335, but interviewed 330 farm qualified households, 50 in each commune. Each interview was around two hours in duration. In this study, the farm household was the unit of analysis and the household heads or their spouses were the interviewees. Total number of observations in the final sample for analysis is 329, after removing an observation with missing value.

The structured questionnaire mainly covers perception of past climate change, climate change adaptation assessment, and a number of influential factors. The questionnaire is refined and finalised based on the information from three focus group discussions in Long An, Ben Tre, Can Tho and six agricultural officers from six provinces. The clarity and relevance of the questions were also tested through the pre-tests with 30 randomly chosen farm households in Ben Tre Province. The data used in this paper are specified from questions about climate change, adaptation assessment, farm characteristics, income, assets, infrastructure and institutional factors.

### 2. Theoretical framework

We framed our analysis using the standard theory of technology adaptation, wherein the problem facing a representative risk-averse farm household is to choose a mix of climate change adaptation strategies that will maximize the expected utility from final wealth at the end of the production period, given the production function and land, labour, and other resource constraints, as well as climate. Assuming that the utility function is state independent, solving this problem would give an optimal mix of adaptation measures undertaken by the representative farm household, as given by

$$A_h = A(x_h^H, x_h^F, x_h^I, x_h^{IN}, x_h^C, x_h^P; \beta) + \varepsilon_h$$

Where $A$ is the adaptation strategy of household $h$; $x^H{}_h$ is a vector of household characteristics (such as gender, age, marital status of the "head" of the household, household size, and wealth), $x^F{}_h$ is a vector to represent farm characteristics (such as farm size, farm and nonfarm income), $x^I{}_h$ is a vector to represent institutional factor (access to credit, tenure), $x^{IN}{}_h$ is a vector to represent infrastructure (distance to input and output markets), $x^Ch$ is a vector to represent climate conditions (sunshine and rainfall), and $x^P{}_h$ is a vector to represent past climate experiences (wind storm, drought, flood, untimely rain, pestilent insect, water shortage). $\beta$ is the vector of parameters; and $\varepsilon_h$ is the household-specific random error term. Households will choose adaptation strategy 1 over adaptation strategy 2 if and only if the expected utility from adaptation strategy 1 is greater than that from adaptation strategy 2, that is:

$E [U(A)] > E [U(A_2)]$

The choice of adaptation strategy is conditioned on a host of household characteristics and climatic, agro-ecological and socio-economic factors. This study focuses on the adaptation definition per se and we therefore employ a dummy variable to measure whether farm households had adapted any measure in response to perceived climate changes. These adaptation measures are elicited at household level.

### 3. Model specification

#### 3.1. General form of model specification

Common approach uses a univariate technique such as probit/logit analysis for discrete choice dependent variables to model each of the adaptation measures individually as functions of the common set of explanatory variables (for example: Nhemachena and Hassan, 2007; Maddison, 2007). The shortfall of this approach is that it is prone to biases caused by ignoring common factors that might be unobserved and unmeasured and affect the different

adaptation measures. In addition, independent estimation of individual discrete choice models fails to take into account the relationships between adoptions of different adaptation measures. Farmers might consider some combinations of adaptation measures as complementary and others as competing. By neglecting these common factors, the univariate technique ignores potential correlations among the unobserved disturbances in adaptation measures, and this may lead to statistical bias and inefficiency in the estimates (Lin et al., 2005; Belderbos et al., 2004; Golob and Regan, 2002).

A multinomial (MNL) discrete choice model is another alternative to the multivariate model with more than two endogenous discrete choice variables (See, for example, Kurukulasuriya and Mendelsohn, 2007; Mendelsohn and Seo, 2007). In the multinomial discrete choice model, the choice set is made up of all combinations of adaptation measures. The shortfall of this technique is that interpretation of the influence of the explanatory variables on choices of each of the original separate adaptation measures is very difficult. The shortfall of this technique is that all multinomial replications of a multivariate choice system have problems in interpreting the influence of explanatory variables on the original separate adaptation measures (Golob and Regan, 2002).

This study follows Zellner's Iterative Seemingly Unrelated Regressions (ISUR) to overcome the shortfalls of using the univariate and multinomial discrete choice techniques. The ISUR technique provides parameter estimates that converge to unique maximum likelihood parameter estimates. The resulting model has stimulated countless theoretical and empirical results in econometrics and other areas (see Zellner, 1962; Srivastava and Giles, 1987). The benefit of this model is that the ISUR estimators utilize the information present in the cross regression (or equations) error correlation and hence it is more efficient than other estimation methods such as the univariate and multinomial discrete choice techniques. The variance inflation factor (VIF) test (Baltagi, 2013) is used to detect potential multicollinearity, because the number of independent variables is high. In addition, the Breusch-Pagan (BP) test (Breusch and Pagan, 1980) is used to validate the SUR model of adaptation choices (see sureg command in Stata software (StataCorp., 2017)).

Analysis of the influence of adaptive perception on adaptation choice generally suffers from endogeneity, in which the adaptive perception would actually be proxying some other omitted household characteristic that is the real cause of adaptation choices. Fixed effects regression uses households to serve as their own controls, thus eliminating the influence of observable and unobservable differences between households in factors that do not vary over time. Time variant factors that differ across households and are correlated with adaptive perception and adaptation choices can be controlled for through careful selection of covariates.

Our data is not simple random sampling it may give some problems. Cameron and Trivedi (2005) claim that stratified and clustered sample can lead to difference in distribution of among stratum and correlation among households within cluster. However, since our purpose is estimating influence of regressors on regressand rather than predict for population and stratifying is not basing on regressand, the variation of sampling rates can be ignored. Thus, stratification is not the matter, but clustering does.

The correlation among households within cluster is caused by some reasons. First, surveyed households may live in the same block. Second, it is existence of unobserved cluster specific variables that affect all households in cluster. Finally, unobserved variables may impact all households in the same province or region such as policy, culture and climate. Since these unobservable variables may correlate with both dependent and independent variables, the estimators under OLS procedure will be bias and inconsistent. In addition, within cluster correlation among error terms makes estimators under OLS approach inefficient.

There are two ways to solve the impact of these unobserved variables, they are cluster specific random effect (CSRE) and cluster specific fixed effect (CSFE). CSRE model is used in the situation that there is no correlation between unobserved cluster variables and independent variables. However, it is not the case of the current paper since as mentioned above unobserved commune variables are likely to affect both adaptive perceptions and adaptation choices. Thus, CSFE model is needed to be applied because it will subtract cluster-invariant variables, but some tests will be used to test whether CSFE is necessary.

Clustering at province level is not appropriate since there is high heterogeneity within province related to social-economic condition, infrastructure, irrigation system, farming practices and even

climate. Similarly, there is also high heterogeneity within district. Meanwhile, commune level gives more homogeneity and correlation among households in agriculture production. Moreover, clusters cannot be too small because they do not give enough information for estimation, each cluster has to have at least two observations. Clustering at commune level can satisfy this condition. Hence, clusters should be communes. Since there are 14 communes and the number of observations in each commune is about 50 on average, it should be classified as many-clusters situation.

The 14 adaptive measures were considered as farmers' adaptive responses to climate change induced natural shocks. These adaptive measures were grouped into four groups: (1) Water use management (Model 1), (2) Adjustments of crops and varieties (Model 2), (3) Adjustments of planting techniques (Model 3), and (4) Adjustments of planting calendar (Model 4). Four types of cluster-specific effects model are written as:

$$WATERUSE_{icj} = \{\beta_{11}.Z_{icj} + \beta_{12}.F_{icj} + \gamma_1.INS_{icj} + \delta_1.INF_{icj} + \eta_1.METE_j + \theta_{11}.PAST_{icj} + \theta_{12}.PERC_{icj} + \alpha_{1cj} + u_{1i} + \varepsilon_{1icj} \geq 0\} \quad (1)$$

$$CROPS_{icj} = \{\beta_{21}.Z_{icj} + \beta_{22}.F_{icj} + \gamma_2.INS_{icj} + \delta_2.INF_{icj} + \eta_2.METE_j + \theta_{21}.PAST_{icj} + \theta_{22}.PERC_{icj} + \alpha_{2cj} + u_{2i} + \varepsilon_{2icj} \geq 0\} (2)$$

$$PLANTINGT_{icj} = \{\beta_{31}.Z_{icj} + \beta_{32}.F_{icj} + \gamma_3.INS_{icj} + \delta_3.INF_{icj} + \eta_3.METE_j + \theta_{31}.PAST_{icj} + \theta_{32}.PERC_{icj} + \alpha_{3cj} + u_{3i} + \varepsilon_{3icj} \geq 0\} (3)$$

$$PLANTINGC_{icj} = \{\beta_{41}.Z_{icj} + \beta_{42}.F_{icj} + \gamma_4.INS_{icj} + \delta_4.INF_{icj} + \eta_4.METE_j + \theta_{41}.PAST_{icj} + \theta_{42}.PERC_{icj} + \alpha_{4cj} + u_{4i} + \varepsilon_{4icj} \geq 0\} (4)$$

Where the script icj denote the $i^{th}$ observation in the $c^{th}$ cluster (commune) and in $j^{th}$ district, $i$ = 1, 2, ..., 329, and $c$ = 1, 2, …, 14. $\alpha_c$ is cluster specific effect which change across clusters and it is assumed that $\alpha_c \sim [0, \sigma^2_c]$. $\varepsilon_{ic}$ is assumed to have zero mean and constant variance. $u_i$ is a household specific fixed effect. We assume that regional differences which control for adaptation variations and across regions are subsumed within the household fixed effect.

The controlling variables include household characteristics (*Z*) (education, gender, age of the household head, household size, household wealth), farm characteristics (*F*) (farm size, farm and nonfarm income, productive assets), institutional factor (*INS*) (access to credit, tenure), infrastructure (*INF*) (distance to input and output markets), climate conditions (*METE*) (sunshine and rainfall), and past climate experiences (*PAST*) (wind storm, drought, flood, untimely rain, pestilent insect, water shortage). The study is interested in the variables related to adaptive perceptions (*PERC*).

### 3.2. About adaptive perception

Studies in Mekong River Delta find that farmers' perception of climate change corresponds with local climate data (Le Dang et al., 2014; Nguyen and Le, 2012; Nguyen, 2007; McSweeney et al., 2008; EU/MWH, 2006; ADPC/GTZ, 2003). In this study, we consider farmers' perceptions of the changes in terms of nine past climate experiences – wind storm, drought, flood, higher temperature, untimely rains, salt water intrusion, eroded shorelines, pestilent insect, and water shortages.

The adaptive perception in this study is based on asking farmers about their perception of availability of climate change responses. The specific question is: "Have you ever heard anything about the following adaptations?" A list of private adaptive measures to climate change has been developed by following the procedures mentioned in Section 2.3.1. Table 1 provides the variables related to adaptive perception, a brief description of each variable, and its value.

Table 1 shows that, in general, measures such as 'Build/repair cistern' (20%), 'Build/repair well' (19%), and 'Water saving technology' (13%) in water use management are not very commonly perceived. Table 1 also shows that while a high proportion of farmers used perceives of 'Change varieties' (53%) as an adjustment of crops and varieties, a lower proportion of farmers perceives 'Change crops/livestock' (26%), 'Change crop structure' (25%) in response to climate change. While a high proportion of farmers perceives measure of 'Change pesticide/herbicides' (43%) as an adjustment of planting techniques, a lower proportion of farmers perceives 'Change crop cultivation' (28%), 'Change fertilizer input/ stimulus' (29%), 'Change crop quantity' (31%), and 'Change farmyard manure' (19%) (Table 1).

Moreover, less proportion of farmers perceives 'Change irrigation schedule' (18%), and 'Change crop rotation' (18%), while even a very low proportion of farmers perceives 'Buy agriculture insurance' (4%), and 'Combination of agriculture and forestry' (2%) (Table 1).

| Variable | Description | Mean | Std. Dev. |
|---|---|---|---|
| **Water use management** | | | |
| Build/repair cistern (1: Yes; 0: No) | Knowing about 'build/repair cistern' | 0.20 | 0.40 |
| Build/repair well (1: Yes; 0: No) | Knowing about 'build/repair well' | 0.19 | 0.39 |
| Water saving technology (1: Yes; 0: No) | Knowing about 'water saving technology' | 0.13 | 0.34 |
| **Adjustments of crops and varieties** | | | |
| Change varieties (1: Yes; 0: No) | Knowing about 'change varieties' | 0.53 | 0.50 |
| Change crops/livestock (1: Yes; 0: No) | Knowing about 'change crops/livestock' | 0.26 | 0.44 |
| Change crop structure (1: Yes; 0: No) | Knowing about 'change crop structure' | 0.25 | 0.44 |
| **Adjustments of planting techniques** | | | |
| Change crop cultivation (1: Yes; 0: No) | Knowing about 'change crop cultivation' | 0.28 | 0.45 |
| Change fertilizer/stimulus (1: Yes; 0: No) | Knowing about 'change fertilizer/stimulus' | 0.29 | 0.46 |
| Change pesticides/herbicides (1: Yes; 0: No) | Knowing about 'change pesticides/herbicides' | 0.43 | 0.50 |
| Change crops quantity (1: Yes; 0: No) | Knowing about 'change crops quantity' | 0.31 | 0.46 |
| Change farmyard manure (1: Yes; 0: No) | Knowing about 'change farmyard manure' | 0.19 | 0.39 |
| **Adjustments of planting calendar** | | | |
| Change irrigation schedule (1: Yes; 0: No) | Knowing about 'change irrigation schedule' | 0.18 | 0.38 |
| Change crop rotation (1: Yes; 0: No) | Knowing about 'change crop rotation' | 0.18 | 0.38 |

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017); N=329

Table 1: Summary statistics of farmers' adaptive perception.

### 3.3. Outcome variables

A list of private adaptive responses (measures) to climate change was initially developed from the literature (Bradshaw et al., 2004; Bryan et al., 2009; Deressa et al., 2009; Hassan and Nhemachena, 2008; Thomas et al., 2007). To ensure the appropriateness, these measures were raised for discussion in focused group discussions. Typical farmers, participants of the focus grouped discussions, were asked to choose the measures that have been used or available in their areas. The same request was given to agricultural province-level officers interviewed. The adaptive measures had finally been refined by the pre-tests before they were actually included in the questionnaire.

In general, Table 2 shows that measures such as 'Build/repair cistern' (5%), 'Build/repair well' (9%), and 'Water saving technology' (3%) in water use management are not very commonly used. The limited use of these adaptations may be attributed to need for more capital.

Table 2 also indicates that while a high proportion of farmers uses measure of 'Change varieties' (40%) as an adjustment of crops and varieties, a lower proportion of farmers uses 'Change crops/ livestock' (9%), 'Change crop structure' (7%) in response to climate change. Local farmers may be lacking skills, motivation and opportunities for other crops and/or livestock.

As shown in Table 2, while a high proportion of farmers uses measure of 'Change pesticide/ herbicides' (31%) as an adjustment of planting techniques, a lower proportion of farmers uses 'Change crop cultivation' (14%), 'Change fertilizer input/stimulus' (16%), 'Change crop quantity' (13%), and 'Change farmyard manure' (4%) in response to climate change. These adaptations may be associated with the less expense and ease of access by farmers than that of adjustments of crops and varieties.

| Variable | Mean | Std. Dev. |
|---|---|---|
| **Water use management** | | |
| Build/repair cistern (1: Yes; 0: No) | 0.05 | 0.23 |
| Build/repair well (1: Yes; 0: No) | 0.09 | 0.28 |
| Water saving technology (1: Yes; 0: No) | 0.03 | 0.16 |
| **Adjustments of crops and varieties** | | |
| Change varieties (1: Yes; 0: No) | 0.4 | 0.49 |
| Change crops/livestock (1: Yes; 0: No) | 0.09 | 0.28 |
| Change crop structure (1: Yes; 0: No) | 0.07 | 0.26 |
| **Adjustments of planting techniques** | | |
| Change crop cultivation (1: Yes; 0: No) | 0.14 | 0.34 |
| Change fertilizer/stimulus (1: Yes; 0: No) | 0.16 | 0.37 |
| Change pesticides/herbicides (1: Yes; 0: No) | 0.31 | 0.46 |
| Change crops quantity (1: Yes; 0: No) | 0.13 | 0.34 |
| Change farmyard manure (1: Yes; 0: No) | 0.04 | 0.19 |
| **Adjustments of planting calendar** | | |
| Change irrigation schedule (1: Yes; 0: No) | 0.07 | 0.26 |
| Change crop rotation (1: Yes; 0: No) | 0.07 | 0.26 |

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017); N=329

Table 2: Summary statistics of farmers' adaptation choices.

Less proportion of farmers use 'Change irrigation schedule' (7%), and 'Change crop rotation' (7%) in response to climate change (Table 3). This is probably because farmers' access to climate change information is rather limit.

### 3.4. Confounding variables

Cluster variant household-level explanatory variables that could be correlated with outcome variables with adaptation choices have also been obtained from the dataset to serve as controls in the fixed effects regression including household characteristics (education, gender, age of the household head, household size, household wealth), farm characteristics (farm size, farm and nonfarm income, productive assets), institutional factor (access to credit, tenure), infrastructure (distance to input and output markets), and experience of past climate (wind storm, drought, flood, untimely rain, pestilent insect, water shortage) (Table 3). We use climate conditions (such as sunshine and rainfall) to capture regional differences.

| Variable | Mean | Std. Dev. |
|---|---|---|
| **Household characteristics** | | |
| Male-headed household (male: 1; female: 0) | 0.89 | 0.31 |
| Years of education by household head (years) | 6.23 | 3.34 |
| Marital status of household head (married: 1; other: 0) | 0.90 | 0.30 |
| Household size (persons) | 4.19 | 1.40 |
| **Farm characteristics** | | |
| Production asset index | 0.01 | 1.32 |
| Land area (log) | 0.45 | 1.22 |
| Proportion of cultivation income in total income (%) | 0.27 | 2.31 |
| Proportion of aquaculture income in total income (%) | 0.20 | 0.44 |
| Proportion of non-agriculture income in total income (%) | 0.24 | 0.44 |
| **Institutional factor** | | |
| Access to loan (1: Yes; 0: No) | 0.21 | 0.41 |
| Proportion of land with Land Right Certificate | 0.95 | 0.18 |
| **Infrastructure** | | |
| Distance from plot(s) to house (km) | 0.69 | 1.69 |
| Distance from plots(s) to nearest commune road (km) | 2.97 | 3.92 |
| **Climate conditions** | | |
| Total hours of sunshine (hours) | 2313.83 | 237.32 |
| Total level of rainfall (mm) | 1503.56 | 450.83 |
| **Past climate experiences on** | | |
| Wind storm (1: Yes; 0: No) | 0.15 | 0.35 |
| Drought (1: Yes; 0: No) | 0.23 | 0.42 |
| Higher temperature (1: Yes; 0: No) | 0.25 | 0.43 |
| Flood (1: Yes; 0: No) | 0.19 | 0.39 |
| Untimely rain (1: Yes; 0: No) | 0.23 | 0.42 |
| Salt water intrusion (1: Yes; 0: No) | 0.04 | 0.19 |
| Eroded shorelines (1: Yes; 0: No) | 0.02 | 0.12 |
| Pestilent insect (1: Yes; 0: No) | 0.70 | 0.46 |
| Water shortages (1: Yes; 0: No) | 0.08 | 0.27 |

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017); N=329

Table 3: Summary statistics on household-level covariates (to be continued).

Table 3: Summary statistics on household-level covariates (continuation).

Following Filmer and Pritchett (2001), principal component analysis (PCA) is used to assign weights to each production asset. The overall production asset index is calculated by applying the following formula:

$$w_j = \sum_{i=1}^{k} [b_i(a_{ji} - x_i)] / s_i$$

where $w$ is the production asset index, $b$ is the weights from PCA, a is the production asset value, $x$ is the mean production asset value, and $s$ is the standard deviation of the production assets.

## Results and discussion

Despite the fact that the majority of the farmers interviewed claimed that they have perceived at least one change in climatic attributes, some of the farmers who perceived climate change did not respond by taking adaptation measures. Here it is argued that farmers who perceive and responded (or did not respond) share some common characteristics, which assist in better understanding the reasons underlying their response (failure to respond) as captured by the ISUR probit model.

The $R^2$ and F test of four ISUR models are in Table 4. The $R^2$ for all models indicated that the statistically significant explanatory variables can explain around 33 to 44 percentage of the variation of farmers' adaptation assessments. Breusch-Pagan test for independent equations were highly significant with values less than 0.00001, implying that equations are correlated. Goodness-of-fit test indicates that four of five models fit the data well. No multicollinearity problems were detected as the variance inflation factor (VIF) for all explanatory variables were less than 1.47.

| | Water use management | Adjustments of crops and varieties | Adjustments of planting techniques | Adjustments of planting calendar |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| R squared | 0.32 | 0.44 | 0.41 | 0.38 |
| Breusch-Pagan test for independent equations (Chi squared and *p* value) | 210.00 (0.0000) | 273.10 (0.0000) | 259.54 (0.0000) | 267.48 (0.0000) |
| Goodness-of-fit test (Pearson chi-square and *p* value) | 297.10 (0.6006) | 326.22 (0.1822) | 375.78 (0.0024) | 165.66 (1.0000) |
| Test for multicollinearity (mean VIF) | 1.41 | 1.35 | 1.47 | 1.36 |

Source: Authors' estimation from climate change survey in the Mekong River Delta (2017)

Table 4: Model summary.

The marginal effects of coefficients in the four ISUR regression models are presented in Table 5. Bootstrap estimates were conducted. The paper uses bias corrected bootstrapped ($n$ =1000) results because they have been shown to perform the best with regards to power and Type I error results (Briggs, 2006), particularly for smaller sample sizes (Preacher and Hayes, 2008).

With respect to household characteristics, male headed household has more probability of specifically adapting to climate change which is revealed by the fact that a change from being headed by a female household to male increases the probability of adapting water use management measures by 11.7 percentage points, *ceteris paribus* (column 1 – Table 5). This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies and take risky businesses than female headed households (Asfaw and Admassie, 2004; Tenge and Hella, 2004).

A one-year increase in the education of the head of the household will have the impact of raising the probability of making adjustments of planting techniques to climate change by about 1.2 percentage points, *ceteris paribus* (column 3 – Table 5). This is in line with studies of Maddison (2007), Lin (1991), and Igoden, Ohoji, and Ekpare (1990). Although a series of adaptive measures has been used by many households, the above findings may imply causes of inefficient adaptation in local areas. Poor education can be one possible cause.

A one-person increase in the household size will have the impact of decreasing the probability of making adjustments of planting techniques to climate change by around 2.8 percentage points, *ceteris paribus* (column 3 – Table 5).

Our results indicate that farm system types alone may not determine climate change's responses; these systems are also imbedded with institutional factors, infrastructure, climate conditions and varying climate experiences as well. With respect to farm characteristics, farming household with higher proportion of aquaculture income has less chances of making adjustments of crops and varieties to climate change by 17.5 percentage points, *ceteris paribus* (column 2 – Table 5), and has more chances of changing water use management by 8.12 percentage points, *ceteris paribus* (column 1 – Table 5).

With respect to institutional factors, farmer with access to credit has higher chances of adapting to changing climatic conditions as found in Nicholas and Gina (2012), and Nhemachena and Hassan (2007). Household with access to credit will have the impact of raising the probability of making adjustments of planting calendar to climate change by 13.5 percentage points, *ceteris paribus* (column 4 – Table 5). According to Nhemachena and Hassan (2007), access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options they might want to take. In addition, household with higher proportion of land with Land Right Certificate will have the impact of raising the probability of changing water use management by 19.5 percentage points, *ceteris paribus* (column 1 – Table 5). With more financial and other resources at their disposal farmers are able to change their management practices in response to changing climatic and other factors.

Regarding to infrastructure, farmer with limiting access to market (as proxied by the distance from plot(s) to nearest commune road) has higher probability of adjustments of crops and varieties to changing climatic conditions by 1.52 percentage points, *ceteris paribus* (column 2 – Table 5). With access to markets farmers are easily able to buy new crop varieties, new irrigation technologies, and other important inputs they may

| | Water use management | Adjustments of crops and varieties | Adjustments of planting techniques | Adjustments of planting calendar |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| **Household characteristics** | | | | |
| Male-headed household | 0.117** | -0.0347 | 0.0758 | 0.0252 |
| | -0.0559 | -0.0931 | -0.106 | -0.0592 |
| Years of education by household head | 0.00408 | -0.00237 | 0.0117* | -0.00237 |
| | -0.00457 | -0.00661 | -0.00713 | -0.0049 |
| Marital status of household head | -0.0537 | 0.000957 | -0.124 | -0.0487 |
| | -0.0683 | -0.0955 | -0.106 | -0.0593 |
| Household size | -0.00427 | -0.0025 | -0.0279* | -0.00938 |
| | -0.0109 | -0.016 | -0.0167 | -0.0123 |
| **Farm characteristics** | | | | |
| Land area (log) | 0.0164 | 0.0336 | 0.0194 | 0.0056 |
| | -0.0174 | -0.0245 | -0.0261 | -0.0158 |
| Production asset index | 0.00152 | -0.0127 | 0.00873 | -0.0135 |
| | -0.0152 | -0.0171 | -0.0196 | -0.0153 |
| Proportion of cultivation income (%) | -0.00187 | -0.00471 | 0.00264 | -0.000346 |
| | -0.0201 | -0.0251 | -0.0261 | -0.0242 |
| Proportion of aquaculture income (%) | 0.0812* | -0.175*** | -0.0609 | -0.0269 |
| | -0.0493 | -0.0618 | -0.0643 | -0.0323 |
| Proportion of non-agriculture income (%) | 0.0402 | 0.0574 | -0.0027 | 0.0783* |
| | -0.0396 | -0.052 | -0.0663 | -0.042 |
| **Institutional factor** | | | | |
| Access to loan | 0.0195 | -0.00157 | 0.0948 | 0.135*** |
| | -0.042 | -0.0599 | -0.058 | -0.0419 |
| Proportion of land with Land Right Certificate (%) | 0.195* | 0.205 | 0.0936 | 0.0834 |
| | -0.104 | -0.156 | -0.167 | -0.112 |
| **Infrastructure** | | | | |
| Distance from plot(s) to house | 0.00651 | -0.0278* | -0.00393 | 0.000549 |
| | -0.0126 | -0.0159 | -0.0139 | -0.0083 |
| Distance from plots(s) to nearest commune road | -0.0113** | 0.0152* | -0.00357 | -0.00321 |
| | -0.00459 | -0.00808 | -0.00623 | -0.00373 |
| **Climate conditions** | | | | |
| Total hours of sunshine | 6.05E-06 | -0.000121 | 5.90E-05 | -7.99E-05 |
| | -0.000107 | -0.00013 | -0.000137 | -8.90E-05 |
| Total level of rainfall | 0.000117** | 0.000133** | 7.20E-05 | 4.01E-05 |
| | -4.73E-05 | -6.32E-05 | -6.57E-05 | -3.76E-05 |
| **Past climate experiences on** | | | | |
| Wind storm | 0.00787 | -0.0356 | -0.00877 | -0.0786 |
| | -0.0519 | -0.0665 | -0.0694 | -0.0498 |
| Drought | -0.0191 | -0.0449 | -0.0721 | 0.0609 |
| | -0.0478 | -0.0563 | -0.056 | -0.0522 |
| Flood | 0.0361 | 0.036 | 0.0546 | 0.0711 |
| | -0.0493 | -0.0618 | -0.0651 | -0.0449 |
| Untimely rain | -0.0238 | 0.167*** | 0.0199 | 0.0156 |
| | -0.0425 | -0.0545 | -0.0568 | -0.0481 |
| Pestilent insect | -0.0626 | -0.0866 | -0.0162 | -0.0398 |
| | -0.0398 | -0.0547 | -0.0568 | -0.0395 |
| Water shortages | -0.0659 | -0.146 | 0.00995 | 0.156** |
| | -0.0593 | -0.0903 | -0.102 | -0.0732 |

Note: Bootstrap (with $n$ =1000) standard errors in parentheses; *** $p$<0.01, ** $p$<0.05, * $p$<0.1; $N$ = 329
Source: Authors' estimation from climate change survey in the Mekong River Delta (2017)

Table 5: Marginal effects of adaptive perception on adaptive measures (to be continued).

| | Water use management | Adjustments of crops and varieties | Adjustments of planting techniques | Adjustments of planting calendar |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| **Farmers' Adaptive perception on** | | | | |
| Water use management | | | | |
| Build/repair cistern | 0.118 (0.0986) | | | |
| Build/repair well | 0.476*** (0.0892) | | | |
| Adjustments of crops and varieties | | | | |
| Change varieties | | 0.576*** (0.0525) | | |
| Change crops/livestock | | 0.0553 (0.0798) | | |
| Change crop structure | | 0.0644 (0.0832) | | |
| **Adjustments of planting techniques** | | | | |
| Change crop cultivation | | | 0.0626 (0.0765) | |
| Change fertilizer/stimulus | | | 0.0765 (0.0690) | |
| Change pesticides/ herbicides | | | 0.459*** (0.0576) | |
| Change crops quantity | | | 0.245*** (0.0688) | |
| **Adjustments of planting calendar** | | | | |
| Change irrigation schedule | | | | 0.354*** (0.103) |
| Change crop rotation | | | | 0.304*** (0.0998) |
| Observations | 329 | 329 | 329 | 329 |
| $R^2$ | 0.318 | 0.44 | 0.409 | 0.385 |

Note: Bootstrap (with $n$ =1000) standard errors in parentheses; *** $p$<0.01, ** $p$<0.05, * $p$<0.1; $N$ = 329
Source: Authors' estimation from climate change survey in the Mekong River Delta (2017)

Table 5: Marginal effects of adaptive perception on adaptive measures (continuation).

need to change their practices to suit the forecasted and prevailing climatic conditions as mentioned by Nhemachena and Hassan (2007). Thus, when limitation in access to market exists, farmers may choose to adjust crops and varieties within the current budget constraints.

Farmer with limiting access to market (as proxied by the distance from plot(s) to nearest commune road) has less probability of changing water use management by 1.13 percentage points, *ceteris paribus* (column 1 – Table 5). In addition, farming household with plots in longer distance from house will have the less probability of making adjustments of crops and varieties to climate change by 2.78 percentage points, *ceteris paribus* (column 2 – Table 5). Overall, the improvement of both the accessibility and usefulness of local services is deemed a necessity for adaptation strategies.

With respect to climate conditions, annual average precipitation is positively related to some type of adaptations. Increasing rainfall increases the probability of conducting water use management measures (column 1 – Table 5) and adapting adjustments of crops and varieties (column 2 – Table 5) by nearly 0.01 percentage points in each case, ceteris paribus. The probable reason for the positive relationship between average annual precipitation and adaptation could be due to the fact that agriculture in the Mekong River Delta faces flood so commonly and increasing precipitation will be harmful for agricultural production.

ISUR estimates show that past climate experiences increase the probability of uptake of adaptation measures as shown in Niles et al. (2015), Nicholas and Gina (2012), and Maddison (2007). In general, farmer who is aware of changes in climatic conditions has higher chances of taking adaptive measures in response to observed changes. Specifically, increasing untimely rain increases the probability of farmers changing their management practices, in particular, adjustments of crops and varieties (including changes in varieties, crops/livestock, and crop structure) by 16.7 percentage points, *ceteris paribus* (column 2 – Table 5). Resulting water shortages leads to adjustments of planting calendar, including changes in irrigation schedule, and crop rotation (as mentioned by Niles et al. (2015)) by 15.7 percentage points, *ceteris paribus* (column 4 – Table 5). Generally, if perception of climate change induced natural shocks are the most salient for farmers, it likely has significant implications for assessing how short-term responses can influence long-term adaptations and the subsequent policies that may be needed to accompany such actions (Carlo et al., 2015; Le Dang et al., 2014;

Park et al., 2012). In addition, because climate variability in higher temperature and accompanied by drought, untimely rain, and water shortages, irrigation investment needs from the viewpoint of Public - Private Partner (PPP) should be reconsidered to allow farmers increased water control to counteract adverse impacts from climate variability and change.

Our main concerns are about the effects of farmers' adaptive perception. ISUR estimates show that farmers' adaptive perception increases the probability of uptake of adaptation measures. In general, farmer who is aware of possible adaptive measures has higher chances of taking adaptive measures in response to observed changes. Specifically, knowing about 'build/repair well' increases the probability of farmers to choose water use management measures by 47.6 percentage points, *ceteris paribus* (column 1 – Table 5). With respect to adjustments of crops and varieties, knowing about 'change varieties' increases the probability of farmers changing their management practices, in particular, adjustments of crops and varieties (including changes in varieties, crops/livestock, and crop structure) by 57.6 percentage points, *ceteris paribus* (column 2 – Table 5). Regarding adjustments of planting techniques, knowing about 'change pesticides/ herbicides' increases the probability of farmers conducting adjustments of planting techniques (including changes in crop cultivation, fertilizer/ stimulus, pesticides/herbicides, crop quantity, and farmyard manure) by 45.9 percentage points, *ceteris paribus* (column 3 – Table 5). And in regard to adjustments of planting calendar, knowing about 'change crops quantity' also increases the probability of farmers conducting adjustments of planting techniques (including changes in crop cultivation, fertilizer/stimulus, pesticides/ herbicides, crop quantity, and farmyard manure) by 24.5 percentage points, *ceteris paribus* (column 3 – Table 5). Knowing about 'change crop rotation' leads to adjustments of planting calendar, including changes in irrigation schedule, and crop rotation by 30.4 percentage points, *ceteris paribus* (column 4 – Table 5).

## Conclusion

This study was based on farm-level analysis of the influence of farmers' adaptive perception on adaptation to climate change induced natural shocks in the Mekong River Delta of Viet Nam. This research has shown that the majority of farmers used adaptive measures that mostly related to their farming practices such as (1) water use management (including: build/repair cistern, build/repair well, and water saving technology), (2) adjustments of crops and varieties (including changes in varieties, crops/livestocks, and crop structure), (3) adjusting planting techniques (such as changes in crop cultivation, fertilizer/ stimulus, pesticides/herbicides, crop quantity, and farmyard manure) and (4) adjusting planting calendar (such as changes in irrigation schedule, and crop rotation). The adaptive measures farmers followed were those that they perceived climate change induced natural shocks such as wind storm (typhoon), drought, flood, higher temperature, untimely rain, salt water intrusion, eroded shorelines, pestilent insect, and water shortages.

This paper explores the influence of adaptive perception on adaptive measures using an ISUR probit model, especially distinguishing commonly-known factors with adaptive perception. The model allows for the simultaneous identification of the factors of all adaptation options, thus limiting potential problems of correlation between the error terms. Correlation results between error terms of different equations were significant (positive) indicating that various adaptation options tend to be used by farmers in a complementary fashion, although this could also be due to unobserved farm-level socioeconomic and other factors. ISUR probit results confirm gender of the farm head being male, education of the farm head, household size, proportion of incomes from aquaculture and non-agriculture activities, availability of credit, access to market, and rainfall have significant impact on choices of adaptation to climate change. Our paper makes a novel contribution to the literature by considering adaptive perceptions as important factors of private adaptive choices, after controlling past climate experiences as well. Results indicate that adaptive perceptions are among the most important factors of farm-level adaptation.

Findings from our study may provide useful information for policy makers as well as development agencies on responses to climate change in Viet Nam. First, findings from the influence of adaptive perception associated with adaptation choices can be useful inputs for policies to response to climate change and weather shocks. Our findings may also provide important implications for other emerging and transition economies similar to Viet Nam and/or regions from developing countries with conditions of natural resources familiar to the Mekong River Delta of Viet Nam.

Sources and quality of information can be of important consideration due to the potential

influences on farmers' past climate experiences and their adaptation assessments. Additionally, awareness creation on climate change and adaptation methods should be focused. On top of that, improvement of both the accessibility and usefulness of local services, such as credit and infrastructure, are deemed a necessity for successful adaptation strategies in the Mekong River Delta. Other policy options could also be suggested, including: strengthening education level of farmers, facilitating cheap technologies for farmers, spurring irrigation investment through PPP. Last but not least, government should support some implementations of the land reform such as farmers' cooperation in large-scale production.

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*Corresponding authors*
*Dr. Quang-Thanh Ngo*
*University of Economics and Law*
*Vietnam National University - Ho Chi Minh City (VNU-HCMC)*
*Quarter 3, Linh Xuan Ward, Thu Duc District, Ho Chi Minh City, Viet Nam*
*Phone: +84 937 105 567, E-mail: thanhnq@uel.edu.vn*

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# Investigation of the Determinants of Market Power on Czech Pork Meat Market

Tamara Rudinskaya

Institute of Agricultural Economics and Information, Prague, Czech Republic

## Abstract

An increasing market concentration in food retailing has generated concerns about the market power of retailers towards consumers and input suppliers. This is especially true for the Czech Republic, which has a CR5 in food retailing greater than 50%. Based on different indicators of food chain and pork meat market with respect to four groups of meat products with low and high value added it was analysed whether the evidence of market power in the Czech pork market exists. Analysis based on a New Empirical Industrial Organization model investigated the degree of market power of meat processing industry. The evidence of market power in meat processing industry is rather weak, although has increasing trend in the last year accompanying by growing market concentration ratio. However, the empirical results suggest that market power of retailing exists towards consumers and towards input suppliers (in particular, in the case of meat products with higher value added).

## Keywords

Food processing, pork market, retailing, market power, concentration ratio.

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## Introduction

The food supply chain plays an important role in the European economy, connecting sectors such as agriculture, food processing industry and the distribution. Though, the question of market power and competition policy in food supply chains has emerged as an important economic issue and a highly sensitive point on the policy agenda around the world.

In economic theory agricultural markets have been considered as an example of perfect competition markets. However, growing concentration at the food processing and retail level change the market structure and shift bargaining power (Sexton, 2013). Consequently, research in last years focused more and more on the food processing and retail sector as a possible source of oligopoly power with welfare loss implications for farmers and final consumers. Due to the great importance of the evaluation of the market structure, there have been numerous studies analysing the competitive conditions in several industries around the world.

For market power investigation, three different approaches have been applied in the literature: the structure-conduct-performance (SCP) approach was first introduced by Mason (1939; 1949) and later extended by Bain (1951; 1968). Structural variables, such as concentration ratios, are used as explanatory variables of firm performance in this analysis. These variables are usually obtained from accounting data. SCP draws a relationship between market concentration and economic performance in terms of profits (Schmalensee, 1989). The positive relation is usually considered as the presence of market power. Demsetz (1973) criticises this approach, as higher profits in an industry might be either the outcome of collusive behaviour of firms or due to differential efficiency. Firms with a higher efficiency can increase market share and receive profits above the average, which causes the positive relation (Sexton and Lavoie, 2001). Consequently, no direction of causality between structure and performance can be derived (Salhofer et al., 2012; Bhuyan, 2014).

Another approach, price transmission analysis, aims to reveal imperfect price transmission and market power. The general idea is that imperfect price transmission might exist when price changes at one level of the supply chain are not immediately reflected at the other level. Imperfect

price transmission can exist either because price changes are not fully transmitted along the food chain, or because increases or decreases at one level of the chain are not transmitted instantaneously, but instead distributed over time. Another explanaton is that the price reaction is different for positive and negative shocks (making the transmission asymmetric) (London Economics, 2004). This may generate temporary profits. Asymmetric price transmission for food products seems to be the rule rather than the exception (London Economics 2004). However, market power is only one possible explanation for imperfect price transmission (Bunte, 2006). Adjustment costs such as labelling, or advertising costs might make price changes rather expensive and can be an explanatory factor for price levelling. Other explanations of imperfect price transmission are stock building or imperfections due to the perishability of products.

The third approach, the New Empirical Industrial Organization (NEIO), began to appear in 1980s (Bresnahan, 1989; Hyde and Perloff, 1995). NEIO focuses on detecting market power or, in general, market imperfections. Most of these studies are based on the Lerner index (Lerner, 1934). Another method for measuring market power within NEIO uses the conjectural variations (CV) to infer competitive behaviour, which assumes that each firm believes that its choice of price will affect the price selected by its competitor, and that the competitor's reaction can be captured by a single parameter (Iwata, 1974, Kutlu and Sickles, 2012, Muth and Wohlgenant, 1999). Kumbhakar et al. (2012) introduced an approach based on stochastic frontier analysis.

Although the NEIO approach has frequently been used to investigate market power in food processing, especially in the world (Schroeter, 1988; Schroeter and Azzam, 1990; Azzam and Pagoulatos, 1990; Azzam, 1997; Bhuyan and Lopez, 1997, O'Donnell et al., 2007, Lopez, 1984), applications to European food markets are rather rare. Exceptions are, for example, Steen and Salvanes (1999) for oligopoly power in the European market for salmon, or Bettendorf and Verboven (2000) for oligopolistic behaviour in the Dutch coffee market. Cechura at al. (2014) investigated market power of European slaughetering, fruit and vegetable dairy, milling industry based on mark-up and mark-down model, and stochastic frontier methodology. The estimated mark-down model revealed some degree of non-competitive behaviour in the input food processing market for all analysed sectors. The degree of market imperfections differs among the sectors. The results of the mark-up model suggest that market imperfections on the output market are not so significant for the slaughtering sector. However, the degree of market imperfections is higher for the output market in the dairy and milling sectors. Cechura et al. (2015) compared market power of dairy industry of 24 EU member states using mark-up model. The results proved the existence of market failures on the EU output milk-processing market. Grau and Hockmann (2016) analysed German dairy supply chain and found lower levels of market imperfections on the raw milk and dairy output market. Bakucs et al. (2009) proved the existence of market power on German and Hungarian pork market, although on a relatively low level.

Market power of retailers in Europe was estimated in a number of papers with, however, very rare used of NEIO approach. Gohin and Guyomard (2000) studied market power in French food retailing considering milk, meat, and other food products. They strongly rejected the hypothesis of perfect competition. Anders (2008) investigated competition in German retailing with respect to meat products. The author's results strongly suggest evidence of retail oligopoly and even stronger oligopsony power. Sckokai et al. (2009) estimated market power in the cheese market in Italy and concluded that evidence for oligopoly power is stronger than for oligopsony power. Salhofer et al. (2012) estimated the market power of food retailers towards consumers and input suppliers with respect to three groups of dairy products. Results of the study suggest that market power of retailing exists towards consumers and towards input suppliers. In the European Union, Mérel (2009) examined behaviour in the French cheese market. The results of the paper do not confirm the evidence of market power. Spicka (2016) analysed the market of grocery retailers in the European Union and concluded that market structure of the Central European grocery retailers has mostly a character of asymmetric oligopoly.

This paper contributes to the analysis of market power in the Czech Republic. The price transmission analysis, provided by the internal project of IAEI (Rudinskaya et al., 2017) found that price transmission on the pork market in the Czech Republic is asymmetric from the point of view of different reaction to positive and negative price change on the different levels of pork chain. The objective of present paper is to extend the analysis of market imperfections on pork market and identify the reasons that may have affected the contemporary development of spreads between

farm gate prices and retail prices in recent years. The study focuses on developments since 2006 till 2016 in the Czech Republic and covers several pork products.

The paper addresses the following research questions. The first question is aimed to the analysis of development of market concentration ratio of retailers in the European Union and in the Czech Republic. The second question relates to the analysis of spread between farm-gate, processor and retailer prices in recent years for pork products with low and high value added. The third question concerns market imperfections in the meat processing market. The aim is to identify the degree of oligopoly market power.

The paper is organised as follows: in the next section (Materials and methods), the theoretical model and its empirical implementation is presented. Section describes the data and estimation techniques. Section Results and discission presents the estimation results and discussion on them. Conclusions are drawn in the last section.

## Materials and methods

There are several different sources of market power in literature. Market power, that can threat agricultural sector, can flow from the companies, which provide inputs for agriculture (feed processing companies, seed suppliers, machinery companies etc.) The second source is food processing companies, which in the case of high concentration ratio have bargaining power and lower the farm-gate prices of agricultural products. The third source is represented by the power of retailers, that can cut the processing prices. This paper is aimed to investigation of the second and third source.

In this chapter, we provide the comparison of market concentration ratio of European and Czech retail sector. Next, we undertake an analysis of development in the level of farmer-processor and processor-retailer price spreads of the several pork products, and then we present the results of correlation analysis between, on one hand, the level of processor-retailer price spreads and, on the other hand, the level of concentration in the food retailing industry. Finally, the estimation of the degree of market power of meat processing companies based on NEIO approach is provided.

The present study is based on data, collected from different sources: Passport database by Euromonitor International, Albertina database, Eurostat database, and Ministry of Agriculture of the Czech Republic. The data covers period 2005-2016. However, taking into account data availability of prices, time period 2006-2016, 2006-2017 was analysed.

The measures of the industry's structure are related to the degree of competitiveness in the industry. Common measures include the concentration ratio (CR), Herfindahl-Hirschman Index (HHI)), the degreeof product differentiation and the economies of scale.

This study uses market concentration ratio CR3 (for European Union) and CR5 (for the analysis of the Czech market structure). These ratios were chosen as the best fitting indicators for Czech food chain based on available data. The concentration ratio ($CR_m$) is calculated as the percentage of market shares held by $m$ largest firms in a sector. Market share of the five biggest companies (CR5) is calculated as:

$$CR_5 = \sum_{i=1}^{5} S_i \quad (1)$$

where $S_i$ denotes the individual market share, i.e. the percentage of the i-th firm calculated as the production of the company divided by the sum of production of all firms in the market.

To assess whether the market concentration ratio and price spreads show any systematic upward or downward trend through the analysed period, a simple equation relating the concentration ratio, farmers-processor or processor-retailer price spread of a specific commodity to a time trend variable was estimated in the following equation:

$$Y_j = \alpha + \beta t \quad (2)$$

where $Y_j$ is concentration ratio of $j$-country or price spread of $j$-commodity, $t$ is a trend variable. Of key interest is the sign of the coefficient $\beta$ and whether it is statistically significant.

To evaluate the relationship between the price spread and market concentration ratio of retailing sector, Pearson correlation coefficient was used (Pearson, 1895).

The research analysis of market power will be provided by estimating a mark-up model and employing stochastic frontier methodology. The mark-up model is derived from the standard profit maximization rule. The solution of the optimization problem results in product price corresponding to marginal costs for a competitive market, and price exceeding marginal costs for a non-competitive (oligopolistic) market:

$$P > MC \equiv \frac{\partial C}{\partial Y} \quad (3)$$

where $Y$ is an output, and $C$ stands for total costs.

If we multiply relation (3) by the share of revenue in total costs, we can write:

$$P\frac{Y}{C} > MC\frac{Y}{C} = \frac{\partial C}{\partial Y}\frac{Y}{C} = \frac{\partial lnC}{\partial lnY} \quad (4)$$

The inequality can be transformed to an equality by adding a non-negative, one-sided error term ($u$), i.e. $u$ represents a measure of market failures (mark-up) (5).

$$\frac{PY}{C} = \frac{\partial lnC}{\partial \ln Y} + u, u \geq 0 \quad (5)$$

The relation (5) can be estimated using stochastic frontier methodology. The stochastic frontier approach for detecting the degree of monopoly power was first introduced by Kumbhakar et al. (2012).

In relation (5) estimation of the first derivative of the cost function must be done. In the case of input and output prices absence, the duality theorem can be applied, and the first derivative of the input distance function can be estimated instead (Kumbhakar et al., 2012):

$$\frac{PY}{C} = \frac{\partial lnC}{\partial lnY} + u = \frac{\partial lnD^I}{\partial lnY} + u, u \geq 0 \quad (6)$$

Input distance function in a translog form can be written as following:

$$\begin{aligned} lnD^I = {} & \beta_o + \beta_T T + 0.5\beta_{TT}T^2 \\ & + \beta_Y lnY + \beta_{YT} lnYT + 0.5\beta_{YY}(lnY)^2 \\ & + \sum_{j=1}^{J-1}\beta_j ln\tilde{X}_j + 0.5\sum_{j=1}^{J-1}\sum_{k=2}^{J}\beta_{jk} ln\tilde{X}_j ln\tilde{X}_k \\ & + \sum_{j=1}^{J-1}\beta_{jY} ln\tilde{X}_j lnY + \sum_{j=1}^{J-1}\beta_{jT} ln\tilde{X}_j T \end{aligned} \quad (7)$$

The function (7) can be estimated as:

$$\frac{PY}{C} = \beta_Y + \beta_{YY} lnY + \sum_{j=1}^{J-1}\beta_{jY} ln\tilde{x}_j + \beta_{YT} T + u + v \quad (8)$$

where $v$ is a variable capturing the statistical noise.

For the purpose of the analysis input distance function was estimated on the form of True Random Effects model (Greene, 2005).

Defining the relative mark-up ($\theta$) as $\theta = \frac{P-MC}{MC}$, we get the estimation of relative mark-up:

$$\hat{\theta} = \frac{\hat{u}}{\hat{\beta}_Y + \hat{\beta}_{YT}T + \hat{\beta}_{YY} lnY + \sum_{j=1}^{J-1}\hat{\beta}_{jY} lnX} \quad (9)$$

The data for the analysis was collected from the Albertina database. The database contains accounting information of companies in the Czech Republic. The panel data set that was used in the analysis contains companies whose main activity is meat processing, according to the NACE classification. It is an unbalanced panel data set, which represents the period from 2005 to 2016 and contains 1,616 observations of meat processing companies.

In the analysis Output, Labour, Capital, Material, and Revenue share variables were used. Output variable is represented by the operating revenue (Turnover) of the company. Labour variable is represented by the cost of employees, Material variable is the total costs of materials and energy consumption, and Capital costs is calculated as the value of net worth with added cost of services and extracted amortization. Revenue share was calculated by the following way: Revenue share = Revenue/Costs. Costs are the sum of Labour, Material and Capital costs. Material and Capital variable were normalised by Labour variable. To eliminate the inflation, Output variable was deflated by the sectoral index of processing price index (in meat processing industry). Material and Capital variables were deflated by the index of processor prices (total index).

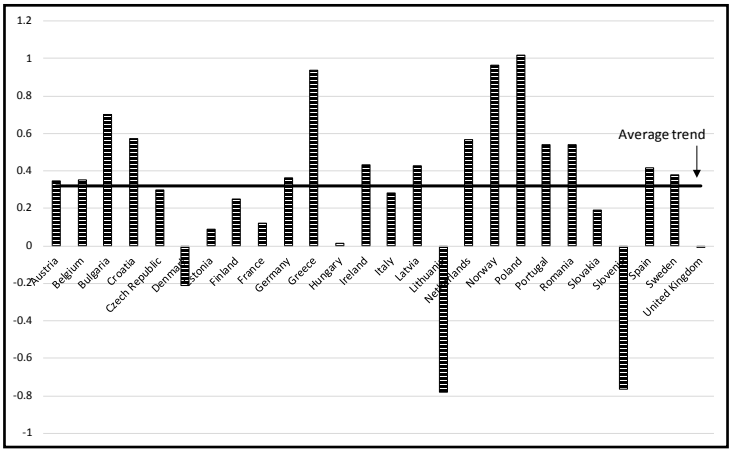
## Results and discussion

In this chapter, we undertake a descriptive analysis of a) market concentration ratio of European Union member states; b) the development of price spread on farmer-processor and processor-retailer level; c) correlation of processor-retailer price spread and retailers market concentration ratio (CR5); and d) estimation of market power coefficient and the relationship of the degree of market power and concentration ratio of meat processors.

### 1. Retail concentration in the European Union

Development of market concentration of retailing of Top 3 companies is presented in the Figure 1. Market concentration ratio represents the share of revenue of the three biggest companies in total revenue including grocery and non-grocery retailing. Development of market concentration was estimated according to (2) and represented by the parameter coefficient of linear trend, which displays whether market concentration ratio has decreasing or increasing trend over the estimated period.

Concentration in European food retailing has increased throughout the European Union. Only in three Member States (Denmark, Lithuania and Slovenia) concentration ratio decreased over the analysed period. The highest growth




Note: Exc. Cyprus, Malta, Luxemburg.
Source: own processing based on Passport data

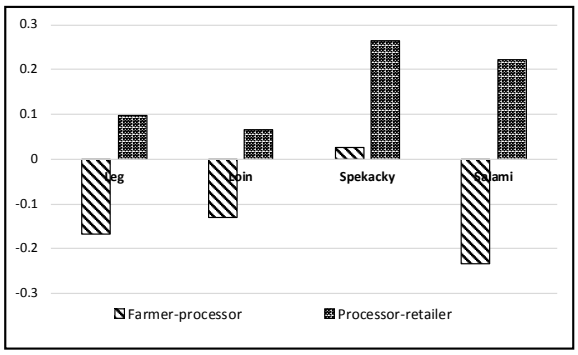
Figure 1: Linear regression of CR 3 in the European Union (2008-2017).

of CR3 experienced Poland, Norway and Greece. Increase of CR3 in the Czech Republic, expressed by the parameter of linear regression, is slightly below average level of European Union Member States.

## 2. Changes in farmer-processor and processor-retailer price spreads in the Czech Republic

Estimated trend coefficients of pork and pork products price spread in the Czech Republic are represented in the Fugure 2. Spread represents the difference between two prices on the different levels of pork chain, i.e. 1) between farm-gate price and processor's price (farmer-processor); 2) between processor's and retailer's price (processor-retailer). Development of prices spreads is represented by the coefficient of linear trend according to (2).

The development of spread has one interesting characteristic: while the spread of processor-retailer prices is increasing for all products over the analysed period, the farmer-processor price spread is decreasing (except "spekacky", that has a growing trend).



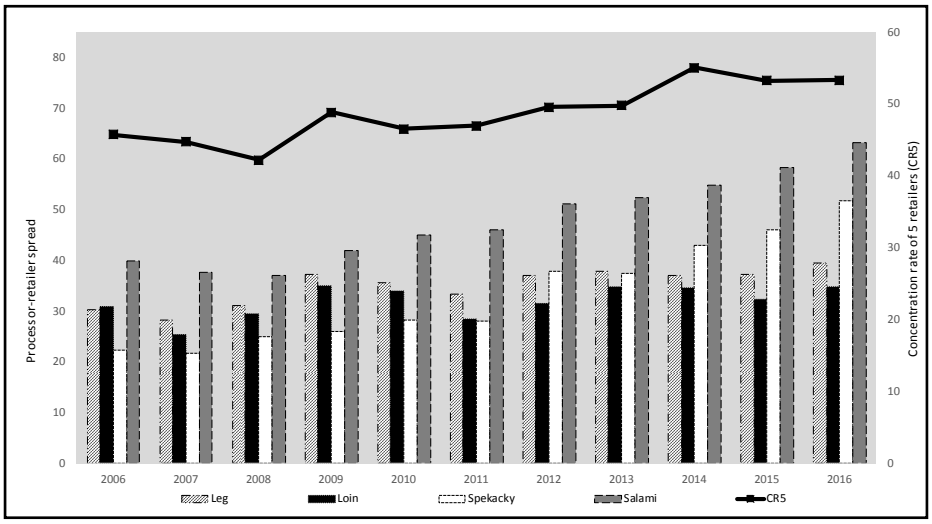

Source: own processing

Figure 2: Development of price spread in the Czech Republic in the years 2006-2017.

The proportion of agricultural products in the final product, used by the food processing industry, has changed in recent years and may have had some impact on price spread development as well as on the bargaining relationships along the supply chain. The negative development of farmer-processor price spread might have been either the result of lower content of agricultural material in final product, or the result of growing market power of retailing sector. Further factor that can have had an impact on farmer-processor price spread is modernization of food processing industry, that can result to higher productivity and lower costs of final products of processing industry. Productivity of meat processing companies, measured by Gross value added per employee, increased from 2008 to 2016 by 31.4 % (Ministry of Agriculture of the Czech Republic, 2017). After the elimination of price changes in meat processing industry (inflation) the indicator amounts to 31.2 %

One of the factors that may affect the size of the spread between farm-gate, processor and retail prices is food retailing concentration ratio. For this part of the analysis concentration ratio (CR5) of Czech retailing was calculated based on Albertina and Eurostat data sources. Turnover of five companies with largest turnover was divided by the total turnover of Czech grocery sector.

Correlation analysis of the processor-retailer price spreads and concentration ratio (CR5) of the food retailing industry in the CR shows that the link between these two variables is very strong (Figure 3). The correlation analysis shows a positive relationship with the highest correlation coefficient of 0.903. The correlation coefficient is higher in the case of products with higher value added (salami and spekacky). The results




Source: own processing

Figure 3: Correlation between processor-retailer spread and CR5 in the Czech Republic in the years 2006-2016.

of the correlation analysis suggest that the impact of food retail concentration on the farm gate-retail spread is rather strong, especially for products with higher value added, that are more heterogenous comparing to unprocessed products (pork leg and loin).

## 3. Mark-up of Czech meat processing sector

Table 1 provides a parameter estimate of the mark-up model for the meat processing sector in the Czech Republic.

| Variable | Coefficient | Standard Error | P>z |
|---|---|---|---|
| Constant | 0.874 | 0.009 | 0.000 |
| Time | -0.003 | 0.001 | 0.000 |
| Output | 0.072 | 0.003 | 0.000 |
| Labour | 0.032 | 0.006 | 0.000 |
| Material | 0.045 | 0.005 | 0.000 |
| Sigma_u | 0.096 | 0.004 | 0.000 |
| Sigma_v | 0.030 | 0.003 | 0.000 |
| Lambda | 3.244 | 0.006 | 0.000 |

Source: own processing

Table 1: Estimated parameters of mark-up model.

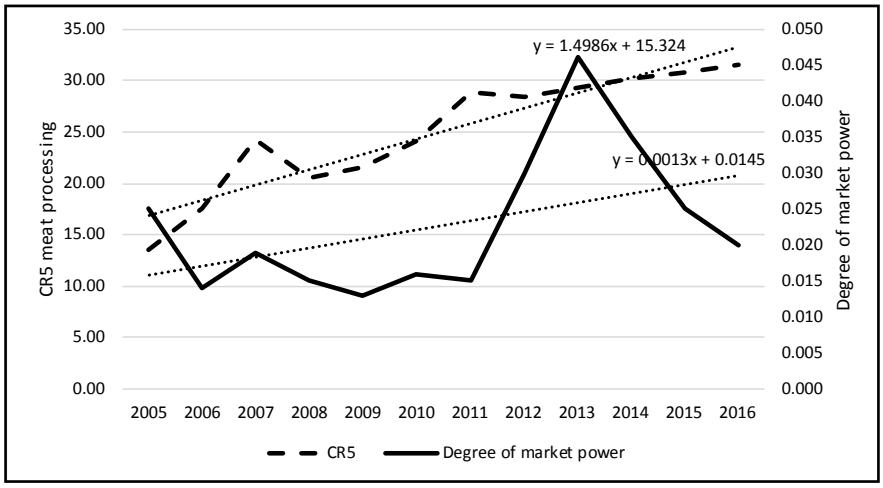
All estimated parameters are significant. The estimates show the positive impact of the output, labour and material inputs on revenue share of the meat processing sector. Higher labour and material inputs relate to a production characterized by higher value added. Finally, the firms with higher output have a higher revenue share. This could be also related to higher degree of market power.

The impact of time on revenue share is negative, although very low. This is in line with slightly decreasing processors' prices and farmer-processor spread of pork meat and pork products.

Figure 4 represents the development of concentration ratio of meat processing industry (CR5) and the estimated degree of market power. CR5 was calculated based on the Albertina database and data of Ministry of Agriculture of the Czech Republic. Turnover of five companies with largest turnover was divided by the total turnover of Czech meat processing sector.

The analysis of development of concentration ratio in meat processing industry (CR5) and the degree of market power shows the similar growing trend. Correlation between CR5 of meat processing sector and degree of market power is 0.419 that is positive and relatively high.

The results of previous studies have different conclusions concerning market power of the food processing and retailing. There are studies of market power of food processing and retailing in European Union that found strong evidence of market power. But there are also studies that found only weak or even no evidence of market power. The food sector in the European Union can be characterised by significant concentration within the food processing industry and the retail sector (Dobson et al., 2001). Number of papers addressed the analysis of market power of milk processing industry. Bakucs et al. (2018) by analysing the market power of Hungarian milk processing found that the effects of market power are statistically significant, and the econometric results are




Source: own processing

Figure 4: Development of CR5 of meat processing and the degree of market power in the Czech Republic in the years 2005-2016.

consistent with a relatively highly concentration in the Hungarian milk processing industry. Cechura et al. (2015) did not find the evidence of significant market power in milk food processing industry in the Czech Republic. However, the degree of market power increased during the analysed period. Cechura et al. (2014) investigated the mark-down and mark-up model for the member countries of EU and found that the slaughtering sector of the Czech Republic is characterised by lower market imperfections as compared to the EU average. Grau and Hockmann (2016) investigated German dairy supply chain and found low levels of market imperfections on the raw milk and dairy output market. Bakucs et.al. (2009) analysed the impact of market power on resource allocation in the German and Hungarian pork markets. The regression analyses suggest that market power exists, although on a relatively low level. In addition, the market power of processors in the German hog sector is decreasing, while in the Hungarian sector it is increasing. Salhofer et al. (2012) proved the existence of market power in retailing based on milk products data. Retailers apply market power towards consumers and towards input suppliers.

These results of the empirical analysis are consistent with the structural developments in pork production and pork processing. The results of this paper are in line with the results of previous studies. Degree of market power of meat processing industry is rather insignificant but increasing in time. The growth of market power corresponds to the concentration ratio of meat processing industry.

Retailer sector evidently has higher degree of market power, based on the results of present paper and the results of internal project of IAEI (Rudinskaya et al., 2017).

## Conclusions

The paper investigates the existence of market power in the food processing and retailing sector of pork meat and pork products. In this regard, one can note that perishable food products with little alternative sale channels are more likely to be subject of market power than products that can be easily stored.

Based on market concentration ratio (CR5), spread of farmer-processor and processor-retailer prices, correlation between spread and market concentration ratio and NEIO approach, it was proved that the degree of market power of meat processing industry is rather low. However, the degree of market power is increasing in time, as well as the concentration ratio (CR5). The development of farmers-processor price spread during the analysed period (2006-2016) has decreasing trend. The development of processor -retailer spread is, in opposite, increasing over time. The concentration ratio of Czech retailing is slightly below the European Union average. Moreover, correlation of CR5 and price spread is very high, that can imply the existence of market power in retailing.

These findings apply the important points towards some policy issues, particularly the fact that governments should be aware of the effect of market power. It is desirable to provide measures for effective strengthening of farmers bargaining

power. Joint selling through producer organisations can be an effective tool for rebalancing power in the agri-food system.

The challenge for future research is to proceed in investigation of the determinants of market power through the estimation of the degree of market power of retailers based on NEIO approach.

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*Corresponding authors*
*Tamara Rudinskaya, Ph.D.*
*Institute of Agricultural Economics and Information, Mánesova 1453/75, 120 00 Prague, Czech Republic*
*Email: Rudinskaya.tamara@uzei.cz*

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# Technical Efficiency Assessment of Intensive and Traditional Olive Farms in Southern Italy

Teodora Stillitano, Giacomo Falcone, Bruno Francesco Nicolò, Claudio Di Girolamo, Giovanni Gulisano, Anna Irene De Luca

Agraria Department, Mediterranea University of Reggio Calabria, Italy

## Abstract

Olive-growing plays an important role in Southern Italy's agricultural sector. However, the profitability of many olive growing farms depends, still today, on public subsidies. The current changes in the European Common Agricultural Policy (CAP) 2014-2020, oriented towards the direct payments decreasing, will inevitably have important effects on farmer incomes. This is why the olive farms will have to increase their level of direct profitability to ensure their resilience on the market. Therefore, the measurement of technical efficiency plays a crucial role in identifying more efficient management practices, and for this aim, Data Envelopment Analysis (DEA) represents the most widely used technique in productivity analysis.

In this paper, constant returns to scale and variable returns to scale input-oriented models were used to investigate the technical and scale efficiency of intensive and traditional olive farms in Southern Italy, in order to highlight the performance of each farm.

Results showed technical inefficiencies in both olive systems and, suggesting that improvements in the input allocation among all farms are needed. Findings could be useful to suggest the adoption of management strategies to optimize the use of inputs, aiming to achieve suitable levels of productive performance.

## Keywords

Olive-growing farms, scale efficiency, nonparametric analysis, Data Envelopment Analysis.

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## Introduction

According to FAOSTAT (2016), the worldwide cultivation of olive trees accounts more than 10.6 million of hectares, in respect to which Italy weights about 11%, keeping itself the second most important producing country of olives, after Spain (with about 24%). Olive growing plays a significant role in Italy's agricultural economy, indeed, in the national agricultural context, olive farms present high incidence, representing about 56% of the total number of Italian farms (ISTAT, 2010). In economic terms, the average value of Gross Saleable Production (GSP) of the olive farms amount to 1.7 million of euros, corresponding to about 3% of the national GSP of the agricultural sector. Relating to the southern Italian regions, this incidence grows to 10% (Scardera and Tosco, 2010); in particular olive-growing is mainly widespread in Apulia, Calabria, and Sicily, which overall account for about 73% of the national olive oil production (ISTAT, 2016). Furthermore, it is noteworthy that olive-growing is able to provide a multifarious range of functions, besides the merely productive one, as for example ecosystem services, support for rural development, and guarantees of food safety (De Luca et al., 2018a, 2018b).

In Calabria region, olive cultivation systems are variegated, due to the co-existence of traditional and intensive orchards with low and high-density planting, respectively (Bernardi et al., 2018a; Stillitano et al., 2017, 2018). Traditional systems, that are mainly developed in hilly and mountainous areas, are characterized by low levels of adaptation, conversion, and mechanisation, often entailing a not economically viable crop management (Bernardi et al., 2016); on the contrary, the intensive systems are represented by higher yields (both of fruits and oil obtained), as well as higher levels of mechanization that result in high-quality

olive oil production, and better levels of farm income (Giametta and Bernardi, 2010). Thus, in an increasingly competitive olive oil market, where the estimated global demand for extra virgin olive oil is steadily growing, modern intensive olive groves can represent an innovative and economically viable opportunity for farmers (Bernardi et al., 2018b; Sola-Guirado et al., 2018). Nevertheless, since the profitability of many Mediterranean olive farms depends, even now, on public subsidies, both reduction in direct payments and internal convergence processes implemented by Common Agricultural Policy (CAP) 2014-2020 reform will entail the decrease in direct support received by farmers, and consequently negative effect on their incomes. This is why the olive farms will have to increase their level of direct profitability to ensure their resilience on the market. In order to do so, a more efficient use of existing resources should be reached. In this context, technical efficiency of olive farms understood as the ability of an entrepreneur to maximize outputs given a certain combination of inputs or to minimize inputs given a certain level of outputs, need to increase. Data Envelopment Analysis (DEA), proposed by Charnes, Cooper, and Rhodes in 1978, has turned out to be the most widely used method in technical efficiency measurement. This paper deals with the analysis of technical, pure technical and scale efficiency of intensive and traditional olive farms in Calabria region (Southern Italy), in order to highlight their inefficiencies in the allocation of resources and thus identifying managerial improvement strategies which, if adopted by Calabrian farms, could represent a key element for their survival in the market.

## Theoretical background

DEA is a non-parametric linear-programming-based method developed by Charnes et al. (1978) and based on Farrell's (1957) efficiency definition. It represents the most widely used procedure in estimating the technical efficiency of decision-making units (DMUs), which convert multiple inputs into multiple outputs. As observed by Joro and Korhonen (2015), DMUs, which may include firms or parts of firms, must be comparable, i.e., they must perform essentially the same task using similar inputs to produce similar outputs, operating in similar environmental conditions. Technical efficiency consists in the ability of a DMU to maximize outputs given the same level of inputs and technology or to minimize inputs given a same level of outputs. In this sense, technical efficiency analysis can be oriented towards two different way: increasing output (output-oriented approach) or reducing input (input-oriented approach).

DEA allows the construction of a "best practice" frontier on which the efficient DMUs are located and that are used to measure the relative enefficiency of remaining inefficient units in terms of their distance from the frontier. For each inefficient DMU, DEA identifies the *reference units or reference set* by projecting it radially onto the efficient frontier. Thus, the reference set is used to benchmark these inefficiencies. When inefficient DMU is projected onto the frontier, its input/output are improved and, then, it can achieve its target values becoming efficient (Joro and Korhonen, 2015; Ozcan et al., 2014).

The most popular DEA approaches in scientific literature are the CCR (Charnes, Cooper, and Rhodes) model by Charnes et al. (1978) under the assumption of constant returns to scale (CRS) and, the BCC (Banker, Charnes, and Cooper) model by Banker et al. (1984) where variable returns to scale (VRS) are assumed. Constant returns to scale indicate that the firm is able to scale the inputs and outputs linearly without increasing or decreasing efficiency. Conversely, if a proportional increase in all the inputs results in a more than proportional increase in the single output, increasing returns to scale (IRS) occur; if it results in a less than proportional increase in the output, decreasing returns to scale (DRS) follow. The efficient DMUs are considered as having constant returns to scale.

The CRS model permits to estimate the overall technical efficiency (TE) of a DMU. TE efficiency, which takes no account of the scale effect, encompasses technical efficiency and scale efficiency. The former describes the efficiency in converting inputs to outputs; the latter identifies the productive scale size of a DMU and recognizes that economy of scale cannot be attained at all scales of production. The VRS model measures the pure technical efficiency (PTE) because it takes into account the variation of efficiency with respect to the scale of operation. The CRS/VRS ratio calculate the scale efficiency (SE). The CRS efficiency of a DMU is always less than or equal to the pure technical (VRS) efficiency. If a DMU is fully efficient in both the CCR and BCC scores, it is operating in the most productive scale size (Cooper et al., 2007; Ramanathan, 2003). A complete theoretical background of the DEA model can be found in Cooper et al. (2006, 2007, 2011).

Technical efficiency in farming and the identification of its sources have received considerable attention by the scientific community as shown by Bravo-

Ureta et al. (2007), who performed a meta-regression analysis including 167 technical efficiency studies at the firm level. Also, Liu et al. (2013) performed a literature survey on DEA applications, showing that agriculture and farm area was among the top-five industries addressed with a total number of papers equal to 258 from 1978 through August 2010. Recently, Emrouznejad and Yang (2018), who carried out a survey of the first 40 years of DEA-related articles in the literature from 1978 to 2016, revealed an exponential growth in the number of DEA applications since the seminal work of CCR in 1978. In this analysis, the agro-food sector was among the top 5 application fields of DEA with the greatest numbers of journal articles in 2015 and 2016.

Several researchers have used DEA for efficiency estimation in crop production. Among these, Banaeian et al. (2011) examined the technical and scale efficiency of Iranian greenhouse strawberry production by applying the input-oriented DEA technique. In another study by Mohammadi et al. (2011), the input-oriented DEA approach was employed to investigate the technical, pure technical and scale efficiency of kiwifruit production in Mazandaran province of Iran. Mousavi-Avval et al. (2012) used the DEA technique to evaluate the technical efficiency and identify the wasteful uses of the energy of barberry production in Iran. Mardani and Salarpour (2015) applied DEA to rank the technical efficiency of potato production in 23 Iranian provinces. Applications of DEA-Tobit two-step method have been found for rice farms: Dhungana et al. (2004) measured the economic inefficiency of Nepalese rice farms by employing the DEA technique to model efficiencies as an explicit function of discretionary variables, and a Tobit regression framework to explain variations in measured inefficiencies, while Boubacar et al. (2016) applied DEA models to estimate technical, pure technical and scale efficiency of rice farms in southwest of Niger, and Tobit regression to identify factors affecting their technical efficiency. With respect to the citrus cultivation, Beltrán-Esteve and Reig-Martínez (2014) compared the relative efficiency of organic and conventional citriculture systems in Spain in relation to a metafrontier that envelops both technologies and they analyzed the efficiency of each system through benchmarking process. Clemente et al. (2015) applied the output-oriented DEA approach in order to assess the technical efficiency of citrus producing properties in Brazil and he used an econometric approach to establish technical efficiency determinants. Focusing on the grape and wine sectors, Khoshroo et al. (2013) used a two-stage methodology, i.e. input-oriented DEA method and Tobit regression, to identify the inefficiencies and their sources in Iranian grape farmers. Vidal et al. (2013) examined the efficiency of Spanish Designations of origin (Dos) in the wine sector through a joint use of DEA and a new additive based measure known as "bounded adjusted measure". Urso et al. (2018) first investigated the comparative efficiency of wine and grapevine producers in Italy by using DEA model and, subsequently, they identified the determinants of the estimated levels of efficiency through an econometric model (Tobit). Applications of DEA can be found also for animal production sector, for example: Galanopoulos et al. (2006) used an input-oriented DEA model to evaluate the degree of technical and scale efficiency of commercial pig farming in Greece; Lansink and Reinhard (2004) applied DEA to compute input-based measures of technical efficiency of Dutch pig fattening farms; and Theodoridis et al. (2012) estimated the level of relative technical efficiency of Chios sheep farms in Greece by applied output-oriented DEA model.

In the field of olive production, several studies dealing with the computation of technical efficiency by employed DEA models. In the work by Amores and Contreras (2009), the DEA techniques were used to examine the economic efficiency of olive-growing farms in Andalusia and provide information for a better assignment of European agricultural subsidies. The results showed that the assignment of subsidies should be made in terms of Farm Efficiency results since the efficiency of farms would be under-estimated by an overall measurement (Overall Efficiency). Moreover, the results indicated that efficiency is positively related to the size of the farm and, then, large farms are more likely to improve their techniques. Artukoglu et al. (2010) compared the technical efficiency of organic and conventional olive farms in Turkey by using both input and output oriented DEA approaches. Their main finding was that the technical efficiency of conventional olive oil farms is lower than that of organic farms. Also, the Authors observed that the inefficiency is caused by the fact that the farms do not use minimum input or do not raise the maximum output from the actual inputs. In another study by Aparicio et al. (2016), a Luenberger-type indicator based on a specific weighted additive model in DEA was used to estimate and decompose productivity change for Protected Designations of Origin (PDOs) in the Spanish virgin olive oil sector. According to their results, the most productive PDOs were

those with an important number of oil mills and packaging/marketing companies. Furthermore, their findings revealed that productivity changes were mostly the consequence of downwards and upwards of the frontier of the technology over time. The Authors suggested that these changes were explained, to a certain extent, by the evolution of the economic crisis. Jurado et al. (2017) employed the DEA method to analyze the level of economic efficiency of organic olive oil producers in Andalusia. In addition, a second DEA stage using quality comparative analysis was applied to obtained levels of efficiency. They found that only a very small number of organizations were efficient in terms of economic profitability. Moreover, the Authors observed that the commitment to online sales, the commitment to web tools, the academic training of the leading manager, exports and the size of the organization were clear determinants of the most efficient organizations.

## Materials and methods

### Experimental design

The data-set used in this study was collected from 40 olive farmers from the area of "Gioia Tauro Plain", located on the northern Tyrrhenian coast of Reggio Calabria province in Calabria (South Italy). This area was chosen as a representative of the Calabrian olive production, where olive growing cover 14.5% of the region's olive area (185,915 ha), representing the most widespread agricultural activity (ISTAT, 2010). Local olive-growing systems are mainly characterized by traditional and intensive orchards: the firsts developed mainly in hilly and mountainous areas with low-density planting (around 100 trees $ha^{-1}$), while the second ones are based on moderate slope land and high-density planting (around 400 trees $ha^{-1}$). Although most of these olive farms present limiting factors to quality of olive production, mainly due to low technological innovation degree in both olive cultivation and olive oil processing, the current tendency among local entrepreneurs is to adopt innovative and efficient management practices that could entail a more competitive position in the market. For sampling, a technique of non-probability sampling with reasoned choice and a stratified allocation was used. So, a sample of 40 olive farms was found and equally distributed between traditional and intensive olive growing systems (i.e., twenty farms for each cultivation system). For gathering the data, face-to-face survey method was conducted. The sample is mainly characterized by family farms with an average size from 4 to 13 ha, located in hilly areas. These farm units were chosen for their representativeness at the regional level.

### DEA model implementation

This study aims at evaluating the performance of a farm by comparing it with the best managerial practices observed on the Pareto-efficient frontier. Specifically, with the purpose to evaluate the TE, PTE, and SE of olive farms examined, the input-oriented CRS and VRS models were applied. The choice to use both models was due to our interest in determining the returns to scale of the farms under study and estimating their scale efficiency. Furthermore, the choice of input-oriented approach finds its meaning in the limited inputs characterizing the agricultural sector (Toma et al., 2015), as well as in the major ability of producers to control inputs rather than output levels (Banaeian et al., 2011; Jiao et al., 2015). Therefore, it may be plausible to state that an input-oriented model is more appropriate to quantify the excess use of inputs during the production processes and to identify inputs optimization strategies also to support agriculturally sustainable pathways.

The following CRS DEA model (Cooper et al., 2011) was used to measure TE of olive farms under study:

$$\min \theta - \varepsilon \left( \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \quad (1)$$

subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io} \qquad i = 1, 2, ..., m;$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro} \qquad r = 1, 2, ..., s;$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \forall i, j, r$$

where $n$ is the number of DMUs to be evaluated; each DMU consumes $m$ inputs to produce s outputs; specifically, a DMUj consumes $x_{ij}$ of input $i$ and produces $y_{rj}$ of output $r$; $\lambda_j$ are the weights assigned by the linear program; $s_i$ and $s_r$ are the input and output slacks (i.e., the additional improvement, decrease in inputs and/or increase in outputs, needed for a DMU to become efficient); $\varepsilon$ is a non-Archimedean element defined to be smaller than any positive real number. The value of θ obtained will determine the technical efficiency score of each DMU: if $\theta = 1$, then DMU is efficient (frontier point); if $\theta < 1$ DMU is inefficient and

must decrease its inputs level. In order to determine PTE scores, a VRS DEA model is applied by adding the constraint $\sum_{j=1}^{n} \lambda_j = 1$ to the equation (1).

Excel 2013 spreadsheet and DEA-Solver-LV were used for data processing. DEA program has been run separately for each olive system considered.

### Input and output description

The input variables used in the efficiency analysis are the following: (1) total olive area (ha), (2) fixed capital costs (€ ha$^{-1}$), (3) variable capital costs (€ ha$^{-1}$) (4) human labour (h ha$^{-1}$). As the output variable, gross saleable production (€ ha-1) was selected. The total olive area included only owned land. Within the fixed capital costs, machinery and land investments ownership costs (i.e. depreciations, insurance, repairs, and maintenance) were included. Variable capital costs (i.e. fertilizers, pesticides, herbicides, and fuel and oil consumption used in the olive production process) were calculated according to the market pricing referred to 2016. Family labour needed during agricultural operations was measured in terms of opportunity cost and was equalized to the employment of casual workers (Stillitano et al., 2016, 2017). Finally, the gross saleable production was evaluated by multiplying the average olive production by its market price referred to the last harvesting season (2015-2016) and by excluding EU Agricultural Policy subsidies. The olive average selling price was provided by the Istituto di Servizi per il Mercato Agricolo Alimentare (ISMEA) and referred to the 2015/2016 harvesting season. To evaluate farm efficiency excluding subsidy contribution, no subsidy was added in farm gross saleable production. Subsequently, the amounts of subsidy were added to estimate the impact on farm efficiency. The variables (inputs and outputs) selected in this study were in line with those utilized in similar studies already mentioned in the introduction section.

Descriptive statistics for inputs and outputs used in each olive system under study are displayed in Table 1. It is worth noting the low variability in the size of all the variables because of the homogeneous features of the sample.

## Results and discussion

In Table 2 the results achieved by the implementation of input-oriented CCR and BCC DEA models are reported. The findings revealed that average technical efficiency (TE score), under CRS assumption and excluding EU subsidies, of intensive olive farms (0.760) was greater than of traditional ones (0.728). This means that, on average, the farms could reduce their inputs, and, then, reducing production costs, by 24% and 27.2%, respectively, providing the same level of production. According to Mohammadi et al. (2011), the variation in the technical efficiency of farmers could be caused by the incorrect application of the appropriate production techniques.

Under VRS assumption and excluding subsidies, the traditional farms had higher PTE score (0.992) compared to intensive farms (0.989), although there are no significant differences. It is worth noting the greater pure technical efficiency than overall technical efficiency in both farm systems. This is highlighted by a low level of average

| | Olive area harvested | Fixed capital costs | Variable capital costs | Human labour | Gross Saleable Production | |
|---|---|---|---|---|---|---|
| | | | | | Without subsidies | With subsidies |
| | (ha) | (€ ha$^{-1}$) | (€ ha$^{-1}$) | (h ha$^{-1}$) | (€ ha$^{-1}$) | |
| **Intensive Farms** | | | | | | |
| Max | 15 | 2,073.10 | 1,994.30 | 146.50 | 9,900.00 | 11,800.00 |
| Min | 5 | 809.20 | 1,043.80 | 102.50 | 4,320.00 | 6,220.00 |
| Average | 8.8 | 1,334.16 | 1,387.33 | 113.36 | 6,568.00 | 8,468.00 |
| St Dev | 2.32 | 324.54 | 248.58 | 9.44 | 1,592.04 | 1,592.04 |
| **Traditional Farms** | | | | | | |
| Max | 13 | 3,208.54 | 1,862.96 | 264.50 | 4,940.00 | 6,840.00 |
| Min | 4 | 1,131.73 | 1,097.50 | 235.50 | 2,040.00 | 3,940.00 |
| Average | 7.75 | 1,882.38 | 1,344.18 | 257.18 | 3,018.80 | 4,931.30 |
| St Dev | 2.26 | 588.74 | 246.79 | 9.12 | 731.31 | 724.16 |

Source: own processing

Table 1: Descriptive statistics of the inputs and outputs used in DEA model.

| DMU | Intensive Farms | | | | | | |
|---|---|---|---|---|---|---|---|
| | TE score | PTE score | SE score | TE score | PTE score | SE score | RTS |
| | Without subsidies | | | With subsidies | | | |
| 1 | 0.6493 | 0.9896 | 0.6561 | 0.7291 | 0.9896 | 0.7368 | IRS |
| 2 | 0.7209 | 1 | 0.7209 | 0.7772 | 1 | 0.7772 | IRS |
| 3 | 0.7067 | 0.9876 | 0.7156 | 0.7636 | 0.9876 | 0.7732 | IRS |
| 4 | 0.7332 | 1 | 0.7332 | 0.7955 | 1 | 0.7955 | IRS |
| 5 | 0.725 | 0.9888 | 0.7332 | 0.7834 | 0.9888 | 0.7923 | IRS |
| 6 | 0.8314 | 0.9757 | 0.8521 | 0.867 | 0.9757 | 0.8886 | IRS |
| 7 | 0.9315 | 1 | 0.9315 | 0.9502 | 1 | 0.9502 | IRS |
| 8 | 0.7049 | 1 | 0.7049 | 0.7768 | 1 | 0.7768 | IRS |
| 9 | 0.8163 | 1 | 0.8163 | 0.8855 | 1 | 0.8855 | IRS |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | CRS |
| 11 | 0.5788 | 0.9856 | 0.5873 | 0.675 | 0.9856 | 0.6849 | IRS |
| 12 | 0.6926 | 1 | 0.6926 | 0.8019 | 1 | 0.8019 | IRS |
| 13 | 0.5844 | 0.9317 | 0.6272 | 0.6553 | 0.9317 | 0.7033 | IRS |
| 14 | 0.7481 | 1 | 0.7481 | 0.8934 | 1 | 0.8934 | IRS |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | CRS |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | CRS |
| 17 | 0.6349 | 0.973 | 0.6525 | 0.6981 | 0.973 | 0.7175 | IRS |
| 18 | 0.6548 | 0.9565 | 0.6846 | 0.7065 | 0.9565 | 0.7386 | IRS |
| 19 | 0.8312 | 1 | 0.8312 | 0.9623 | 1 | 0.9623 | IRS |
| 20 | 0.6604 | 1 | 0.6604 | 0.7352 | 1 | 0.7352 | IRS |
| Average | 0.76 | 0.989 | 0.767 | 0.823 | 0.989 | 0.831 | |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | |
| Min | 0.579 | 0.932 | 0.587 | 0.655 | 0.932 | 0.685 | |
| St Dev | 0.134 | 0.018 | 0.129 | 0.114 | 0.018 | 0.107 | |
| DMU | Traditional Farms | | | | | | |
| | TE score | PTE score | SE score | TE score | PTE score | SE score | RTS |
| | Without subsidies | | | With subsidies | | | |
| 1 | 0.6245 | 0.9844 | 0.6344 | 0.7432 | 0.9844 | 0.755 | IRS |
| 2 | 0.7266 | 0.9896 | 0.7342 | 0.817 | 0.9896 | 0.826 | IRS |
| 3 | 0.8361 | 1 | 0.8361 | 0.8979 | 1 | 0.898 | IRS |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | CRS |
| 5 | 0.854 | 1 | 0.854 | 0.9181 | 1 | 0.918 | IRS |
| 6 | 0.6976 | 1 | 0.6976 | 0.8043 | 1 | 0.804 | IRS |
| 7 | 0.8724 | 0.9993 | 0.873 | 0.9275 | 0.9993 | 0.928 | IRS |
| 8 | 0.8513 | 0.9936 | 0.8568 | 0.8975 | 0.9936 | 0.903 | IRS |
| 9 | 0.6165 | 1 | 0.6165 | 0.7586 | 1 | 0.759 | IRS |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | CRS |
| 11 | 0.583 | 1 | 0.583 | 0.7544 | 1 | 0.754 | IRS |
| 12 | 0.4818 | 0.9403 | 0.5124 | 0.6257 | 0.9403 | 0.665 | IRS |
| 13 | 0.6559 | 1 | 0.6559 | 0.9123 | 1 | 0.912 | IRS |
| 14 | 0.7351 | 0.9774 | 0.7521 | 0.847 | 0.9774 | 0.867 | IRS |
| 15 | 0.5352 | 0.9938 | 0.5385 | 0.6725 | 0.9938 | 0.677 | IRS |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | CRS |
| 17 | 0.682 | 0.9796 | 0.6962 | 0.7723 | 0.9796 | 0.788 | IRS |
| 18 | 0.4951 | 0.9818 | 0.5043 | 0.6551 | 0.9818 | 0.667 | IRS |
| 19 | 0.6878 | 1 | 0.6878 | 0.8268 | 1 | 0.827 | IRS |
| 20 | 0.6194 | 1 | 0.6194 | 0.864 | 1 | 0.864 | IRS |
| Average | 0.728 | 0.992 | 0.733 | 0.835 | 0.992 | 0.841 | |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | |
| Min | 0.482 | 0.94 | 0.504 | 0.626 | 0.94 | 0.665 | |
| St Dev | 0.163 | 0.015 | 0.159 | 0.113 | 0.015 | 0.104 | |

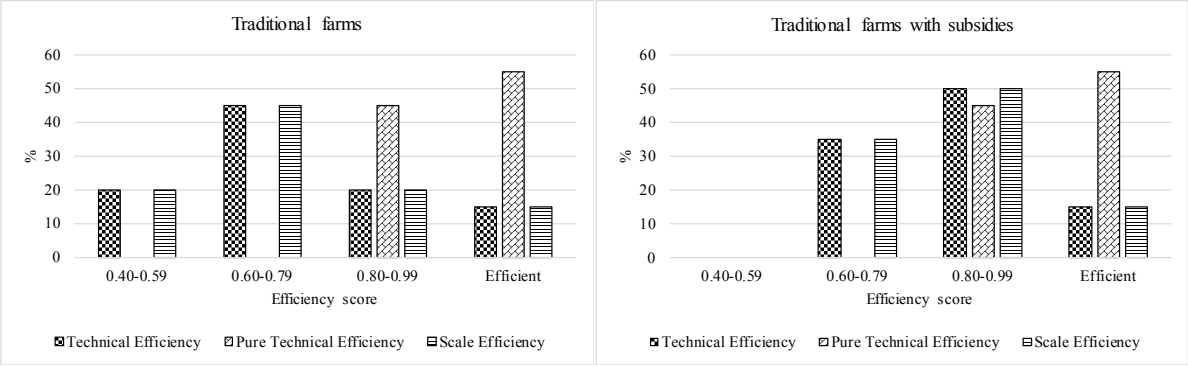
Source: own processing

Table 2: DEA scores and returns to scale for the farms under study.

scale efficiency which was far to the optimal size, with a value of approximately 0.733 and 0.767 in traditional and intensive systems, respectively. This results in a production scale that is not generally optimal in olive cultivation, as observed by Idda et al. (2004) who investigated technical and economic efficiency of Sardinian olive farms (Italy) by applied DEA technique. Also, Mousavi-Avval et al. (2012) confirm that the high difference between TE and PTE scores designates disadvantageous conditions of scale size.

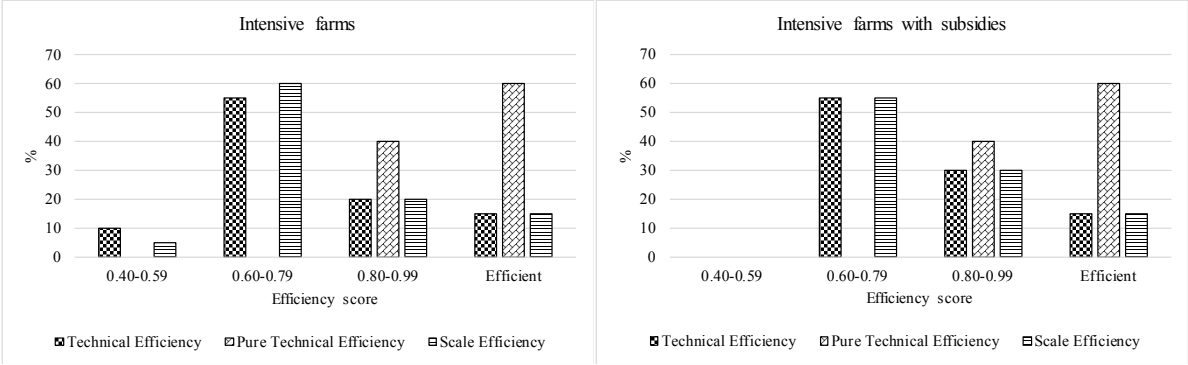
The outcomes achieved so far, can be better explained by analyzing the efficiency score distribution as illustrated in Fig. 1 and 2. By applying the CRS model (excluding subsidies), the most of the intensive olive farms, equal to 55% of total, had technical efficiency between 0.60 and 0.79; 10% had technical efficiency of less than 0.60 and 20% of farms were close to the DEA frontier, showing technical efficiency score between 0.80 and 0.99. Only 15% of farms were full technical efficient, indicating rational management of existing technology and no improvement on input use. When the VRS model is carried out, 60% of the intensive farms exhibited the full efficiency score and no farm operated below 0.80 of the efficiency level. This wide variation between TE and PTE score confirms that the majority of farms in the samples don't achieve the optimal scale size. Also analyzing the Return to Scale (RTS) it occurs that 17 intensive farms operated under increasing returns to scale and only three exhibited constant returns to scale (see Table 2). These findings suggest that small farm size of the olive farms under study leads to a failure to achieve an optimal production scale.

As to the traditional olive farms, under CRS assumption the analysis showed that 15% of farmers had a technical efficiency of unity; 20% operated between 0.80 and 0.99 of the efficiency level and 65% below 0.80. Under the VRS model, 55% of traditional farms exhibited a pure technical efficiency score of one and the remaining farms (45%) had a score between 0.80 and 0.99. The return to scale analysis revealed that only three DMUs operated at the most productive scale size under CRS model and showing scale efficiency of one. The remaining farms revealed increasing returns to scale, indicating that technological change are necessary for changes in yield, as debated by Banaeian et al. (2011), as well as the need to increase their size in order to reach cost savings, as argued by Jiao et al. (2015).




Source: own processing

Figure 1: Efficiency score distribution for the traditional farms under study




Source: own processing

Figure 2: Efficiency score distribution for the intensive farms under study.

When EU subsidies are included in the output, improvements in terms of overall technical efficiency and scale efficiency are identified. For intensive farms, the average TE score (0.823) and SE score (0.831) were higher than that obtained by excluding subsidies (0.760 and 0.767, respectively). In terms of efficiency score distribution, an increase in farms' number of the 0.80 and 0.99 range was achieved. Also for traditional farmers, a higher TE score (0.835 vs. 0.728) and SE score (0.841 vs. 0.733) were found. However, the addition of subsidies did not affect the farms' percentage which reaches the all-out efficiency, endorsing the results obtained by Oxouzi et al. (2012). As debated by Galanopoulos et al. (2006), DEA model provides valuable information about managerial evaluation of all technically inefficient DMUs, allowing to identify and compute the sources of inefficiency. This is in turn enables a DMU to achieve the potential improvement of their productive performance. As an example, in Table 3 the evaluation of the efficient input use levels of two inefficient DMU, i.e. DMU17 for intensive farms and DMU18 for traditional ones, is reported. The technical efficiency (TE) of DMU17 was found to be 0.635 suggesting that a 36.5% decrease of its inputs is possible without decreasing the level of gross saleable production. Thus, by reducing its actual input (second row of Table 3) DMU17 is projected radially onto the best practice frontier. As this olive farm still cannot reach the efficiency frontier, slack adjustments are needed to push the DMU to the frontier (Ozcan, 2014). By adding these further input reductions and, especially, reducing variable capital costs and human labour by another 9.2% and 5.9%, respectively, DMU17 reach its efficiency target (at frontier) becoming Pareto-efficient (fifth row of Table 3).

DMU18 with a TE score of 0.495 could reduce its input levels proportionally by 50.5%, providing actual production level. For this olive farm, only slack adjustments in human labour (-13.58 h $ha^{-1}$) are needed in order to become a Pareto optimal point.

As reported by Joro and Korhonen (2015), DEA is a benchmarking technique since inefficient DMUs are benchmarked against the efficient frontier. For each inefficient unit, efficiency analysis in DEA identify the corresponding peers, named reference set or peer group, within the efficient existing units. If an inefficient DMU corresponds more than one peer, then it is necessary to identify for each peer its contribution (i.e., peer weight or lambda) to the computation of score (Cooper et al., 2011). In Table 4, for the inefficient DMUs 18 and 12, the corresponding peer group, as well as efficiency targets for inputs, are identified. For DMU18 the peers and their corresponding weights were 2(0.31), 10(0.063) and 16(0.628). By multiplying the lambda value by the input level of the respective efficient DMU, the input targets were calculated. The results revealed that the most influential benchmark was DMU16, representing the 62.8% of the ideal peer for DMU18. For DMU12, the benchmark DMUs were 10(0.7), 11(0.242) and 13(0.058). It can be seen that DMU10 was the best reference unit, with 70% of the ideal peer. As argued by Hosseinzadeh-Bandbafha et al. (2018), the benchmarking approach allows inefficient farms

| **Intensive Farms** | | | | |
|---|---|---|---|---|
| **DMU17** | Olive area harvested | Fixed capital costs | Variable capital costs | Human labour |
| | (ha) | (€ $ha^{-1}$) | (€ $ha^{-1}$) | (h $ha^{-1}$) |
| Actual values | 9.00 | 1,206.60 | 1,525.73 | 111.00 |
| Radial movement | -3.29 | -440.53 | -557.05 | -40.53 |
| Projected point | 5.71 | 766.07 | 968.69 | 70.47 |
| Slack adjustment | 0.00 | 0.00 | -140.56 | -6.58 |
| Pareto-efficient point | 5.71 | 766.07 | 828.13 | 63.89 |
| **Traditional Farms** | | | | |
| **DMU18** | | | | |
| Actual values | 9.00 | 1,510.07 | 1,516.53 | 255.50 |
| Radial movement | -4.54 | -762.44 | -765.70 | -129.00 |
| Projected point | 4.46 | 747.64 | 750.84 | 126.50 |
| Slack adjustment | 0.00 | 0.00 | 0.00 | -13.58 |
| Pareto-efficient point | 4.46 | 747.64 | 750.84 | 112.91 |

Source: own processing

Table 3: Actual and efficient input use levels of DMU17 and DMU18.

| | Intensive Farms | | | | |
|---|---|---|---|---|---|
| | **DMU18** | Input use levels of peers | | | Input Targets |
| | | DMU2 | DMU10 | DMU16 | |
| ***Lambda*** | | *0.31* | *0.063* | *0.628* | |
| ***Input*** | | | | | |
| Olive area harvested | 10 | 9 | 8 | 10 | *9.57* |
| Fixed capital costs | 1,223.588 | 1,136.23 | 1,306.19 | 1,173.70 | *1,171.61* |
| Variable capital costs | 1,994.30 | 1,230.63 | 1,369.60 | 1,299.10 | *1,283.62* |
| Human labour | 109.1 | 108.5 | 102.5 | 102.5 | *104.46* |
| ***Output*** | | | | | |
| GPV | 6,600.00 | 6,600.00 | 92,40.00 | 9,900.00 | 6,600.00 |
| | **Traditional Farms** | | | | |
| | **DMU12** | Input use levels of peers | | | Input Targets |
| | | DMU10 | DMU11 | DMU13 | |
| **Lambda** | | *0.7* | *0.242* | *0.058* | |
| **Input** | | | | | |
| Olive area harvested | 6 | 6 | 5 | 4 | *5.64* |
| Fixed capital costs | 2,442.06 | 2,102.64 | 2,638.45 | 3,208.54 | *2,296.45* |
| Variable capital costs | 1,530.90 | 1,239.40 | 1,640.20 | 1,553.50 | *1,354.61* |
| Human labour | 260 | 237.5 | 261 | 260 | *244.49* |
| ***Output*** | | | | | |
| GPV | 2,380.00 | 4,940.00 | 2,400.00 | 2,160.00 | 2,380.00 |

Source: own processing

Table 4: Input Targets of DMU18 and DMU12 referred to their peers (based on BCC model).

to identify the reasons for inefficiency and find the best practices for improving production processes.

As mentioned before, several studies in scientific literature dealing with the efficiency assessment of olive farming, but most of these do not compare traditional and intensive olive-growing systems. The only ones to do it are Gómez-Limón et al. (2012) that use a different empirical (and then not comparable with the present) DEA approach and pressure distance functions to assess the eco-efficiency of Andalusian traditional and irrigated intensive groves, and Niavis et al. (2018), which assess technical efficiency levels of extensive olive tree cultivation in Greek by implementing DEA input-oriented model, but without extend the sample to intensive systems.

## Conclusion

This paper based on a sample survey of local farms assessed the technical efficiency of intensive and traditional olive farms in Southern Italy by employing input-oriented CRS and VRS models. The findings showed that intensive farms achieve a greater technical efficiency, under CRS assumption and excluding EU subsidies than traditional ones, while under VRS assumption their efficiency is lower, although no significant differences have emerged. However, technical inefficiencies among all farms, regarding the use of inputs, were found and, likely caused by the incorrect application of the appropriate production techniques. The variable capital costs and the use of human labour, especially in traditional farms, were the worst managed input in the sample examined. Thus, these inefficiencies need to be correct in order to increase farms' performance and, therefore, their profitability. A higher level of technical efficiency through a potential reduction in input use would bring a decrease of average production cost and improve the competitiveness of farms.

The results also showed the greater pure technical efficiency than overall technical efficiency in both farm systems, suggesting disadvantageous conditions of scale size. This wide variation between TE and PTE score endorse that the majority of farms in the samples don't achieve the optimal scale size. Likewise, return to scale analysis revealed that only a very small number of farms may be considered full efficient, while the remaining ones operated under increasing returns to scale, suggesting that small farm size

leads to a failure to achieve an optimal production scale. When EU subsidies were included in the analysis, findings highlighted improvements in terms of overall technical efficiency and scale efficiency, though this did not affect the farms' percentage which reaches the all-out efficiency.

The choice to use an input-oriented DEA model was due to the great potential of this approach to provide useful information about the excess use of inputs during the production processes. A better understanding of the resource use can offer evidence supporting inputs optimization strategies not only for cost savings but also for contributing to a more sustainable olive production. Although this study is the first step to a more extensive research work in which a more structured model will be implemented, it can contribute to expanding the knowledge of olive growing contexts in terms of production efficiency. However, some limitations of the research need to be furtherly investigated in order to guarantee a more adequate assessment of the farm's efficiency. Two concerns, in particular, are those to extend the data sample and justifying the efficiencies differences in the input use.

*Corresponding authors*
*Anna Irene De Luca,*
*Agraria Department, Mediterranea University of Reggio Calabria*
*Feo di Vito, 89122 Reggio Calabria, Italy*
*Email: anna.deluca@unirc.it*

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# Economic Aspect of Growing Pigs with Respect to Sex and Immunocastration

Michal Šprysl, Eva Kluzáková, Jaroslav Čítek, Roman Stupka, Kateřina Zadinová

Department of Animal Science, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Czech Republic

## Abstract

The minimization of boar taint according to welfare appears to be immunocastration. For this purpose a test was carried out for a total of 80 piglets in the growing stage. Animals were housed by sex, respectively 20 boars, 20 immunocasatrates, 20 barrows and 20 gilts. Animals were fed ad libitum, and the production variables were observed with an emphasis on the overall economy of their production. Intergroup differences were tested by variance analyse and the test groups of growing pigs were evaluated using a profit formula.

It was shown that animals in the growing period had excellent parameters of the fattening (in the 65 days, the total gain was 19 kg, with daily feed intake below 0.7 kg, feed conversion ratio 1.2 kg and average daily gain 540-560 g). The effect of sex, or the castration of young pigs on the economy of the pig production in growing period is proved to be insignificant. This hypothesis was confirmed.

## Keywords

Pig, grower period, fattening capacity test, sex, immunocastration, profit formula, economy.

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## Introduction

Nowadays the emphasis is put on the food production. Problems of dioxins, GMOs, general protein deficit, antibiotics, use of animal proteins in animal feed, mycotoxins, BSE, etc. have been and are being solved. For pig production, this means, on the one hand, constant improvements their performance by classical zootechnical organizational tools, ie hybridization and selection (Tholen et al., 1996; Edwards, 2005; Ngapo, Gariepy, 2008; Babovic, 2011). On the other hand, an implementing a new technologies to make more efficient and improve living conditions. Technology innovations take place in all categories of pigs, some of them raise a debate on ethics and welfare. At present, within welfare of livestock, it is using the influence of different sexes on their production performance. In this case, it is a solution to the problem of eliminating castration of the boar piglets (Dekkers and Hospital, 2002; Krieter, 2002; Prunier et al., 2006; Fredriksen et al., 2011; Maiorano et al., 2012; Velechovská, 2012; etc.). Measure eliminates the occurrence of "boar taint" in pork meat and fat. This is unacceptable for consumers (Engelsma et al., 2007). Admissible levels of both are for androstenone > 1ppm, skatole > 0.25 ppm (Xue et al., 1996; Whittington et al., 2011). The problem is still realized by surgical castration without anesthesia (Edwards 2008; Fredriksen et al., 2008; Boneau et al., 2009; Batorek et al., 2012). The above mentioned thema solve and realize in the EU the European Food Authority, the trade chains and the relevant legislation (Bernardy, 2010). This measure is tolerated by the end of 2018.

The recommended option of eliminating boar taint at minimal economic loss is immunostaining. It is a vaccine stimulating the production of specific gonadotropin-releasing hormone (GnRH) antibodies suppressing testicular function (Zamaratskaia et al., 2004). Its application is recommended at 8 weeks of age with subsequent revaccination after 4 weeks. The thesis deals with the extent to which the sex and immunocastration of pigs influences their production performance in the growing period, respectively their impact on the production economy.

The objective of the test in the growing period fattening (GP), (7-30 kg), was to verify

the influence of sex, respectively the method of castration (boars-♂, immunocastrates-ik, barrows-⚥, gilts-♀) on its parameters of fattening capacity with emphasis to the overall economy of their production.

## Materials and methods

### 1. Hypothesis

The first vaccine of boar has no significant effect on the production level performance and effectiveness compared to other sex categories in pigs.

### 2. Animals

The research test was conducted in March-April 2017. A total of 80 pigs crossbred population D x (LWxL) were housed in the Experimental Test Station of the Czech University of Life Sciences Prague and divided according to sex. There were 20 boars (♂), 20 immunocastrates (ik), 20 barrows (⚥) and 20 gilts (♀). All animals were labeled by electronic ear chips. The growing period of animals lasted 36 days (from weaning to 66 days of age) of their age with a live weight of 9-30 kg.

### 3. Housing, microclimate

In the growing period, the animals were housed in groups of 20 by sex (♂, ik, ⚥, ♀). Microclimate in the test station, respectively temperature, gas concentration, relative humidity, were controlled automatically and monitored every hour to meet the requirements of the animals of the given age (MÖLLER, s.r.o., AGE s.r.o.).

### 4. Castration

In order to obtain the immunocastrates, the 2nd group of boars was chemical castrated the 5th day after penned. This group of animals received Improvac®, which contained 200 μg of GnRH protein conjugate/ml in an aqueous adjuvant solution.

### 5. Nutrition, feeding

They were fed ad libitum with complete feed mixtures (CFM) the composition of which were continually adjusted with respect to the age and weight of the pigs. In the growing period, the CFM-starter (creap and weaning by De Hoist, The Netherlands), ČOS and $A_1$ were used (Table 1, Table 2).

### 6. Variables

The purpose was to obtain a longitudinal size-age type dataset, where all the animals have all the data from the same age in the test. Due to the technological equipment of the test station, the data characterizing the growing stage in pigs were obtained as an average.

For data describing the growth of the monitored animals, at each stage of each animal we regularly weighed at the same time at weekly intervals, at the same time, to obtain a live weight in kg (LW). In addition, the animal´s daily feed intake in kg (DFI), feed conversion in kg (FCR) and average daily gain in g (ADG) were monitored as well.

| CFM | Feeding time (day) | Price of 1 kg CFM (CZK/EUR) |
|---|---|---|
| Creap | 31-38 | 17.85/0.66 |
| Weaning | 38-45 | 14.95/0.55 |
| ČOS | 45-59 | 9.85/0.37 |
| A1 | 59-66 | 7.09/0.26 |

Note: CFM prices and food components relate to January-March 2017
Source: Pig Breeding Test Station CULS Prague

Table 1: Feeding scheme for pigs in the growing period.

| ČOS | % | CZK/kg (EUR/kg) | CZK/EUR | A1 | % | CZK/kg(EUR/kg) | CZK/EUR |
|---|---|---|---|---|---|---|---|
| wheat | 40 | 5.5 (0.20) | 2.2/0.08 | wheat | 44 | 5.5 (0.20) | 2.42/0.09 |
| barely | 29 | 5 (0.19) | 1.45/0.05 | barely | 35.3 | 5 (0.19) | 1.76/0.07 |
| soya | 20 | 11.5 (0.43) | 2.3/0.09 | soya | 17.7 | 36 (1.33) | 2.04/0.08 |
| sugi | 10 | 36 (1.33) | 3.6/0.13 | sugi | . | 36 (1.33) | . |
| oil | 1 | 30 (1.11) | 0.3/0.01 | oil | . | 30 (1.11) | . |
| aminogold | . | 29 (1.07) | . | aminogold | 3 | 29 (1.07) | 0.87/0.03 |
| Total | 9.85 (0.37) | | | Total | 7.09 (0.26) | | |

Note: CFM prices and food components relate to January-March 2017
Source: Pig Breeding Test Station CULS Prague

Table 2: Composition and price of used CFM.

### 7. Processing results

All partial data were processed by common mathematical and statistical methods (SAS Inst. Inc., Cary, NC), expressed with respect to sex in tables. Differences between groups were tested by variance analysis (Tuky test).

When determining the yields of subpopulations in pigs, it is necessary to assess their performance fundamentally complex (Sellier, 1976). It is the expression of the profitability of the test groups using the profit formula, which is determined by the profit equation used in the production economy and the econometrics in finding the variable cost corresponding to the maximum profit that can be achieved.

The test was therefore evaluated economically with regard to test groups of pigs using a profitable function (Poděbradský, 1980; Župka, 1992) of the following shape:

$$Zc = \{c_1 y_1 - [n_1 x_1 + n_2 x_2 + (n_3 : x_3) + A]\} \times r,$$

where

$$r = 365 : (x_2 + k);\ x_2 = (\acute{y}_1 - \acute{y}_0) : \acute{}x_2;\ Zc = Z \times r,$$

where:

$Zc$ - profit per capita unit per year,

$Z$ - profit per slaughter pig,

$r$ - the rate of pig turnover per year,

$c_1$ - the average realization price per unit of half-carcasses production,

$n_1$ - cost (price) per CFM unit,

$n_2$ - fixed costs for 1feeding day of fattening pig,

$n_3$ - costs per 1 sow and litter without the costs of nursing and feeding of piglets,

$A$ - costs of nursing and feeding of piglets,

$y_1$ - carcasses weight,

$\acute{y}_1$ - live weight of slaughter pig,

$\acute{y}_0$ - live weight of grower when start of fattening,

$x_1$ - amount of CFM consumed,

$x_2$ - fattening time,

$\acute{}x_2$ - average daily weight gain from start of growing to removal,

$x_3$ - number of reared piglets per sow and litter,

$k$ - days between 2 turns.

In our case, this is reduced only to indicators that measure the running test costs, ie the cost of purchasing weaners and feed costs.

## Results and discussion

Evaluation of the fattening capacity of tested pigs by sex in the growing period is showed in Tables 3-4.

At the beginning of the growing period (at 31 days), the highest average starting weight had boars (9.4 kg) and barrows (9.1 kg). Followed by immunocastrates (9 kg) and the lightest live weight were in gilts (8.9 kg). Because the differences in weights were insignificant, other phenotypic values of production performance can be compared to each other.

In the following weeks, the order of precedence was alternated, so at the end of the test, the order f convenience was boars (29.1 kg), immunocastrates (28.4 kg), gilts (28.3 kg) and barrows (28 kg). Concerned of the total gain per grower period (Σ), the order of convenience was 19.7 kg for boars, for gilts and immunocastrates 19.4 kg and barrows 19 kg.

In the daily feed intake (DFI) at the beginning (31 days of age) was the order barrows and boars (0.3 kg/day), then gilts with immunocastrates

| Variable | LW (kg) | | | | | | | | DFI (kg/day) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age (days) | ♂ | | ♀ | | ♂ | | ik | | ♂ | ♀ | ♂ | ik |
| | x | s | x | s | x | S | x | s | x | x | x | x |
| 31 | 9.1 | 1.4 | 8.9 | 0.4 | 9.4 | 1.8 | 9.0 | 0.4 | 0.3 | 0.2 | 0.3 | 0.2 |
| 38 | 11.0 | 1.8 | 9.9 | 3.0 | 10.8 | 1.5 | 11.2 | 3.0 | 0.4 | 0.3 | 0.3 | 0.3 |
| 45 | 12.8 | 2.4 | 13.8 | 1.0 | 13.7 | 2.6 | 16.2 | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 |
| 52 | 18.1 | 4.7 | 18.1 | 1.7 | 18.8 | 2.7 | 18.4 | 3.5 | 0.9 | 0.8 | 0.8 | 0.6 |
| 59 | 21.8 | 6.4 | 23.5 | 2.8 | 23.3 | 3.3 | 23.5 | 2.8 | 0.9 | 1.1 | 1.0 | 1.1 |
| 66 | 28.0 | 7.5 | 28.3 | 3.0 | 29.1 | 3.3 | 28.3 | 3.0 | 1.3 | 1.2 | 1.3 | 1.3 |
| Σ | 19.0 | 7.1 | 19.4 | 2.9 | 19.7 | 2.5 | 19.4 | 2.9 | 0.69 | 0.69 | 0.68 | 0.66 |

Note: Significance: all intergroup differences were statistically insignificant
Source: Pig Breeding Test Station CULS Prague

Table 3: Fattening capacity evaluation with respect to sex of the growing period in pigs (n = 79).

| Variable | FCR (kg CFM/kg gain) | | | | ADG (g) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age (days) | ♂ | ♀ | ♂ | ik | ♂ | | ♀ | | ♂ | | ik | |
| | x | x | x | x | x | s | x | s | x | s | x | s |
| 38 | 1.4 | 2.34 | 1.6 | 1.0 | 273 | 94 | 139 | 449 | 207 | 160 | 317 | 148 |
| 45 | 2.2 | 1.01 | 1.4 | 0.8 | 266 | 240 | 555 | 461 | 417 | 271 | 705 | 187 |
| 52 | 1.2 | 1.36 | 1.1 | 1.9 | 744 | 543 | 613 | 143 | 721 | 165 | 319 | 228 |
| 59 | 1.7 | 1.44 | 1.5 | 1.7 | 540 | 296 | 773 | 184 | 653 | 147 | 640 | 196 |
| 66 | 1.4 | 1.81 | 1.5 | 1.7 | 884 | 232 | 688 | 127 | 817 | 142 | 784 | 119 |
| Σ | 1.28 | 1.25 | 1.21 | 1.20 | 541 | 202 | 554 | 83 | 563 | 70 | 553 | 136 |

Source: Pig Breeding Test Station CULS Prague

Table 4: Fattening capacity evaluation with respect to sex of the growing period in pigs (n = 79).

(0.2 kg). Over the next weeks the DFI of all groups were practically the same. At the end of the growing period, the lowest daily feed intake was in gilts (1.2 kg), the other categories showed this variable 1.3 kg. The order of total daily feed intake is barrows and gilts (0.69 kg), boars (0.68 kg) and immunocastrates (0.66 kg).

As the feed conversion ratio (FCR) is concerned, at the beginning growing period (38 days), the order of convenience was immunocastrates (1 kg), barrows (1.4 kg), boars (1.6 kg), gilts (2.34 kg), however in the next following weeks the order was changed. In terms of economic advantage, the overall average feed conversion ratio for barrows was the worst (1.28 kg), following gilts (1.25 kg), immunocastrates (1.21 kg) and boars (1.20 kg).

When it comes to the growth intensity of the test groups of animals in the test, at the beginning test the highest ADG shows immunocastrates (317 g), barrows (273 g), boars (207 g) and gilts (139 g). At the end of the growing period the order of advantage was barrows (884 g), boars 817 g), immunocastrates (784 g) and gilts (688 g). Regarding the overall order of average growth intensity, the order of the groups were boars (563 g), gilts (554 g), immunocastrates (553 g) and barrows (541 g). However the differences between groups were statistically insignificant.

The following Table 5 evaluates the indicators influencing the economy of pigs in the growing period.

It is clear from the table that the initial body weight of all groups were balanced, they moved in a range of 0.5 kg. This fact is most important for tests, because the body weight/age, significantly affecting other performance indicators. Gilts at 31 days reached the lowest average weight, 8.9 kg. The heaviest were the boars (9.4 kg) who also reached the highest absolute body gain (19.7 kg) at the end of the growing period. The same values (19.4 kg) achieved immunocastraces and gilts, barrows then 19 kg. The initial body weight then affected the price of piglets, ranging from 1 162/43.01 (gilts) to 1 216/45.00 CZK/EUR (boars).

As it was mentioned above, the economic evaluation of the test included only the costs of buying weaner and feed. The facts are documented in Tables 6 and 7.

It is clear that the DFI of the experimental animals in the test without respect to sex was virtually the same (28-29 kg), which was reflected at practically the same feed cost (242-264 /8.96 – 9.77 CZK/EUR) and the average price of 1 kg CFM (8.70 - 9,08/0.32 – 0.34 CZK/EUR).

The lowest cost per 1 piglet, due to low weight, are in gilts (1 162/43.01 CZK/EUR), the highest, due to the highest weight, is for boar (1 216/45.00 CZK/EUR). The purchase price of the immunocastrate was 1 170/43.30 CZK/EUR and the barrow CZK /EUR 1 179/43.63. Adding the cost of a feed then costs per 1 piglet ranging from 1 418/52.48 CZK/EUR (gilts) to 1 472/54.48 CZK/EUR (boars).

By dividing them by the weight of a given group at the end of the test, the cost per 1kg of the test can be determined. However, the differences between groups are small, at an absolute value of 1.85/0.07 CZK/EUR. It can be said that the most expensive kilogram of the animal was for the barrow (51.57/1.91 CZK/EUR), the cheapest for the immunocastrate (49.72/1.84 CZK/EUR). Price of 1 kg of boar, resp. gilt, then 50.58/1.87, respectively 50.11/1.86 CZK/EUR.

As far as the test results are concerned, Hovorka et al. (1983) has already pointed out that the sex or castration, and hence the economy of production, significantly affects production characters in pigs. But this influence starts be

| Variable / sex | ♂ | ♀ | ♂ | Ik |
|---|---|---|---|---|
| Average live weight (LW) at 31 days (kg) | 9.1 | 8.9 | 9.4 | 9.0 |
| Piglet price (130 CZK/kg) / (4.81 EUR/kg) | 1 179 / 43.63 | 1 162 / 43.01 | 1 216 / 45.00 | 1 170 / 43.03 |
| Average live weight (LW) at 66 days (kg) | 28.0 | 28.3 | 29.1 | 28.4 |
| Total body gain (kg) | 19.0 | 19.4 | 19.7 | 19.4 |

CFM prices and food components relate to January-March 2017
Source: Pig Breeding Test Station CULS Prague

Table 5: Cost per 1 weaner in the growing period with respect to sex.

| Component | Price / kg CZK / EUR | ♂ | | ♀ | | ♂ | | ik | |
|---|---|---|---|---|---|---|---|---|---|
| | | kg | CZK/EUR | kg | CZK/EUR | kg | CZK/EUR | kg | CZK/EUR |
| Creep | 17.85 / 0.66 | 0.8 | 14/0.52 | 0.6 | 10/0.37 | 0.8 | 14/0.52 | 0.5 | 9/0.33 |
| Weaning | 15.0 / 0.56 | 2.7 | 40/1.48 | 2.3 | 34/1.26 | 2.3 | 34/1.26 | 2.1 | 32/1.18 |
| ČOS | 9.9 / 0.37 | 10.2 | 101/3.74 | 9.8 | 96/3.55 | 9.9 | 97/3.59 | 8.2 | 81/3.00 |
| A1 | 7.1 / 0.26 | 15.4 | 109/4.03 | 16.5 | 117/4.33 | 15.7 | 112/4.15 | 16.9 | 120/4.44 |
| Total (kg) | . | 29 | 264/9.77 | 29 | 257/9.51 | 29 | 257/9.51 | 28 | 242/8.96 |
| Price (CZK/kg)(EUR/kg) | . | 9.08 (0.34) | | 8.84 (0.33) | | 8.95 (0.33) | | 8.70 (0.32) | |

CFM prices and food components relate to January-March 2017
Source: Pig Breeding Test Station CULS Prague

Table 6: Consumption and price of TFMs in test with respect to sex.

| Variable / sex | ♂ | ♀ | ♂ | ik |
|---|---|---|---|---|
| Cost per: | | | | |
| - 1 weaner CZK (EUR) | 1 179 (43.63) | 1 162 (43.01) | 1 216 (45.00) | 1 170 (43.30) |
| - feeding one weaner in test CZK (EUR) | 264 (9.77) | 257 (9.51) | 257 (9.51) | 242 (8.96) |
| Cost per 1 weaner (CZK (EUR) / head) | 1 444 (42.34) | 1 418 (52.48) | 1 472 (54.48) | 1 412 (52.26) |
| Cost per 1 weaner (CZK(EUR) / kg) | 51.57 (1.91) | 50.11 (1.86) | 50.58 (1.87) | 49.72 (1.84) |

CFM prices and food components relate to January-March 2017
Source: Pig Breeding Test Station CULS Prague

Table 7: Economic evaluation of test groups of pigs on the basis of purchase price of pigs and CFMs by sex.

significant approximately from the body weight of 50 - 70 kg in pigs (Stupka et al., 1998; Vanheukelom et al., 2012; Robina et al., 2013; Serano et al., 2013). With respect of the genetic shift in the pig population, as well as the economics, Morales et al. (2011), Grela et al. (2013), Čítek et al. (2014), Šprysl and Stupka (2003) also confirm this.

## Conclusion

The animals in the test during the growing period showed excellent fattening parameters, with a total increase of 19 kg in 65 days, a DFI of 0.7 kg, a FCR 1.2 kg and an ADG of 540-560 g.

The high performance of current modern pig genotypes, especially in the growing periode later influencing the overall production economy, was pointed out by Stupka et al. (1998). They mentioned that due to "maker assisted selection (MAS)" can be expected a significant changes in reproductive and production performance in pigs. This phenomenon also needs to be adapted to new technologies. The authors also demonstrated that the influence of sex and castration in young pigs is insignificant as mentioned already Hovorka et al., (1983). Genetic progress in production performance in the pig population, and the impact of sex on the economy also showed above mentioned authors (Šprysl and Stupka, 2003; Morales et al. 2011; Grela et al. 2013; Čítek et al. 2014).

In assessing the overall economy showed that the ascending order of preference, in terms of economic benefit, in this test achieved

immunocastrates, gilts, barrows and boars. It was confirmed, that the influence of sex or castration in young pigs is insignificant. This fact confirmed the given hypothesis.

It can be said that "classical" pathways, minimizing boar taint in pork meat (castration, immunocastration), with regard to the pig production economy and "no harm to the animals", will be pursued in the future in other ways by breeding (Wood et al.) and successive changes in consumer habits (Lamb, 1994).

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*Corresponding authors*
*doc. Ing. Michal Šprysl, CSc.,*
*Department of Animal Science, Faculty of Agrobiology, Food and Natural Resources*
*Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague – Suchdol, Czech Republic*
*Email: sprysl@af.czu.cz*

*Ing. Eva Kluzáková, Ph.D.*
*Department of Animal Science, Faculty of Agrobiology, Food and Natural Resources*
*Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague – Suchdol, Czech Republic*
*Email: kluzakova@af.czu.cz*

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# How Rural Development Programmes Serve for Viability of Small farms? Case of Latvia and Lithuania

Armands Veveris[1], Vaida Šapolaitė[2], Agota Giedrė Raišienė[2], Yuriy Bilan[3]

[1] Institute of Agrarian Resources and Economics, Riga, Latvia

[2] Lithuanian Institute of Agrarian Economics, Vilnius, Lithuania

[3] Rzeszow University of Technology, Poland

## Abstract

The analysis of structure of agricultural sector shows a poor viability of small-scale farms in new EU member states despite support of the Common Agricultural Policy. Considering this problem, the aim of the article is to identify indicators that can be used to show changes in the viability of small farms in order to bring policy makers more attention to this very important group of farms in the context of the agricultural economy in Latvia and Lithuania. For this purpose, 4 economic indicators were selected, analyzed and their impact to the change in the level of viability of small farms during 2007-2016 was assessed. The research based on the data of Farm Accountancy Data Network and Farm Structure Survey, using statistical data comparison, systematic indicator selection and mathematical induction methods. The results shows that despite growing of the rate of subsidies on investment and improving income level in small farms over the observed period , the viability of small farms remains heterogeneous and insufficient to contribute in constructing more resilient and sustainable agricultural sector both in Lithuania and in Latvia. Thus, in the upcoming Rural Development Programming period, the priority should be given to small-scale farms since they play a significant role not only in development of viability of agriculture in general but also are important to agricultural sustainability.

## Keywords

Rural development, small farms, viability, agricultural sustainability.

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## Introduction

European Commission (EC) gives a lot of attention to the strategies of European Union (EU) member states (MS) development. As in the majority of countries, Lithuania and Latvia approved long-term perspective sustainable development strategies called "Lithuania 2030" and "Latvia 2030" respectively. The priorities important for functioning in the EU are defined in the strategies. It is also anticipated to increase the viability of rural regions and to reduce social and economic disparities. Nevertheless, according to the Competitiveness Index of 2015-2016 and 2016-2017, the Baltic States are still in the lowest ranking group. This means that even by following Common agricultural policy (CAP) it is not simple to ensure the sufficient competitiveness of particular country. Poor country's competitiveness results are mostly influenced by poor viability indicators of regions, especially rural areas (Rivza, Kruzmetra, 2017; Melnikienė et al., 2018). According to Tvaronaviciene and Gatautis (2017), the health of local economy should be seen as one of the key factors for maintaining viability, thus economic activity plays a significant role in ensuring viability.

In the recent years, evaluation of economic activity of small farms has received a lot of attention as it was observed that small farms often depend on EU subsidies to survive (Hanrahan et al, 2018; Ryan et al., 2014; Poór et al., 2018). Furthermore, small farms have the potential to grow both in size and capability, become more competitive and be an economic core in agricultural structure. Thus, more attention has to be paid to their economic development, while EU support has to contribute to the decreasing of the variability in farm income.

The direct payments helped to reduce the income inequality among farmers of different economic size (Latruffe, Bojnec, 2013; Namiotko et al.,

201 Kharlamova et al., 2018), nevertheless, some of them are too small to be self-sufficient in the terms of efficiency and profitability (Vrolijk et al., 2010). They cannot supply a large volume and homogeneous agricultural production, thus generate not enough profit which has become the standard of modern farming. Small farms can flexibly adapt to various environmental and market changes and are playing a great role in rural employment. However, competitiveness of small farms is determined by possibility to acquire the modern agricultural machinery and new technologies, to improve farm's infrastructure, etc. (Gioia, Rioufol, 2017; Soumaya, 2012). So though small farms can be economically and socially viable and valuable to society (Gołaś, 2017; Moroz, et al., 2014; Samberg et al., 2016), they need support. Therefore, two problems need to be addressed, 1) whether the support actually has a positive effect on the viability of small farmers; 2 if so, which level of support is sufficient to reach small farms' long-term viability is relevant. As was mention earlier, there are researches proving the need of support for small farms. Nevertheless, the CAP support measures is aimed at promoting all agricultural areas and farms of different size, the situation is specific in such EU countries with extremely dominating number of small farms as in Lithuania or Latvia which small farmers account for the majority of support beneficiaries and receive almost smallest support in EU (Veveris, Šapolaitė, 2017). Classical economic indicators in the agricultural sector are among the most suitable for measuring the economic viability of small farms. Thus, the paper is aimed to analyse the relationship between four indicators: farm income and output, subsidies on investment and EU support by Rural Development Programme (RDP) in Latvia and Lithuania, and to reveal the dynamics of small farms viability in period of 2006-2017.

## Materials and methods

### Main concepts and context of measuring small farms viability

An exploration of the economic viability of French micro farms research shows that by invoking saving investment, self-organization and use of secondary materials, even the smallest, such as family farms can be economically viable (Morel et al., 2017). On the other hand, the necessity to save leads to work overload which negatively affect the perspectives of small farms viability. In different countries, small farmers make different decisions on solving the problem of lack of resources. For example, in France cooperation is evaluated positively (Morel et al., 2017), whereas in Lithuania, as our previous research show, neither small nor larger scale farm holders are keen on cooperating (Raišienė et al., 2018). Other studies (Guiomar, et al., 2018; Samberg, et al. 2016) focus on analysing the contribution of small farms to local food supply, food security and food sovereignty and they are often seen as an alternative to large and specialized farms. However, it can be noted that small farms are successfully developing mixed agricultural production, predominantly with part-time employment.

However, a tendency of broadening of the agricultural production and/or producing premium class product sector's variety is developed by large scale farms in the whole western world. According to Kirschenman et al. (2008), due to this reason, medium and small farms gradually disappear because they lack the capacity to both compete in a rapidly changing market of wide variety and specialize in highest class product market. As this process is observed in various countries with different political decisions, researchers claim that farm viability should not be directly linked to political decisions. On the contrary, sustainability of agriculture requires the opposite. Scientists note that economic viability is a favourable indicator to determine whether a farm will remain active in the near future. However, this does not necessarily forecast the long-term sustainability of the farm which depends not only on economic changes and circumstances but also on social capital and social inclusion (Hooks et al., 2017). Thus, sustainability in agriculture is often described as a consequence of national and international politics which puts into balance the economic, social and ecologic priorities. The authors also take note that the demographic problem is often concealed when speaking about the sustainability of agriculture. Preserving the vanishing small farms becomes increasingly harder. Thus, it must be understood that taking care of the small farms' viability is not only the country taking care of its citizens, it is mandatory to take into consideration the cost of demographic changes on the society, economy and ecology (Seghezzo, 2009; Dillon et al., 2016). Along with the decrease of rural population, the whole rural infrastructure is waning away which is harder to recreate than uphold.

The scale of the problem is quite large. According to the data of Eurostat, there are approximately 2 million small farms in the EU which cannot survive without subsidies. In order to fundamentally

strengthen them, the problem must be solved systematically, i. e. taking care of the viability of the whole agricultural sector, taking into consideration the influence of abovementioned factors of sustainability and resilience. As Hooks et al. (2017) state, all these areas are intertwined and measuring the progress of one of them, ignoring the situation in another is inadequate.

The majority of recommendations contain an urging to produce more in order to reach farm viability. However, research shows that small farm viability is influenced not so much by the amount of production but by the structure of the farm and type of production (Lyson et al., 2008). On the other hand, economically "non-viable" farms are often very environmentally sustainable and vice versa (Macken-Walsh, Roche, 2012; Hooks et al., 2017). Therefore, various opinions are expressed in the scientific discussion on measuring viability and issues of it forecasting. For example, O'Donoghue et al. (2016) noticed that agricultural viability is comprehended differently in Northern and Southern regions while Hooks et al. (2017) pointed out that even in the same region, measurements could be complicated by the lack of unified system for the evaluation of agricultural viability.

Sustainability can be named as viability with environmental goals; and attempt to balance the economic, social and environmental goals together with adoption of innovation, though unified methodology on measuring progress is also absent (Guiomar et al., 2018; Dillon et al., 2016). Nevertheless, researchers place more and more value on socio-cultural capital, not just the economic capital when speaking about agricultural sustainability (e.g. Galdeano-Gomez et al., 2016). Thus, small farms viability, as a core element on social dimension of sustainability, is extremely important in whole sustainable development of states agricultural sector.

Finally, the small farms support and increasing of its viability is linked to the resilience of the agricultural sector. It should be highlighted that the content of the resilience concept is also defined differently due to its nature while its evaluation causes problems just like the viability and sustainability discussed earlier. Essentially, resilience is a capacity of a system to absorb disturbance and reorganize while undergoing change so as to easily retain essentially the same function, structure, identity and feedbacks" (Walker et al., 2004, p. 4; Folke et al., 2010). Literature also insists that resilience cannot be measured or expressed only quantitively because resilience is formed by the ability of farms to maintain viability and seek for sustainability. When measuring the viability and sustainability of farms, economic resilience could be evaluated as an adaptational skill, mandatory in times of adversity and crisis (Hooks et al., 2017). Emphasizing the importance of social aspects on the economic resilience of agriculture, some characteristics stand out, such as the farmers' ability to cooperate, participation in making various, including political level decisions, membership in different organizations etc. On the other hand, small farms also benefit from slow way of life which is developing as an alternative to intense farming. Widely spreading propagation of organic farming allows small farms to find a place in the market dominated by large scale farms, hereby providing products with exceptional qualities that can be reached through active participation in EU RDP.

## Rural development challenges

In order to provide all farmers with equal and favourable conditions, EU financially supports agriculture through various dedicated programmes. Rural development policy, known as the "second pillar" of the common agricultural policy (CAP), is based on EU funds' and national funding's co-financing principle and implemented through multiannual programming periods. The current programming period 2014-2020 offers a total of 19 different RDP measures from which MS and their regions may choose, designing sub-measures suitable to local needs (Stanczuk-Galwiaczek, 2018). Due to programmes covering all EU member states and significant amounts of funds, both political institutions and scientists analyse and evaluate the success of rural development policy implementation and assimilation of support (Caruso, 2015).

Unfortunately, financial support programmes are not always as effective as expected: research shows that final support reaches only a third or less than half of farms (the majority of which are large scale), calculating by area (Sarvašová et al., 2017). The effectiveness of EU support is a problem that is being solved by politics on the level of different countries and the EU as a whole. This problem is not only complex but includes contradictions which prevent the fluent strive for common goals of the EU policy. On one hand, financial support to agriculture is expected to improve the condition of farms, the changes of which is measured through economic indicators. In turn, economic interests stimulate farms to increase agricultural output which is obtained by increasing the intensity of agricultural

activity. However, such intensification negatively affects the condition of the land, thus violating the environmental goals. On the other hand, even though economic indicators allow defining the condition of economic resilience of a country, evaluating the condition of social welfare using same indicators would be difficult. In addition, they do not say anything about the country's success in maintaining population and its variety in rural areas (Hooks et al., 2017). As it is evident, support for agriculture creates a conflict between different poles of EU. Therefore, in spite of food safety, energy security and climate change being seen as the most relevant challenges of current times by EU, some specific difficulties prevent contribution to overcoming these challenges.

The problem of agricultural development among and within countries is extremely important in the EU because as much as 80 percent of the EU territory consists of rural areas with half of its population living in these areas. However, according to Eurostat (2017), rural citizens are more at risk of poverty or social exclusion than urban inhabitants (according to statistics obtained by Stanczuk-Galwiaczek (2018), 42 and 25.5 percent respectively). Emigration and migration also negatively affect the viability of rural areas and vice versa. To solve these problems, the 2014-2020 RDP, promoting social inclusion, poverty reduction and economic development in rural areas is signed as one of six priorities (European Commission, 2016). Noted amongst the priorities are topics like resilient economy, sustainable management and viability of all types of agriculture. Although Lithuania and Latvia as well as the majority of other new MS tend to allocate more funding to priorities of social inclusion, poverty reduction and economic development than old MS, viability indicators as shown by research are unsatisfactory (Stanczuk-Galwiaczek, 2018). According to the results obtained by other researchers, while examining effects of various types of subsidies on investment, it was noticed that the investment (especially of small or medium scale farms) is viably important on the current farm production level which depends on past investment decisions. Annual investment decisions affect both the current level of capital, and future production (Svoboda et al., 2016). Talking about the small farms structure and tendencies, same authors used to examine the viability of farms on the basis of Farm Accountancy Data Network (FADN) data and revealed that investment had significant impact on income, which represents possibilities for extending new property (Svoboda et al., 2016). It is also noted that the subsidies for investment of countries with a high asset value do not reach the growth rate of such values. Clearly, this is due to the overall economic level of those countries where investment growth is not dependent on the subsidies provided (Guiomar, et al., 2018)

Thus, the article aims to investigate the variability of farm income and the effect of farm size on gross investment in the agricultural sector while analysing farm income, output and gross investment indicators. Their more detailed analysis leads to assumptions and recommendations for policy formation.

## Methodological approach

In order to analyse the small farms viability, Lithuanian and Latvian agricultural structures through 4 selected economic indicators of viability were under comparison.

Physical measure (the 1st indicator) such as gross farm income (*GFI*) was calculated per one annual work unit AWU:

$$A_{GFI}=\frac{\sum_j GFI}{\sum_j AWU}, \quad (1)$$

where:

$A_{GFI}$ – average gross farm income measured by farm net value added per *AWU(FNVA/AWU)*;

$j$ – set of farms.

The 2nd indicator – standard output (*SO*):

$$A_{SO}=\frac{\sum_j SO}{\sum_j UAA}, \quad (2)$$

The 3rd indicator – gross investment (*GI*):

$$A_{GI}=\frac{\sum_j GI}{\sum_j UAA}, \quad (3)$$

The 4th indicator – subsidies on investment (*S on I*) per one hectare of utilised agricultural area (*UAA*) can clearly be used:

$$A_{S\ on\ I}=\frac{\sum_j S\ on I}{\sum_j UAA}. \quad (4)$$

where:

$A_{SO}$ – standard output is the average value of the agricultural output at the farm-gate price of each agricultural product (crop or livestock) in a given country;

$A_{GI}$ – gross investment is purchases (expenses on land, improvements, machinery, building) minus sales of fixed assets plus breeding livestock change of valuation.

$A_{Son\,I}$ – subsidies for investment are regarded as part of the RDP payments.

This estimation was made using the FADN – an instrument for evaluating the income of agricultural holdings; and Farm Structure Survey (FSS) which provides detailed information on production structure of the EU farms with the period of 2007–2016. While calculating at the national level the data was taken from Eurostat. Meanwhile, at the farm level the FADN data was used. The structure of the farms is being analysed, using distribution based on farms economic size, where standard output used as the criterion applied. Taking into account the purpose of the paper and the actual structure of the farms in Latvia and Lithuania, the farms with SO value from 2 000 up to 8 000 EUR are considered as small.

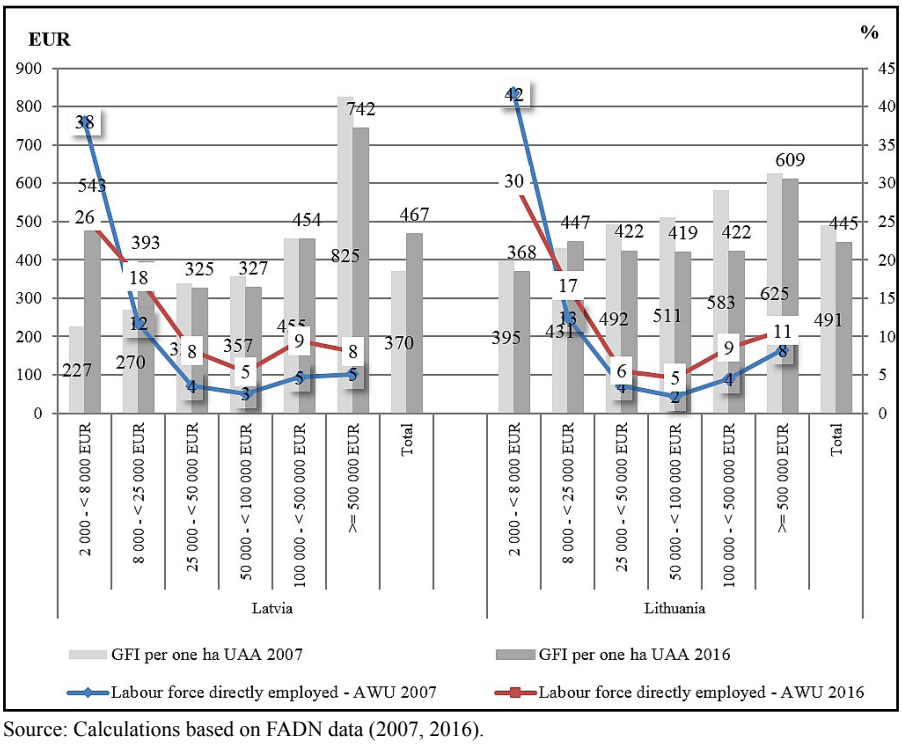
## Results and discussion

The small farms are identified with the aim of highlighting their need for special rural support measures by RDP, applying the economic size criterion seems to be most appropriate (Lowder, et al., 2015).

In order to identify and evaluate viability and the competitiveness contribution of small-scale farms to the welfare of the country, their potential, and the development of farming-related employment was based on FADN data and the groupings selected according to the following groups. Six different groups have been defined according to their economic size: 2 000 < 8 000 EUR; 8 000 < 25 000 EUR; 25 000 < 50 000 EUR; 50 000 < 100 000 EUR; 100 000 < 500 000 EUR; ≥ 500 000 EUR.

According to the FSS data (2016), the share in agricultural output of small farms (SO 2000 < 8000 EUR) in Latvia was equal to 7% in the total production and in Lithuania – 11%; employment – 26% and 30% respectively. Latvia and Lithuania are MS characterised by a large number of small farms. This means that they play a significant role in supporting rural employment, they are important for local production, particularly contributing to territorial development (Gioia, Rioufol, 2017).

Many scientists agree that small farms can indeed be viable if they are planned well (Moroz et al., 2014). This means that small farms also need more and better support. Development of the gross farm income over the past ten years has highlighted a more equal distribution of income in 2016 compared to 2007 both in Latvia and Lithuania; although in Latvia there are still larger differences between different size groups (Figure 1). In the largest size group the average income was




Source: Calculations based on FADN data (2007, 2016).

Figure 1: Gross farm income per one AWU and labour force directly employed (AWU) in Latvian and Lithuanian farms in 2007 and 2016.

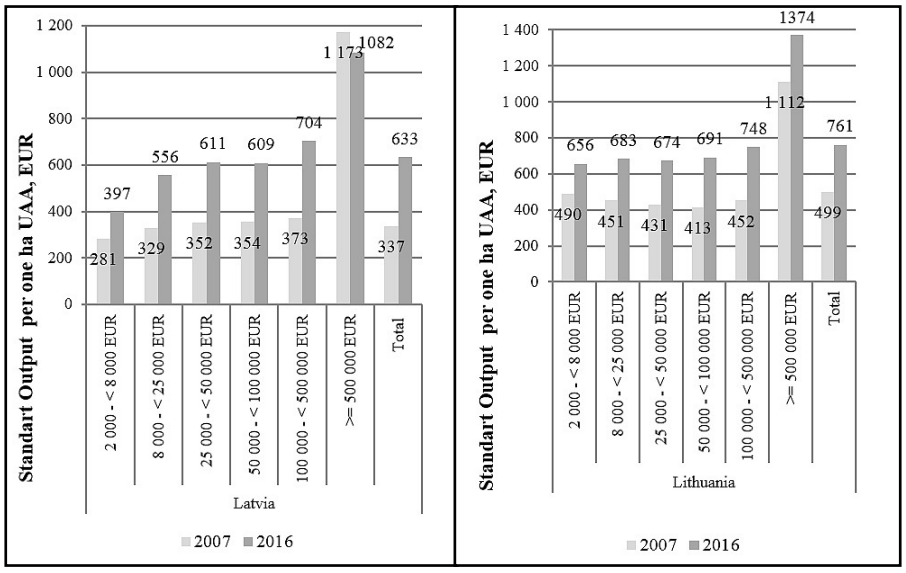
by 137% in Lithuania and by 159% in Latvia higher than national total in those countries. Although the income change of farms has improved slightly during the 2007-2016 period: income of small farms increased 2.4 times in Latvia and decreased by 6.8% in Lithuania. These differences are based on the capacities of small farmers to absorb support, which depends on provided opportunities for small farms to reach it at national level.

Despite these differences in investment, the employment of small farms remains an important aspect in both the Lithuanian and Latvian agricultural structures.

The share of AWU in Latvian small farms is 26%, in the largest group – 8.1%, in Lithuania – 30% and 10.8% respectively. On the other hand, a high proportion of small farms play an important role in supporting rural employment and contributing to territorial development, providing specialized local products and/or higher quality products as well.

According to the Figure 2, results show, that on average, SO per one UAA ha in small farms in Latvia was equal to 397 EUR/ha in 2016, i.e. by 51% less than in total average; in Lithuania – 646 EUR/ha and by 14% less in comparison to total in 2016. From 2007 to 2016 the average SO of small farms in Latvia increased by 41% and by 34 % in Lithuania. It was primarily influenced by the volatility of input and output prices and changing of yields. A common trend shows that the small farms' SO per UAA ha is significantly lower than in the largest farms.

It is difficult to coexist for small farms, which are still prevalent in the EU, among farms of other economic size. Nevertheless, the issue of the size of farm is still of high importance, as small farms largely maintain social dimension of agricultural sustainability and actively engage in production on farms. Most often scientists indicated the importance of gross investments and subsidies on investments in small farms, the higher income is one of the factors which improve the level of small farms viability and their ability to develop in countries (Morkūnas et al., 2018; Soumaya, 2012). The levels and dynamics of the investment depend on the size of the holding and their financial situation. Large scale farms have a better financial condition; they have more financial resources to spend on investment, to modernise of production processes faster. In 2007 Latvian and Lithuanian larger farms bought twice more agricultural machinery and buildings than small farms. It should be noted that the average gross investments in farms of all sizes are increasing annually. In 2016, gross investment per one UAA ha in small farms was equal to 386 EUR/ha in Lithuania, i.e. 4 times higher compared to 2007; and 338 EUR/ha in Latvia, i.e. 3.8 times higher in comparison to 2007. In the old EU member states the change is not so significant as in Latvia or Lithuania. However, the current level of gross investment is about 7-8 times higher (or by 87% lower than in EU-28 on average), which reflects the greater viability and activity of small farms based on the long-term sustainability that most promotes the resilience of the agricultural sector.



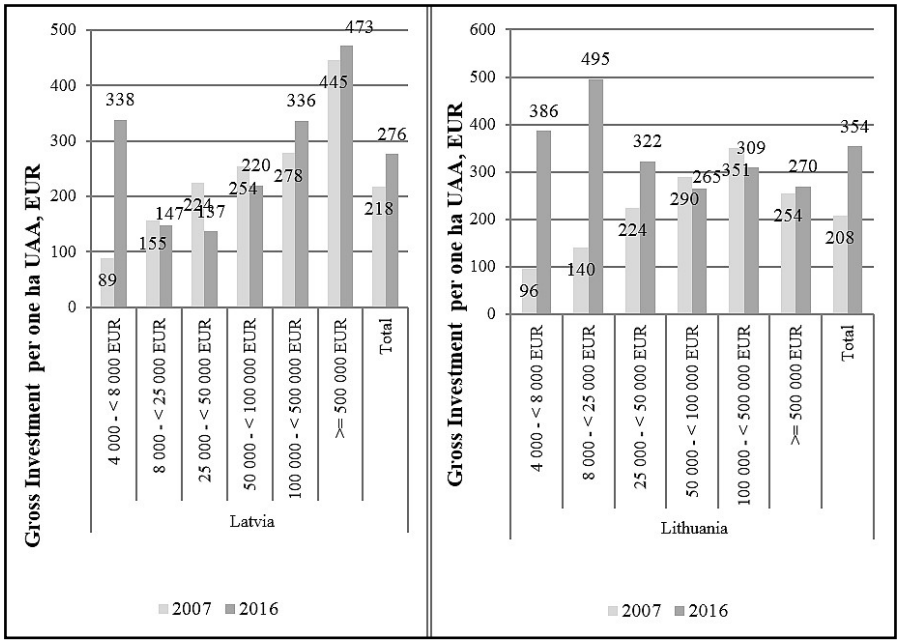

Source: Calculations based on FADN data (2007, 2016).

Fig. 2. Standard output per one ha UAA in Latvian and Lithuanian farms by size groups in 2007 and 2016, EUR.

The growth of gross investment shows that farmers can modernize production processes and can increase the efficiency of economic activity. This leads to economic results of agricultural activity production and financial stability of the farms (Figure 3).

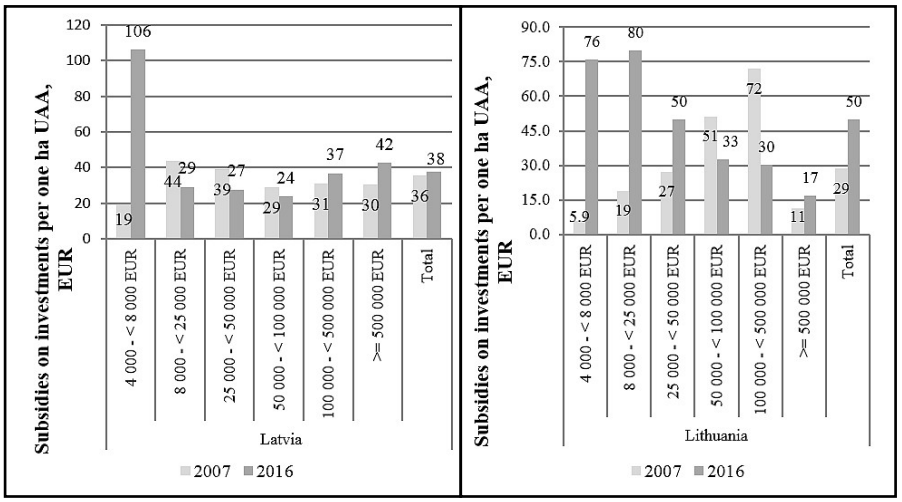
The development of agricultural gross investment is influenced by EU and national support for agricultural farms. According to the 2016 FADN study, the support provided to small farmers made up to almost one fifth of all gross investments in Lithuania and one third in Latvia.

The share of subsidies on investments to gross investments in all farms of Lithuania was 14.1%, in Latvia – 13.6% in the year of 2016 (Figure 4). This share varies among different economic size groups as well. This share of Lithuanian small farms was equal to 20%, in the large scale farms – 6.2%; meanwhile in Latvia – 31.4% and 9% respectively. It should be noted that in the structure of agricultural investment, the share of self-financing of economic entities is increasing. Farmers themselves invest in renovation of agricultural machinery, industrial buildings, and other assets. Our findings illustrate that the support on investments in the small farms gives positive results. It is therefore necessary further to explore the impact of investments,




Source: Calculations based on FADN data (2007, 2016).

Figure 3: Gross Investment per one ha UAA in Latvian and Lithuanian farms in 2007 and 2016, EUR.




Source: Calculations based on FADN data (2007, 2016).

Figure 4: Subsidies on investments per one ha UAA in Latvia and Lithuania in 2007, 2016, EUR.

as changes in the new RDP support rules for supporting small farms has occurred.

In addition, many of farms, having benefited from the EU and national support and previously acquired for modern high-performance equipment and production technologies, were able to improve their performance and generate revenue, allowing them to continue to modernize production processes at their own expense.

On the other hand, the 2007-2016 period was intensive in terms of the investment of small farms. Nevertheless, due to limited financial possibilities, the large amount of used equipment in comparison to new ones was acquired by them. "Investment in agricultural holdings" under the RDP, was provided only to farms purchasing new agricultural machinery. According to the current and the future RDP measures, both small farms and young farmers are targeted as high importance in agricultural viability terms, thus agricultural machinery sellers start more intensively provide farmers not only expensive machines orientated to large scale farms, but also smaller tractors and other equipment for small scale and start-up farmers. The possibilities of accumulation of own financial resources, EU and national support to small farms in future may determine the scope of modern production buildings and the availability of modern technical resources which in turn have to increase viability, social and economic sustainability of small farms both in Latvia and Lithuania.

## Conclusion

When analyzing the linkage among sustainability, viability and resilience, it was found that the contribution of small farms to the agricultural sustainability is of particular importance. Therefore, in order to promote it, it is valuable to ensure and monitor the level of viability of small farms, which also stimulates the country's socio-economic resilience.

The results of the research shows that in order to evaluate the viability of small farms it is necessary to spread indicators that allow identifying restrictions on the development of small farms, related with capital renewal, and create preconditions for a timely policy review. The selected indicators are intended to measure the upgrading of all forms of capital used by small farms; and that are involved in decision-making process on certain forms of capital renewal.

The analysis of selected economic indicators allowed identifying important aspects of viability of small farms. Small farms both in Latvia and Lithuania accumulate a large share of total agricultural employment. Gross farm income per one ha UAA in small farms is not much different than the average in total farms, and there is a tendency to decrease the differences among different farms size groups. Over the last decade, level of gross investment per ha in small farms has raised 3.8 times in Latvia and 4 times in Lithuania, and it is much higher than in medium size farms. Thus, small farms are in specific need of more support and accessibility to it through various instruments, which would help to increase viability of small farms in Latvia and Lithuania.

The analysis shows that a rate of subsidies on investment in small farms has grown over the period and situation has slightly improved. In Lithuania the trend is turned upside down from greatest support for larger farms in 2007 to opposite trend in 2016. As can be seen, changes in trends of subsidies on investment have consequences in income trends of small farms in Latvia and Lithuania. Although the high growth of subsidies on investment is most noticeable in small Lithuanian and Latvian farms, their level compared to the EU is extremely low, as the overall viability of these farms. This shows a necessity of a strong incentive for policy makers to prioritize small farms, while forming a national agricultural strategy and by creating RDP support structure.

*Corresponding authors*
*Yuriy Bilan*
*Rzeszow University of Technology*
*Powstańców Warszawy 12, 35-959 Rzeszów, Poland*
*Email: bilan@prz.edu.pl*

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