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Content:

<b>G. Adamides, A. Stylianou:</b> ICT and Mobile Phone Use for Agricultural Knowledge Sharing by Cypriot Farmers .....	3
<b>J. O. Animashaun, F. E. Williams, A. A Toye:</b> Towards Validating Moringa's Nutraceutical Benefits: An Examination of Consumers' Perspectives vis-à-vis Health Benefits Efficacy and Willingness to Pay ...	11
<b>R. Aulová, T. Hlavsa:</b> Capital Structure of Agricultural Businesses and its Determinants .....	23
<b>M. A. Carravilla, J. F. Oliveira:</b> Operations Research in Agriculture: Better Decisions for a Scarce and Uncertain World .....	37
<b>J. Homolka, V. Bubeníková:</b> Economic Evaluation of Intensive Growing of Selected Crops .....	47
<b>Z. Křístková, T. Rättinger:</b> Modelling the Efficiency of Agri-Environmental Payments to Czech Agriculture in a CGE Framework Incorporating Public Goods Approach .....	59
<b>M. Svatoš, M. Maitah, A. Belova:</b> World Sugar Market – Basic Development Trends and Tendencies ..	73
<b>J. Špička:</b> The Competitive Environment in the Dairy Industry and its Impact on the Food Industry .....	89
<b>L. Tomášik, J. Jobbágy:</b> Optimization of Irrigation Spray Distribution in the Term of its Uniformity ..	103
<b>C. A. Wongnaa, D. Awunyo-Vitor:</b> Factors Affecting Loan Repayment Performance Among Yam Farmers in the Sene District, Ghana .....	111



## ICT and Mobile Phone Use for Agricultural Knowledge Sharing by Cypriot Farmers

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### Abstract

The aim of this paper is to reveal the current situation regarding the use of mobile phones as a mean of information sharing by Cypriot farmers. In particular, a project at the Agricultural Research Institute is underway, to survey methods currently used for agricultural information and knowledge sharing, to determine the level of satisfaction of the farmers of the available sources of information, and to suggest how ICT tools can be applied to help in transferring agricultural knowledge to farmers who live and work in rural and remote areas. The results showed that nearly 98% of the farmers in Cyprus use the mobile phone as a source of agriculture information. Furthermore it was found that there are no differences between educational groups and between crop farmers and their livestock counterparts concerning mobile phone usage. Future research is needed to examine the factors that affect mobile phone usage, its usefulness and the possible benefits for the Cypriot farmers.

### Key words

Rural areas, mobile telephone, ICT, agriculture, information sharing.

### Introduction

In the past decade, there has been a rapid growth of mobile phones usage all over the world. As of 2012, while the world population is 7.1 billion, the International Telecommunication Union estimated that there were 6.8 billion mobile phone subscribers worldwide (ITU 2013). In fact, according to Rashid and Alder (2009), most developing countries have skipped fixed-line infrastructure and have moved directly into mobile technology.

Within the discourse of “Information Society”, “Knowledge Society”, “Information Economy” and the like, it is maintained that information and knowledge play a key role in ensuring sustainable development (Amponsah, 1995; Koutsouris, 2010). However, it is generally acknowledged that the rural population still faces problems accessing vital information that could help in making timely and accurate decisions (Anandaraja, Rathakrishnan & Philip, 2006).

Today, in many countries, mobile phones are being used by farmers, not only as a person to person voice communication medium, but also, to provide access to information though sending messages service (SMS), multimedia messages service (MMS), and

access to the Internet. Hence, we are now talking about mobile technology that includes mobile phones, smartphones, tablets and the technologies that surround them.

The main aim of this paper is to present the findings of a survey carried out in Cyprus, about the use ICT and mobile phones by Cypriot farmers, specifically as a mean for access to agricultural information. The introductory part is organized as follows: the literature review is presented followed by an outline of the profile of the Cypriot agricultural economy through which the main goal of this study is documented. In Section 4, the research materials and methodology is described. What follows is the presentation of the research results (Section 5). Finally, the conclusions and prospects for further research are presented in Section 6.

There is a growing literature related to the adoption and usage of ICT and mobile phones in rural areas in general and in agriculture specifically (Vanek et al. 2008; Rashid and Elder 2009; Ballantyne 2009; Aker 2010; Michailidis et al 2010; Vanek et al, 2010; Aker, 2011).

The adoption and usage of mobile phones by Cypriot farmers has not been examined so far.

In contrast, several studies on this subject have been conducted in other countries and regions (Canada, Greece, sub-Saharan countries, India, China, Latin America and the Caribbean, etc.).

The mobile phones are regarded as more accessible and less expensive mean to close the digital divide compared to other ICT technologies (Wade 2004). In fact, Rashid and Elder (2009) state that, "...mobile telephony is the predominant mode of communication in the developing world". Furthermore, these studies found that mobile phones usage appears to be an effective and low-cost mean of providing information, and as a consequence are considered to be an effective tool for poverty reduction for poor rural households (Rashid and Elder, 2009; Aker, 2010). According to Aker (2010, 2011), mobile phone infrastructure can have a positive spillover effect on markets with higher transport costs, with a reduction of 10 to 16 percent in price dispersion across markets.

Mobile phones significantly reduce communication and information costs. Poor communication facilities lead to limited access to information and this can lead to loss of income. For example, farmers who do not have access to prices before travelling to the market often rely to middlemen who take advantage of this ignorance and offer to buy crops at prices far lower than they would get if they travelled to market themselves (Rashid and Edler, 2009). According to de Silva (2008), the "cost of information" constitutes eleven percent of the total cost of farmers, from Sri-Lanka, from the time of deciding what to grow to the time of selling. To support the above finding, another study (BBC, 2002) carried out in Senegal showed that farmers who were able to check market prices before setting off and find out the best price of their produce, using a mobile phone, were able on average to have fifteen percent higher profits.

Aker (2011) explains that the use of mobile phones provides new opportunities for farmers to obtain access to agricultural information, such as market prices, weather reports, transport information and agricultural techniques, in various formats like audio (voice), video (internet), and text (SMS).

Michailidis et al (2010), explain why the mobile technology has been accepted and adapted much faster compared to other ICTs in rural areas. In their paper, they categorize the benefits from using mobile technology into two groups: (a) socio-economic, for example reducing the distance between individuals and institutions,

thus making the sharing of information easier and more effective, and (b) rural, for example making local content available and making rural services more efficient in terms of logistics and coordination, and cost-effective.

The Cypriot economy in general and as a consequence its rural economy, is in a transitional period, due to the new economic environment that was created, as a result of Cyprus' accession to the European Union (EU), in May 1<sup>st</sup>, 2004 (DOA, 2010).

According to the Organization for Economic Cooperation and Development (OECD), rural areas are defined as the local units (e.g. municipalities) with a population density below 150 habitants per square kilometer. However, this definition is not used in the case of Cyprus, as it is a small island, with small agricultural land ownership and small to medium size cities. Therefore, in Cyprus, an area is characterized as rural, if it is not defined as urban by the national cadastre. Consequently, the rural population of Cyprus is the population that lives permanently in rural areas, regardless the kind of employment. The farming population is not identical to the rural population but rather it is a subset of the rural population (DOA, 2010).

Based on data provided by the Statistical Service of Cyprus (2012) the rural population of Cyprus is 32.6% of the total population. Since the beginning of the 20th century, the rural population of Cyprus accounted for the largest percentage of the total population. Particularly, in 1901, 81.2% of the total population was living in rural areas, while in 1960 that percentage dropped to 64%. Following the Turkish invasion in the island in 1974, the rural population was forcefully reduced and in 1982 was only 36.5% of the total population. From 2000 onwards, a small annual increase is observed and the percentage is now stabilized around 30%. This stabilization is attributed to the development of the infrastructure and of the road network, to the improvement of services in the rural areas, the creation of job opportunities in these areas, as well as to both the increased cost of living and the degradation of quality of life in the cities (DOA, 2010; Vakakis & Associates, 2010).

However, the rural areas are also facing major problems and these are more significant and obvious in less favored, remote and mountainous areas. To start with, these areas have a low population density and unfavorable demographics.

The population is relatively isolated, mainly due to the absence of direct connection with cities, limited public transportation and low quality of the rural road network. Furthermore, the rural population of Cyprus, as compared with the urban population, is lacking behind in education, present skewed age distribution and has lower incomes. Specifically, the level of education is lower than the national average, the majority of the residents are old people and the job opportunities are limited. In addition, the infrastructures for education and for healthcare provision are deficient. A serious weakness of rural areas is that a large proportion of the rural population is dependent heavily on agriculture, an activity that is shrinking. The dependence of the rural population on agriculture, due to the lack of alternative employment opportunities, is a barrier for the development of rural areas. Hence, there is a need for socioeconomic diversification and combination with complementary activities, such as rural tourism (agritourism). On the other hand, rural areas have significant advantages, like the natural resources and cultural heritage (DOA, 2010; Planning Bureau, 2006).

Despite the fact that the agricultural sector is shrinking, it is still considered as important in the Cyprus' economy and to rural population livelihood. Agriculture contributes merely 2.4% to the Gross Domestic Product (GDP), compared to 20.9% in 1965, 4.8% to employment and 17.6% to total exports for 2011 (Statistical Service of Cyprus, 2012). The most important Cypriot agricultural products are early potatoes, citrus fruit, olives, as well as vegetables and wine products. The most important animal products are meat (beef, pork, poultry and goat/sheep) and milk (cow and goat/sheep). As for processed Cypriot agricultural products (including traditional products), stable demand, both in the internal and third markets, is for: "haloumi", "lountza", "trahanas", „flaouna“, „soutzoucos“, "zivanja" and local wines (DOA 2010).

The agricultural sector of Cyprus is facing several structural problems including the small size of holding and farm fragmentation, the aging and low educational level of the farming population, land degradation, water shortage, high production costs, limited agricultural research and marketing problems (Papadavid, 2008; DOA, 2010).

In relation to the adoption of ICT, there is a gap between rural and urban areas (Ramirez, 2001; Madden & Coble-Neal, 2003; Michailidis

et al., 2011). The rural areas of Cyprus are not an exception. According to the Broadband Performance Index (BPI) of the European Commission, Cyprus is ranked second to last, before Bulgaria (European Commission, 2008). Based on data by the Department of Agriculture (2010) there are 151 small and remote communities in Cyprus with no broadband access and are characterized as "white areas". Furthermore, ICT in agriculture is still very limited with the exception of certain intensive livestock units and food processing industries.

According to the Statistical Service of Cyprus (2012) in 2011 there were 1.266 mobile subscriptions per 1000 inhabitants. Furthermore, 54.1% of farming households in Cyprus have access to a PC and 47.6% have access to the Internet. For urban households these percentages are 67.8% and 61.3%, respectively, showing the digital divide between urban and rural areas. In Cyprus, almost 30% of the persons that use the Internet in the first quarter of 2012, use mobile phone or smart phone to access the Internet away from home or work while 25,9% use a laptop, notebook or netbook

It is worth mentioning here that there are no research works dealing particularly with the usage of mobile phones in the Cypriot agriculture sector. Hence, it was considered that this should be studied by field research and by using a structured questionnaire on a representative sample.

## **Materials and methods**

To examine the usage of mobile phone by Cypriot farmers, a stratified random sample of 250 producers was developed, covering all areas under the authority of the Republic of Cyprus. The sampling frame was based on applicant-beneficiaries of the Rural Development Plan 2007-2013, and specifically on Measures 1.5.1 "Modernization of agricultural holdings" and 1.2 "Setting up of young farmers". Given that currently an official National Farmers' Registry is not available, based on our experience, we consider that the sample size selected is satisfactory. We followed the rules of the stratified random sampling method based both on crop and livestock production (two strata), and on location districts (five strata), as our main criteria for the categorization. Hence we consider that the results are reliable to the entire population where the sample was based.

The majority of the beneficiaries possess farms

with fruits and vegetables, potatoes and cereals, whilst from the animal production farms most are breeders of sheep and goats, cattle and pigs. Between May and July 2011 we have visited 219 rural communities and with face to face interviews we collected 142 filled questionnaires, giving a response rate of 56.8%. The non-respondents fall into three categories: those who rejected the interview (10.6%), those who did not show up to the interview (either due to illness or other personal reason) (26.7%), and those who did not answer the phone in order to make arrangements for an interview appointment (62.7%).

The main aim of this paper is to identify the farm and farmer preferences of sources of agricultural information in general, with focus on mobile phones and ICTs. Specifically, we investigate the frequency of use of these sources, and mobile phone applications most frequently used for obtaining agricultural information. Finally, we examine if there are any differences between educational groups and between agriculture activity groups, in relation to mobile phone usage. For this purpose, descriptive and inferential statistics have been used.

### Results and methods

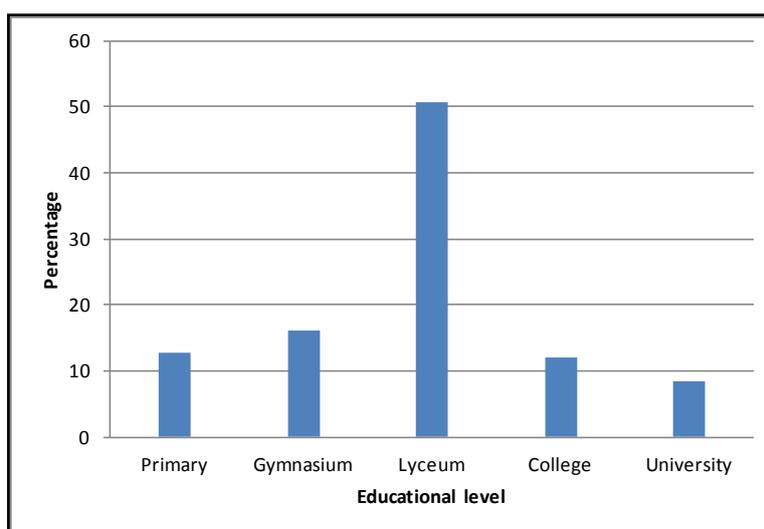
Regarding demographics 88.5% of the participants were male and 11.5% female, with mean age 39. Moreover, farmers' location was found to be as follows: 28% live and work in Limassol

district, 20% in Larnaka district, 18% in Paphos district and 6% in Famagusta. Their educational level is illustrated on Figure 1. As shown, 12.7% of the farmers had completed primary education, 66.8% secondary education, and 20.5% tertiary education. Moreover, 64.8% of the participants were crop farmers and the remaining 35.2% were livestock farmers.

The participants were asked to answer several questions related to the usage of mobile phone and ICTs for business purposes. The statistical analysis for the survey was carried out by using the statistical package IBM SPSS Statistics version 20.

In Table 1, the responses related to the tools that farmers use as sources of agricultural information are presented. As shown, 98% of the participants are using the mobile phone as an information source. The second most favor source of information that farmers use is other farmers (89%), followed by Extension Service officers visits to the fields (85%), private sector Extension consultants (81%), and input suppliers (74%).

In Table 2, the responses of the participants, based on how often they use each tool is presented (1 = daily, 2 = weekly, 3 = bi-weekly, 4 = monthly, 5=never). The results depict that farmers use mobile phone on a daily basis to obtain agricultural information. Specifically, mobile phone ranked first among eight information sources. The remaining sources are used less frequently, once every two weeks, on average.



Source: own processing

Figure 1: Educational level of respondents.

<b>Information source</b>	<b>%*</b>
Mobile phone	98
Through other farmers	89
Extension Service	85
Extension consultants	81
Input suppliers	74
Newspapers/Magazines	69
TV (agricultural related programmes)	67
Cooperatives	51
Radio (agricultural related programmes)	42
Internet	40
Experts	15

\*Note: Multiple answers were allowed

Source: own processing

Table 1: Sources of agriculture information (N=142).

<b>Information source</b>	<b>Mean</b>	<b>Rank</b>
Use Mobile phone	1,50	1
Watch TV show ‘Ypaithros’	3,46	2
Use Computer	3,77	3
Use World Wide Web	3,82	4
Listen to Radio ‘Ora tis Ypaithrou’	4,13	5
Use e-mail	4,43	6
Read e-Newspapers/e-Magazines	4,44	7
Use Social Media	4,81	8

Source: own processing

Table 2: Frequency of use.

<b>Variable</b>	<b>Mean</b>	<b>Rank</b>
Voice calls	1,00	1
Calendar/Reminder	2,57	2
SMS	2,72	3
Take photographs	3,92	4
Take video	4,40	5
Used to transfer data	4,40	6
Listen to radio	4,43	7
MMS	4,65	8
3G/WIFI Internet access	4,69	9
Check e-mail	4,72	10
Used as voice recorder	4,77	11
Social network applications	4,82	12
GPS	4,88	13

Source: own processing

Table 3: Mobile phone applications.

Regarding mobile phone applications and their frequency of use (1 = daily, 2 = weekly, 3 = bi-weekly, 4 = monthly, 5 = never), the results show that, as expected, the most frequently used mobile application is voice calls, followed by calendar/reminder application, sending text messages (SMS), taking photographs and videos, and so on.

To examine if there are any differences between crop farmers and livestock farmers concerning the frequency of mobile phone use, Independent t-test was used. It was found that there are no differences between the two groups, indicating that crop farmers and livestock farmers use mobile phone to the same extent. On the other hand, to examine if there are any differences between farmers educational groups, One-way ANOVA was used. It was found that there are no differences between educational groups in relation to the frequency of mobile phone use. As a result, farmers of all educational levels, use mobile phone for obtaining agricultural information to the same extent.

## **Conclusion**

This paper presents the current situation regarding the use of mobile phones as a source for access to agricultural information by Cypriot farmers. We

surveyed the methods currently used for agricultural information and knowledge sharing, the frequency of use of each information source, and mobile applications most commonly used by farmers.

The results showed that nearly 98% of the farmers in Cyprus use the mobile phone as a mean to access agricultural information. Moreover, farmers use mobile phone on a daily basis to obtain agricultural information. Using inferential statistics, we found no differences between educational groups and between crop farmers and their livestock counterparts, concerning mobile phone usage.

The results of this research provide strong evidence that Extension Service should examine ways of enhancing the sharing of agricultural information and focus on the development applications targeted to farmers and their information needs. This study concluded that mobile phone is a very common source to farmers for obtaining agricultural information. Thus, Extension Service should take advantage of the mobile phone and its applications and use it more extensively for the dissemination of agricultural information to the farmers.

Future research is needed to examine the factors that affect the usage of mobile phones and whether current practices and available mobile applications satisfy the needs of the Cypriot farmers.

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## Towards Validating Moringa's Nutraceutical Benefits: An Examination of Consumers' Perspectives vis-à-vis Health Benefits Efficacy and Willingness to Pay

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### Abstract

This study examined the validity of claimed Nutraceutical benefits of *Moringa oleifera* products through the lens of consumers' perceptions and Willingness to Pay (WTP) for perceived benefits. Data were randomly collected from 120 sampled Moringa consumers. Results indicate that knowledge of *Moringa oleifera*'s benefits is high among respondents and Moringa is consumed for various preventive and curative purposes. On the average, respondents were willing to pay about 5% over and above the current price of Moringa product so as to have access to perceived product's Nutraceutical benefits. WTP was found to be significantly influenced by perception of efficacy of product's benefits ( $p = 0.01$ ), education ( $p = 0.02$ ) and occupation of respondents ( $p = 0.03$ ). The study emphasizes the need for further clinical and pharmacological double-blind placebo test trials to ascertain the acclaimed therapeutic benefits of the product.

### Key words

Nutraceutical benefits, willingness to pay, double-blind placebo clinical trials.

### Introduction

*Moringa oleifera* or simply Moringa is the most widely cultivated of the 13 different species of the family Moringaceae or Horseradish tree (Fahey, 2005). It has been identified to contain several nutritional and therapeutic properties which make it ideal for combating malnutrition and certain health related disorder. Many sources reveal that, for each equal weight, Moringa leaves contain more beta-carotene than carrots, more iron than spinach, more potassium than bananas, more vitamin C than oranges and more protein than peas (Palada, 2003). In addition, Moringa contains a unique blend of phytochemicals which may have an impact on health but are not required by humans as essential nutrients (Fahey, 2005), and a group of compounds called glucosinolates and isothiocyanates which are reported to have hypotensive, anticancer and antibacterial effects (Fahey, 2005; Siddhuraju and Becker, 2003).

For centuries, these nutritional and therapeutic properties have been utilized in the traditional

treatment of several health disorders in various cultures (Saint Sauveur, 2001). Fahey (2005), made a review of the medical uses of Moringa and identified several curative and preventive usages ranging from asthma, cancer, immunity build up and skin disorder to digestive disorders (Fahey, 2005).

However, the validity of these claims is undermined among scientific and medical communities and unsurprisingly, disclaimer notices are placed on some Moringa websites that denounce the therapeutic claims of the product (Schneemann, 2011). This contrast between conventional western medical opinion and claims by practitioners of traditional/herbal medicine could be as a result of the approach used in verifying these medicinal claims. Medical professionals have been observed to focus more narrowly on a medical model of health care (a history and examination) followed by investigation and treatment, and finally clinical measures of successful outcome (Detmar et al., 2002). While the sole application of this method in justifying the usefulness of a drug is faulted

in certain quarters (Detmar et al., 2002), modern medicine is slowly beginning to recognize the importance of patient/consumer perspectives to health care delivery with more emphasis placed on the understanding of the importance of the inter-relationships among health needs, satisfaction, and quality of life.

Furthermore, within the prism of consumer behavior theory the decision to consume a marketable commodity is influenced by the utility or satisfaction such a good provides which is could translate as their willingness to pay for such a good. This could be due to the goal of utility maximization pursued by all rational consumers and, expectedly, demand might be placed on a particular product after such is perceived to maximize utility or satisfaction. Several studies have identified perceived quality as a strong determinant of patients' choice of health provider and willingness to pay (Akin and Hutchinson, 1999; Annis, 1981; Masatu, et al., 2001; Newman, et al., 1998).

Within these contexts and given the increasing consumption of the Moringa product worldwide and locally in Nigeria, as well as the growing attention from various institutional, scientific and industrial bodies involved in the development of this product, the objectives of this study were to;

- examine respondents' knowledge of nutritional and therapeutic use of Moringa,
- identify consumers' Nutraceutical and therapeutic choice(s) of Moringa uses
- examine consumers' perceptions of Nutraceutical and therapeutic efficacy of Moringa,
- determine consumers' willingness to pay (WTP) for Moringa benefits, and,
- assess the determinants of consumers' willingness to pay for Moringa perceived health benefits

The study is justified on two grounds. First, with the current emphasis on the patient as a consumer, pharmaceutical manufacturers are increasingly interested in obtaining feedback about their product from patients. Showing greater satisfaction with a product provides a marketing advantage and the feedback can also be used to further improve products. There is also the inference that increased satisfaction will lead to increased adherence, better clinical outcomes and reduced healthcare expenditures, but literature to support these

associations are rare hence this study would upgrade existing literatures. Second with conflicting claims and counterclaims on the validity of health benefits of Moringa, this study could initiate rekindled interest in the clinical assessment of Moringa's health benefits.

## **Materials and methods**

The study was conducted in Kwara State, Nigeria. Kwara State is located in the North-Central geographical zone of Nigeria within latitudes 70°45' and 90°30'N and longitudes 40°30' and 60°25'E. The state has two main climatic seasons; the dry and wet seasons which make it well suited for the cultivation of the Moringa crop. The state equally hosts several educational and research institutes committed to the development of the Moringa crop. University of Ilorin which is located in the state's administrative headquarters is one of such educational institutes engaged in the development of the Moringa crop both for consumption and research purposes.

The sampling technique for this study involved the random sampling of Moringa consumers who had purchased Moringa product for consumption within the past six month from the date of the survey. The sample list was generated from the marketing outlet of the University of Ilorin Moringa Plantation where consumers purchase the Moringa product. Overall, 120 questionnaires were administered in an interview schedule conducted in July, 2012 on each respondent.

We pre-tested the questionnaire by initially administering it on a pilot sample of 10 persons in the way and manner suggested by Aaker and Day (1986) and used by DiPasquale (2012). Thereafter, the questionnaire was redesigned to reflect some observations pointed out during the pre-test stage. Overall, the questionnaire was found relatively easy to understand by respondents and respondents reported finding it interesting to complete.

### **1. Analytical framework**

This study employed descriptive statistics, four-point Likert scale, Ordered Logistic Regression and the Binary Logistic Regression to achieve the stated objectives.

### **2. Exploratory analysis**

A four-point Likert scales was used to obtain participant's preferences or degree of agreement with a set of statements that examined perceptions

of the Nutraceutical benefits of Moringa. Specifically, Respondents were asked to indicate their level of agreement with the effectiveness of the Nutraceutical benefits of the Moringa product in a given statement by way of an ordinal scale. The four-point scale ranged from “Strongly Disagree” and “Strongly Agree” on one end, to “Neither” in the middle, and agrees or disagrees at the quartile points on the scale. Each Individual response was treated as an ordinal data because although the response levels do have relative position, we cannot presume that participants perceived the difference between adjacent levels to be equal a requirement for interval data. Doing otherwise, from a statistical standpoint could be dangerous as there is no way to ensure that participants view the difference between “agree” and “strongly agree” the same as they might view the difference between “agree” and “neutral.”

The four-point Likert scale data were analyzed with descriptive statistics. The mode was computed as a measure of central tendency for our study because of the nature of the data. We deliberately did not include the mean because adding a response of „strongly agree“ (4) to two responses of „disagree“ (1) would give us a mean of 3, which has no significant meaning to our study.

### 3. Econometric analysis

The Ordered Logistic Regression (OLR) model was applied to estimate some socio-economic characteristics that influenced respondents' responses to each of the four-point Likert response item. Ordinal logistic regression, or PLUM (Polytomous Universal Model), is an extension of the general linear model to ordinal categorical data. Ordinal logistic regression models have been applied over the last few years for analyzing data, the response or outcome of which is presented in ordered categories. Ordered information in score-form has been increasingly used in epidemiological studies, such as quality of life in interval scales, health condition indicators and even for indicating the seriousness of illnesses (Ananth and Kleinbaum, 1997). Depending on the study's purpose, these models also allow the odds ratio (OR) statistic or the probability of the occurrence of an event to be calculated (Anath and Kleinbaum, 1997).

The dependent variable (Y), for this study ranges from 1 to 4, corresponding to four-point scale levels of: (4) strongly disagree, (3) agree, (2) neither agree nor disagree, (1) disagree,

and. If  $P_i$  is the probability for  $Y = i$ , and  $P(Y \leq j) = P_1 + P_2 + \dots + P_j$  represents the probability that a respondent falls in a category less than or equal to the  $j^{\text{th}}$  category ( $j = 1, 2, \dots, 4$ ), then we have a collection of cumulative probabilities for each case. The final category  $P(Y \leq 4)$  has a cumulative probability of 1. Following Zhang, et al., (2010) the OLR model based on the cumulative probability can be specified as:

$$\text{Logistic}[P(Y \leq 1)] = \ln [P_1/1 - P_1] = k_1 - \sum_1^n \beta_i X_i + e \quad (1)$$

$$\begin{aligned} \text{Logistic}[P(Y \leq 2)] &= \ln [P_1 + \frac{P_2}{1} - (P_1 + P_2)] \\ &= k_2 - \sum_1^n \beta_i X_i + e \end{aligned} \quad (2)$$

$$\begin{aligned} \text{Logistic}[P(Y \leq 3)] &= \\ \ln [P_1 + P_2 + P_3/1 - (P_1 + P_2 + P_3)] & \\ &= k_3 - \sum_1^n \beta_i X_i + e \end{aligned} \quad (3)$$

$$P(Y \leq 4) = 1 \quad (4)$$

Where  $\alpha_1, \alpha_2, \dots$  and  $\alpha_5$  are the intercepts,  $\beta_1, \beta_2, \dots,$  and  $\beta_n$  are the coefficients to be estimated, and  $e$  is the error term. For this study,  $X_i$  ranges from  $X_1$  to  $X_5$ . Where  $X_1$  is age of the consumer,  $X_2$  is the gender of the consumer,  $X_3$  is livelihood activity of respondent,  $X_4$  education of the respondent and  $X_5$  is the marital status of respondents. The cumulative model constrains the coefficients in these models to be the same but allows the intercepts to vary (Allison, 1999; O'Connell, 2006).

In order to access the determinants of willingness to pay for the Moringa by-product, a logistic regression model was used for analysis of data obtained, in which the dependent variable used assumes the value of 1 if the consumer declared his willingness to pay more for Moringa by-product based on the satisfaction derived from the product, 0 otherwise. The basic analytical method for studying individual willingness to pay is grounded in consumer behavior theory (Ben-Akiva and Lerman, 1985). The foundation of this theory is the concept that individuals choose from among alternative bundles of goods and services with the objective of maximizing their overall satisfaction, or utility. Consumers may also derive satisfaction not by the good itself but by attributes or characteristics of the good that provide utility (Lancaster, 1966). WTP is the maximum amount of money a consumer would be willing to pay for the new product. These surveys only give

meaningful results if they are properly grounded in a consumer maximization framework (Hanemann and Kanninen 1998).

The formal specification of the model used was as follows:

$$P_i = P\left(Y_i = \frac{1}{x_i}\right) = E\left(Y = \frac{1}{x_i}\right) = \frac{1}{1} + e^{-\beta x_i} = \frac{1}{1} + e^{-z_i} \quad (5)$$

Equation 5 accessed the impact of independent variables on the likelihood that a consumer will consume moringa by-product or not.  $X_i$  is the set of independent variables and, as in standard regression models,  $\alpha$  is the intercept and  $\beta$  is the vector of coefficients for the vector of independent variables.

The explicit function could be denoted using a set of cognitive and socioeconomic factors  $X$ , that could explain the decision to pay. For each respondent,  $j = 1, \dots, N$  in the sample, the latent variable, WTP, can be written as a single bounded model:

$$WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon_j \quad (6)$$

With WTP being a dichotomous variable representing 1, if the respondent is willing to pay more for Moringa by-product, 0 otherwise, and  $X$  being the variables of interest that could influence the decision. For this study,  $X_i$  takes the value from  $X_1$  to  $X_5$  and these include; age, gender, education attainment, livelihood activity and perception of effectiveness of the product.  $\beta$  is the coefficient and  $\epsilon$  is the error term.

## Results and Discussion

### 1. Distribution of respondents' socioeconomic characteristics

The distribution of gender, age, education, marital status and livelihood activities of respondents are presented in Table 1.

As revealed in Table 1, 68% of the respondents are male, the minimum and maximum ages of the respondents are 20 and 63 years respectively and the mean age of respondents is 35 years. Majority (98%) of the respondents are literates, with tertiary education attainment being the modal education by the respondents. About 61% of the respondents are engaged in public and government service as a source of livelihood, while about 17% are artisans and commercial traders, and 6% of the respondents are engaged into farming as a source of livelihood. About 14% of the respondents are students based in tertiary education.

<b>Socio-economic Characteristics (N=120)</b>		
	<b>Frequency</b>	<b>%</b>
<b>Gender</b>		
Male	82	68.3
Female	38	31.7
<b>Total</b>	<b>120</b>	<b>100</b>
<b>Age</b>		
<30	24	20
31-40	33	27.5
41-50	49	40.8
51-60	11	9.2
>60	3	2.5
<b>Total</b>	<b>120</b>	<b>100</b>
Mean age (35yrs)		
Minimum age (20yrs)		
Maximum age (63yrs)		
<b>Highest education attained</b>		
No formal	2	1.7
Adult education	1	0.8
Secondary	8	6.7
Tertiary	104	86.7
Quranic	5	4.2
<b>Total</b>	<b>120</b>	<b>100</b>
<b>Marital status</b>		
Single	38	31.7
Married	78	65
Divorced	4	3.3
<b>Total</b>	<b>120</b>	<b>100</b>
<b>Occupational Activity</b>		
Farming	8	6.7
Public/Government service	74	61.7
Artisans/commercial traders	21	17.5
Tertiary-based students	17	14.2
<b>Total</b>	<b>120</b>	<b>100</b>

Source: Field survey, 2012

Table 1: Distribution of socio-economic characteristics of respondents.

The socio-economic distribution of the study participants reflects the structural characteristics of a population living in close proximity to an university geographic location; majority of the respondents are educated and are involved government-based occupational activity. This is expected, as our sample was drawn from the Moringa consumer list generated from Moringa sales outlet located in the University. Our sample socio-economic characteristic in terms of education, marital status and occupational activity

is comparable to the studies of Theodoropoulou and Petros (2007) and Tesfay et al. (2012) which were conducted in similar study areas.

However a substantial minority of our sample are artisans and farmers who are non-literates and female respondents. This may tend to bias our result in favor of these socio-economic categories as against the general population of active Moringa consumers (Mitchell and Carson, 1989). With this population choice bias, we caution that our findings may not be representative of the population of Moringa consumers.

### 2. Awareness of nutraceutical use(s) of Moringa by-products by respondents

The result of awareness of various Nutraceutical uses of Moringa products by respondents is described in Table 2.

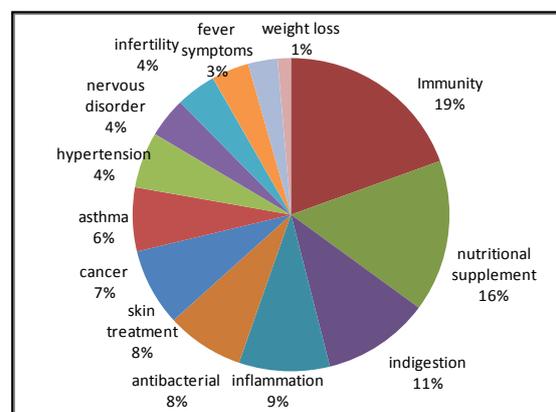
Table 2 indicates that Moringa awareness with respect to immunity build-up was ranked the first with about 74 % of the respondents reporting awareness of Moringa product use for this Nutraceutical purpose. This was followed by awareness as a nutritional supplement which ranked second, and indigestion and antibacterial uses occupying the third position respectively. Other uses include; skin treatment in 4<sup>th</sup> position, fertility and reproductive health related uses in 5<sup>th</sup> position, anti-inflammatory uses in 6<sup>th</sup> position, high blood pressure in 7<sup>th</sup> position, asthma treatment in 8<sup>th</sup> position, nervous disorder in 9<sup>th</sup> position, cancer prevention in 10<sup>th</sup> position, fever symptoms in 11<sup>th</sup> position, weight reduction in 12<sup>th</sup> position, and diabetes in 13<sup>th</sup> position respectively. The result of this finding is unsurprisingly supported with the findings of Saint Sauveur (2001) and Fahey (2005). Specifically, the study of Fahey (2005) made an extensive review of the therapeutic

and health uses of Moringa and identified with the therapeutic and nutritional uses reported in this study.

### 3. Consumers' nutraceutical and therapeutic choice(s) of Moringa use

In addition to identifying consumers' level of awareness of Moringa Nutraceutical benefits (Table 2), the study further identified and ranked the various nutritional and therapeutic uses those consumers actually put Moringa to use for. This is necessary because there might be a gap between what consumer knows and what actually operates with respect to Moringa Nutraceutical benefits.

The result Nutraceutical choices of Moringa products usages by respondents is described in Figure 1.



Source: Field survey, 2012

Figure 1: Distribution of consumers' choice(s) of nutraceutical use of Moringa products.

Figure 1 indicates that consumers' use of Moringa was ranked the first for immunity build up (19%) with about 16 % of the respondents reporting the use of Moringa product for this Nutraceutical purpose. This was followed by use for indigestion (11%).

Use Awareness of Moringa product by Respondents	Freq	%	Rank	Use Awareness of Moringa product by Respondents	Freq	%	Rank
Immunity build-up	89	74.2	1 <sup>st</sup>	High blood pressure	55	45.8	7 <sup>th</sup>
Nutritional supplement	82	68	2 <sup>nd</sup>	Asthma	55	45.8	8 <sup>th</sup>
Indigestion	74	61.7	3 <sup>rd</sup>	Nervous disorder	49	40	9 <sup>th</sup>
Antibacterial	74	61.7	3 <sup>rd</sup>	Cancer	46	38.3	10 <sup>th</sup>
Skin treatment	72	60	4 <sup>th</sup>	Fever symptoms	46	38	11 <sup>th</sup>
Fertility and reproductive health	68	56.7	5 <sup>th</sup>	Weight reduction	38	31.7	12 <sup>th</sup>
Anti-inflammation	58	48.3	6 <sup>th</sup>	Diabetes	24	20	13 <sup>th</sup>

Source: field survey, 2012

Table 2: Perceived nutraceutical awareness and ranking of awareness of Moringa products.

This study is consistent with previous research which underscored the use of the entire parts of Moringa in various culture and tradition for the treatment of these therapeutic disease conditions (Fahey, 2005).

The relative distribution and proportion of Moringa therapeutic use in this study, may however, slightly depart from sources from different regions of the world as the prevalence and epidemiology of disease is a function geographic and socio-economic predisposition of a particular population.

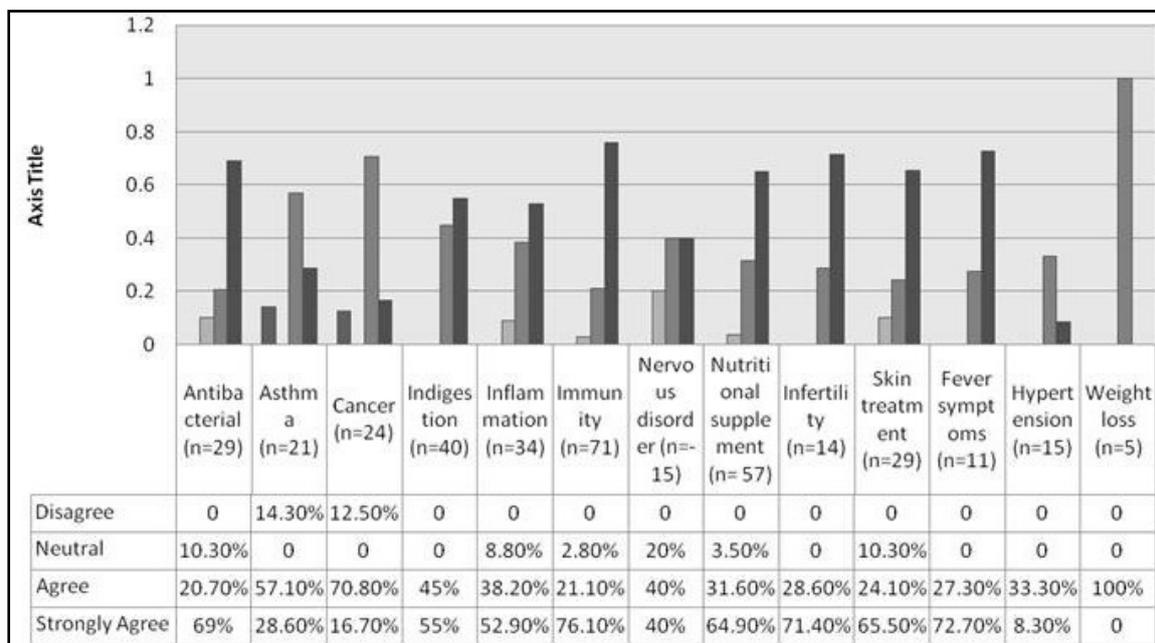
#### 4. Consumers' perceptions of effectiveness of Moringa's nutraceutical benefits

The result of consumers' perception with respect to the efficacy of Moringa in alleviating the symptom conditions for which is was used for is presented in Figure 2.

The result of the perception of respondents with respect to the efficacy of Moringa use in relieving certain disease condition is shown in Figure 2. The result shows that across each use category, majority of respondents indicate 'agree' and 'strongly agree' to the claims and efficacy of Moringa in satisfying the uses it was put to use. "Nether" of which indicates a state of neutrality to the health claim of Moringa was less indicated by

respondents except for antibacterial uses, immunity, nervous disorder, anti-inflammation uses and skin uses. "Disagree" which represents objection to the effectiveness of the purported claims of Moringa product by respondents was sparsely indicated for al use categories except for asthma and cancer. The apparent confidence in the nutritional properties of Moringa as revealed in this study is well supported in several oral and traditional literatures of communities where Moringa is used for health benefit (Fuglie, 1999 and Fuglie, 2000).

However, the validation of this perceptual evidence still requires clinical validation. It is acknowledged that several of Traditional Medicine claims have been validated following the claims of efficacy as attested to by users. For instance, the study of van Agtmael, et al. (1999) validated the use of *Artemisia annua* in treating drug resistant malaria, Le Bars et al. (1997) validated the use of garlic in lowering blood cholesterol and Reginster et al. (2001) validated the use of Glucosamine in the treatment of osteoarthritis. The use of Moringa for therapeutic benefits equally falls within the traditional medicine approach and a need for further clinical trials to validate these claims may be justified.



Source Field survey: 2012

Figure 2: Distribution of respondents' perceptions of the nutraceutical effectiveness of moringa.

Predictor variables	Coef.	Std. Err.	z	P>z
Gender (Male)	-0.9197942	0.3804909	-2.42	0.016***
Age	0.0141688	0.0206388	0.69	0.492
Marital status	0.2227772	0.2716128	0.82	0.412
Highest Education Attained (Tertiary)	0.062647	0.2881585	0.22	0.828
Occupational Activity	0.3781028	0.253344	1.49	0.136

Note:  $p > \chi^2 = 0.01$ \*\*\*  
 pseudo R<sup>2</sup> = 0.33  
 log likelihood = -134.227  
 key: \*\*\*significant at 1%

Table 3: Parameter estimates of the determinants of respondents' perceptions of moringa's effectiveness.

#### 4.1. Socio-economic determinants of respondents perceptions of nutraceutical effectiveness of moringa by-product

The result of the ordered logistic regression is presented in the parameter estimates in Table 3.

The model parameter estimates; the likelihood ratio test as observed by the significance of the  $\chi^2$  at 1 % shows that the model fits well with the predictor variables on it (Table 3). Accordingly, respondents' perception of the Nutraceutical claims of Moringa's was significantly related to gender ( $p < 0.05$ ) holding all other variables constant. Essentially, coefficient for male gender is negative implying that male respondents are less likely to affirm efficacy of Moringa products. Studies have confirmed that biological sex and socio-cultural gender influence stress-related diseases which may subsequently have an impact on response to treatment (Juster and Lupien, 2012; Mora, et al., 2012; Verdank and Kinge, 2012). However, the fundamental basis of the observed sexual dimorphism in perception of Moringa efficacy which may be inherent in the biological differences and/or the interactions of other factors including the differences in the socio-economic characteristic within and between the groups of this sample is unknown and may be the cause of further investigation.

#### 5. Distribution of consumers' willingness to pay for Moringa's processed dried-leaf powder

The distribution of consumers with regards to how much they are willing to pay for Moringa given their perceptions of the health benefits of the product over and above the current price at varying degree of 5%, 10%, 15%, 20%, and 25% increase is presented in Table 4.

According to the Table, about 58% of the respondents would not pay above the current price for the Moringa product used. However, 9.2%,

15%, 10% and 6.75 of the respondents were willing to pay 5%, 10%, 15%, and 25% respectively over and above the current price of their favorite Moringa product so as to have access to the perceived health benefits that the product offers.

Prices Consumers are WTP (N)	Freq	%
Current Price	70	58.3
5% increase	11	9.2
10% increase	18	15
15% increase	13	10.8
25% increase	8	6.7
<b>Total</b>	<b>120</b>	<b>100</b>

Note: Std deviation = 149.98  
 Source: Field survey, 2012

Table 4: Distribution of respondents willingness to pay for Moringa product (100g).

Few published data are available on the price of processed Moringa dried leaf powder in developing countries. Majority of data available through internet sales shows a lot of price differentials [www.siteserver2.co.uk/leonerresources/downloads/moringamarketreview.pdf](http://www.siteserver2.co.uk/leonerresources/downloads/moringamarketreview.pdf). The indication of willingness by respondents to pay a relatively higher price for Moringa at varying amount may be indicative of the satisfaction and/or the relative non-availability of alternative conventional therapies. This finding is supported by similar findings of Marvin et al, 2004 which indicated that consumers are willing to pay higher prices for processed foods that are closely related to Moringa product in terms of nutritional benefits.

#### 6. Determinants of respondents' willingness to pay for moringa's perceived benefits

The logistic regression model parameter estimates of the determinants of respondents' willingness to pay above the current offered price for Moringa by-products are presented in Table 5.

Predictor Variables	Coeff	Std. Err.	Z	P>/z/
Satisfaction with Benefits	1.451185	0.4528996	3.2	0.001***
Gender	0.5376934	0.5016848	1.07	0.284
Age	-0.0000737	0.239783	0	0.998
Marital status	0.0482926	0.3229728	0.15	0.881
Education	0.7797345	0.3546667	2.25	0.025**
Livelihood activities	-1.046816	0.3499478	-2.99	0.003***
Constant	-2.270687	2.074167	-1.09	-6.335

Note: Log likelihood = -62.38, P > chi<sup>2</sup> = 0.01, LR chi<sup>2</sup> (6) = 28, Pseudo R<sup>2</sup> = 0.483,

\*\*\*= significant at 1 %

\*\*=significant at 5%

Source: Field survey, 2012

Table 5: Determinants of respondents' willingness to pay for moringa products.

The model parameter estimates; the log likelihood ratio (LR) test significance at 1% indicates that the model with the predictor variables in it is statistically different from the one with only the constant and suggests the fitness of the model in explaining the predictor variables (chi<sup>2</sup> = 28, p < 0.01, diff = 6). The R<sup>2</sup> of 0.483 indicates that 48% of the variation in consumers' WTP could be attributed the variables in the model and the need for further studies that would capture other variables which could significantly contribute to explaining the variations in the consumers' WTP. According to Table 5, willingness to pay above the current price was found to be significantly related to satisfaction derived from using the product (p = 0.01), education (p = 0.03) and livelihood activities of the respondents (p=0.01).

The result shows that respondents' satisfaction with the health benefits of the product positively (p<0.01) influenced their willingness to pay, holding all other variable constant. This is expected in theory and corroborated by previous literatures. Confidence in the efficacy of the treatment may influence willingness to pay in line with utility maximization theory. Furthermore, the study of Winston and Patel (1995) identified that the primary factor in opting for a traditional medicine is the confidence in the treatment, ease of access, and convenience (Winston and Patel, 1995). The willingness of respondents to pay more for Moringa products due to the perceived health benefits could possibly justify the Nutraceutical claims of the product, however, more clinical trials still need to be carried out to further validate this result and or define the gap between perception and conventional medical (clinical) evidence in case versus control and double blind placebo trials.

Equally, the possession of formal education significantly increased the likelihood of willingness to pay for Moringa product (p<0.05) given that all other variables are held constant. The possession of formal education may have an influence on access to both printed and/or digital information which would subsequently enhance access to information pertaining to the Nutraceutical benefits of Moringa. The interpretation of this information may be of relevance in influencing certain decision pertaining to respondents' willingness to pay. The interpretation of this knowledge is however subjective to each individual consumer disposition to the credibility of the source of the information.

Conversely, respondents engaged in public service likelihood were less likely to pay more for Moringa products in the study area given that all other variables in the model are held constant (p<0.01). This may be because such category of respondents has a relatively higher access to alternative health products and facilities as a result of their institutional affiliations. Or it could equally be as a result of access to subsidized prepaid health schemes as most respondents engaged in public services in the study area are usually involved in government-assisted prepaid health insurance scheme. This may influence their decision not to incur any additional financial cost for the purchase of Moringa as such are not likely to be covered by the health insurance scheme since it is not dispensed in registered health centers.

## Conclusion

The main objective of this study was to explore the validity of claimed Nutraceutical benefits of Moringa through the lens of consumers'

perceptions of its effectiveness in alleviating certain health conditions and to define factors that determine their willingness to pay for access to these benefits. Based on the study's findings, the following conclusion could be drawn from the study:

1. Majority of the consumers are aware of one Nutraceutical benefits or another of Moringa consumption; however, awareness was in varying degrees depending on the type of usage.
2. Majority of respondents consuming Moringa for preventive and treatment of health reasons are satisfied with the product and agree to its effectiveness.
3. The perception of that Moringa is effective in delivering desired Nutraceutical benefits was significantly influenced by gender of respondents. Males were skeptical in expressing satisfaction to efficacy.
4. While the basis of the observed sexual dimorphism in perception of efficacy is unknown, the very fact is instructive for planning product packaging advertising and promotion in a way that caters for this particular differences between gender groups.
5. Respondents are equally willing to pay more at various levels of 5%, 10%, 15% and 25%

over and above Moringa's current price so as to have access to the desired benefits of Moringa products.

6. Willingness to pay was found to be significantly related to consumers' perception of satisfaction derived from using Moringa products, education and working with a government based public service at 5% and 1% level.

From the results of this study, the authors advance the following recommendations:

- i. intensify clinical and pharmacological research to test claims of the therapeutic benefit Moringa;
- ii. marketing should take cognizance of the significant gender and livelihood activity effects on perception;
- iii. a survey of non-adopters may shed additional light on consumer behavior as it relates to claimed health benefits of Moringa;
- iv. the power of the R<sup>2</sup> in the models estimated for the determinants of perceptions and Willingness to Pay calls for additional studies to be undertaken that would identify other factors that could be influence consumers perceptions to product efficacy and WTP.

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## Capital Structure of Agricultural Businesses and its Determinants

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### Anotace

Príspevek se zabývá analýzou kapitálové struktury zemědělských podniků právnických osob a jejich determinant. Je řešen vliv vybraných determinant na kapitálovou strukturu podniků, vyjádřenou prostřednictvím třech kategorií zadluženosti. Analýza determinant kapitálové struktury je provedena prostřednictvím vícenásobné lineární regrese. Rovněž je ověřována hypotéza, zda vliv jednotlivých determinant kapitálové struktury je v souladu s teoretickými předpoklady podmíněných teorií kapitálové struktury a empirickými studii.

Panelová data pro článek byla získána z databáze Albertina, poskytovaná společností Soliditet, s.r.o. Konkrétně byla využita data z účetních výkazů za roky 2004 – 2010 u zemědělských podniků právnických osob. Celkem bylo předmětem šetření 16075 podniků, které byly rozděleny dle právních forem (akciová společnost, družstvo a společnost s ručením omezeným) a následně příslušné velikostní skupiny. Celkem vzniklo 18 skupin podniků, kdy za každou skupinu byla sestavena průměrná rozvaha a výsledovka, na jejichž základě byly provedeny příslušné výpočty. Příspěvek je součástí grantového projektu IGA 20121069 „Identifikace hlavních determinant výsledku hospodaření zemědělských podniků právnických osob a určení jejich specifik“ a výzkumného záměru MŠMT 6046070906 „Ekonomika zdrojů českého zemědělství a jejich efektivní využívání v rámci multifunkčních zemědělskopotravinářských systémů“.

### Klíčová slova

Kapitálová struktura, determinanty kapitálové struktury, zemědělské podniky, vícenásobná lineární regrese, podmíněné teorie kapitálové struktury.

### Abstract

The article deals with the analysis of the capital structure of agricultural businesses of legal entities and its determinants. It discusses the effect of selected determinants on the capital structure of businesses, expressed by way of three categories of indebtedness. The analysis of the determinants of capital structure is conducted by way of multiple linear regression. Also being verified is the hypothesis of whether the effect of individual determinants of capital structure is in accordance with the theoretical assumptions of conditional theories of capital structure and empirical studies.

The panel data for the article were acquired from the Albertina database, provided by the company Soliditet, s.r.o. Specifically, the data used were those from accounting statements for the years 2004 – 2010 for the agricultural businesses of legal entities. In total, the object of examination was 16075 businesses, which were divided up according to legal forms (joint stock company, cooperative, and limited liability company) and subsequently the relevant size group. In total, 18 groups of businesses were created, whereby the average balance and profit and loss account were drawn up for each group, on the basis of which the relevant calculations were conducted. The article is a part of the grant project IGA 20121069 “Identification of the main determinants of the result of economic activity of agricultural businesses of legal entities and the determination of their specifics” and of the institutional research intentions MSM 6046070906 „Economics sources of Czech agriculture and their efficient use in the context of multifunctional agri-food systems“.

### Key words

Capital structure, determinants of capital structure, agricultural businesses, multiple linear regression, theories of capital structure.

## **Introduction**

The agricultural sector is a very significant part of the national economy. It is also included among the very sensitive areas of the economy, as it has its specifics that must be respected. Its specificity is caused primarily by the seasonal character of production, a high level of dependence on natural conditions, as well as the production structure. Those specifics are clearly reflected in the economic results of agricultural businesses and also affect the set-up of their capital structure.

The capital structure of agricultural businesses, which enables the monitoring of the utilization of capital within a business, is greatly differentiated. Such differentiation is seen at the level of countries, sectors, and of course within areas of business. The effective set-up of the capital structure is the main objective of the financial management of a business. The decision on the proportion of own and external sources of financing is key for a business in terms of further development. The generally applicable rule is that external capital is cheaper for a business than its own capital, as the business is able to maintain the control of the owners, spread risk among the owners and creditors, and can also utilize the deduction of interest from the tax base. However, that applies only up to a certain level of indebtedness, or until the moment when the costs for own capital are higher than for external capital. Then we can say that a business is able to increase the value of capital at a greater rate than is the interest rate on external resources, which has a positive effect on the rate of return of own capital. On the other hand, the utilization of an excessive amount of external capital, in the absence of the above condition, leads to a decrease in the possibility of acquiring further sources of financing and also to an effect on the actions of management, which must take into consideration the requirements of creditors. It is therefore necessary to regularly assess and effectively manage the capital structure and its determinants.

Every business aims for such a capital structure that fulfills the basic presumption of doing business, i.e. the achievement of maximum profit for the owners. For such reason, the structure of a business must be designed with the goal of its optimization, i.e. with the securing of sufficient capital with minimum costs expended for it (Nývtlová, Marinič, 2010). It is therefore evident that the utilization of any capital is associated

with costs expended for it. In the case of external capital, these are represented primarily by cost interest, and in the case of own capital they are expressed at the level of opportunity costs. In financial theory, the issue of the relationships between own and external capital is dealt with by so-called conditional theories of capital structure of businesses. Those can basically be divided up into two basic groups. The first group consists of static theories of capital structure, which are based upon economic theory, and create a proposal or model of capital structure of businesses specifically on the basis of information from economic theory. Subsequently, their theoretical verification is performed. The conclusions of individual exponents of this group differ, but they do have a common theme in that they discuss whether there is an objective balanced target state of the business, in terms of the relationship between its market value and the chosen capital structure. At the same time, they deal with whether businesses should make an effort to achieve it and secure it by way of financial decisions (Kislingerová et al., 2007). The second group consists of dynamic theories of capital structure, which are based upon a completely different principle. In creating proposals or models of capital structure, they focus on information on the actual behavior of businesses and, on the basis of that, they create theoretically generalized concepts (Kalouda, 2009). The basis of this theory is the opinion that an optimum capital structure basically does not exist and that the attempt to generalize in the area of the optimization of capital structure and its effect on the market value of a business can be misleading. They base their opinion on the assumption that every business continuously optimizes its financial decisions in view of changing specific conditions.

The evaluation of capital structure and its determinants is the object of research of a number of authors and it is thus possible to identify a broad spectrum of professional literature and articles that focus on such area. Such research comes primarily from the USA and focuses primarily on industrial businesses, specifically on small and mid-sized businesses. In the area of Europe, such research is then usually based on the USA, and is variously expanded and supplemented. Most recently, such issues are increasingly often coming to the forefront of interest of both theoretical as well as empirical studies, which focus not only on the practical utilization of individual conditional theories

of capital structure, but a number of them focus primarily on the discussion relating to the definition of the term of capital structure and the analysis of its determinants. The results of the empirical verification of the effect of selected determinants of capital structure can be summarized in the following Table 1.

The set-up of the capital structure within a business is a demanding process that is affected by a number of factors. The identification of such factors is very important primarily in terms of the future development of the business in the sense of the process of optimization of the structure of its capital, which is the result,

Determinants	Theoretical prediction	Conclusions of empirical studies
Size	(-) Pecking order theory	<b>Total Debt (+)</b> Rajan, Zingales (1995); Weill (2004); Song (2005); Michaelas, Chittenden, Poutziouris (1999); Delcoure (2007); Hutchinson, Hall, Michaelas (1998); Kayo, Kimura (2011); Chen (2004); Friend, Lang (1988); <b>Total Debt (-)</b> Chittenden, Hall, Hutchinson (1996) <b>Long-term Debt (+)</b> Michaelas, Chittenden, Poutziouris (1999); Mateev, Poutziouris, Ivanov (2012); Chittenden, Hall, Hutchinson (1996); Hutchinson, Hall, Michaelas (1998); Bevan, Danbolt (2002); <b>Long-term Debt (-)</b> Chen (2004); Delcoure (2007); Song (2005) <b>Short-term Debt (+)</b> Song (2005); Delcoure (2007); Mateev, Poutziouris, Ivanov (2012); <b>Short-term Debt (-)</b> Chittenden, Hall, Hutchinson (1996); Hutchinson, Hall, Michaelas (1998); Michaelas, Chittenden, Poutziouris (1999);
	(+) Trade-off theory	
Profitability	(-) Pecking order theory	<b>Total Debt (+)</b> Weill (2004); <b>Total Debt (-)</b> Rajan, Zingales (1995); Song (2005); Michaelas, Chittenden, Poutziouris (1999); Delcoure (2007); Chittenden, Hutchinson, Hall (1996); Hutchinson, Hall, Michaelas (1998); Bevan, Danbolt (2002); Kayo, Kimura (2011); Chen (2004); Friend, Lang (1988); Prášilová (2012); Bradley, Jarell, Kim (1984); <b>Long-term Debt (-)</b> Song (2005); Michaelas, Chittenden, Poutziouris (1999); Delcoure (2007); Mateev, Poutziouris, Ivanov (2012); Chittenden, Hutchinson, Hall (1996); Hutchinson, Hall, Michaelas (1998); Bevan, Danbolt (2002); Chen (2004); <b>Short-term Debt (-)</b> Song (2005); Michaelas, Chittenden, Poutziouris (1999); Delcoure (2007); Mateev, Poutziouris, Ivanov (2012); Chittenden, Hutchinson, Hall (1996); Hutchinson, Hall, Michaelas (1998); Bevan, Danbolt (2002);
	(+) Trade-off theory	
Tangibility	(-) Pecking order theory	<b>Total Debt (+)</b> Rajan, Zingales (1995); Song (2005); Michaelas, Chittenden, Poutziouris (1999); Delcoure (2007); Bevan, Danbolt (2002); Kayo, Kimura (2011); Chen (2004); Friend, Lang (1988); <b>Total Debt (-)</b> Weill (2004); Chittenden, Hall, Hutchinson (1996); Hutchinson, Hall, Michaelas (1998); <b>Long-term Debt (+)</b> Prášilová (2012); Song (2005); Michaelas, Chittenden, Poutziouris (1999); Delcoure (2007); Mateev, Poutziouris, Ivanov (2012); Chittenden, Hall, Hutchinson (1996); Hutchinson, Hall, Michaelas (1998); Bevan, Danbolt (2002); Chen (2004); <b>Short-term Debt (+)</b> Michaelas, Chittenden, Poutziouris (1999); Delcoure (2007);
	(+) Trade-off theory	

Source: own processing

Table 1: Theoretical prediction and conclusions of empirical studies of selected determinants of capital structure.

Determinants	Theoretical prediction	Conclusions of empirical studies
Non-debt tax shield	(-) Trade-off theory	<b>Total Debt (+)</b> Delcoure (2007); Bradley, Jarrell, Kim (1984); MacKie, Mason (1990); <b>Total Debt (-)</b> Chen (2004); DeAngelo, Masulis (1980) <b>Long-term Debt (+)</b> Delcoure (2007); Long-term Debt (-) Song (2005); Michaelas, Chittenden, Poutziouris (1999); Chen (2004); <b>Short-term Debt (+)</b> Song (2005); Delcoure (2007);
Retained profits	(-) Pecking order theory	<b>Total Debt (+)</b> Brav (2009)
	(+) Trade-off theory	
Liquidity	(-) Pecking order theory	<b>Total Debt (-)</b> Šarlija, Harc (2012); <b>Long-term Debt (+)</b> Šarlija, Harc (2012); Mateev, Poutziouris, Ivanov (2012); <b>Short-term Debt (-)</b> Šarlija, Harc (2012); Mateev, Poutziouris, Ivanov (2012);

Source: own processing

Table 1: Theoretical prediction and conclusions of empirical studies of selected determinants of capital structure, continuation.

and the determinants are the cause of such process. The individual determinants of capital structure are very closely interconnected with conditional theories of capital structure. Based on conditional theories of capital structure and in terms of the empirical studies that have already been conducted, it can be stated that the determinants of capital structure can be divided up into so-called external and internal determinants of capital structure (Prášilová, 2012). The group of external determinants includes those that the business **cannot** affect, such as economic policy, for example (primarily monetary policy and its effect on the development of interest rates), the legislative environment (level of taxation), the degree of the development of the economy, the environment, governmental intervention, the situation on the capital market, informational asymmetry, and others. The group of internal determinants, i.e. the determinants that the business can affect to a certain extent, can then be considered to include a number of factors that are primarily given by the type and economic activity of the company. In this group, Prášilová (2012) includes, for example, some indicators of the productivity of a business, such as the asset structure, the profitability of assets, liquidity, profit stability and cash-flow, or also the uniqueness of the product, the growth opportunities of the business, sector pertinence, and the age of the business.

The objective of this article is to identify the main determinants of the capital structure of agricultural businesses of legal entities in the Czech Republic and to quantify their effect, including the interconnection of the results with the conclusions of conditional theories of capital structure and empirical studies. The main objective is fulfilled by way of the following partial objectives:

- the definition of the main indicators of indebtedness, by way of which the capital structure of agricultural business will be expressed, on the basis of the recommendations of empirical studies;
- the identification of the main determinants of capital structure on the basis of the theoretical definition of the analyzed issue;
- the quantification of the effect of the main determinants, the determination of the direction of their dependency, and the assessment of their development in relation to capital structure, on the basis of multiple regression analysis;
- the definition of statistically significant determinants and the interconnection of the results of regression analysis with the conclusions of conditional theories of capital structure and the conclusions of empirical verification.

Also being verified is the hypothesis of whether the effect of individual determinants of capital structure is in accordance with the theoretical assumptions of conditional theories of capital structure and empirical studies.

## Materials and methods

The analytical section is based on the data of agricultural businesses of legal entities in the Czech Republic within the period of 2004 – 2010. The data base of agricultural businesses of legal entities was obtained from the Albertina database of business entities, created by the company Soliditet, s.r.o. The object of examination was the businesses of legal entities, specifically joint stock companies, cooperatives and limited liability companies, with predominating activity in agriculture, classified as OKEČ 01 according to the OKEČ classification. The obtained accounting statements of individual businesses were further supplemented with the area of agricultural land for each business. That was obtained from a publicly accessible database administrated by the State Agricultural Intervention Fund (hereinafter the “SZIF”), containing information regarding the amount of direct payments provided to businesses of legal entities. On the basis of such information, the area of individual agricultural businesses was subsequently determined, by way of the proportion of the obtained SAPS subsidy and its unit rate in the given year.

The data were aggregated from several different information sources and the resulting table contained more than sixteen thousand entries. For the subsequent examination, only the data of companies with accounting statements pertaining to an extent of at least 6 months within the given accounting period were utilized.

The object of assessment was 16075 businesses, which were divided up according to legal forms (joint stock company, cooperative, and limited liability company) and subsequently the relevant size group (six groups). In total, 18 groups of businesses were created, whereby the average balance and profit and loss account were drawn up for each group, on the basis of which the relevant calculations were conducted.

For the quantification of the relationships between the variables and primarily also for the modeling of the dependency of selected variables on pre-defined factors, a regression model in linear form is used, which was evaluated as

the most appropriate on the basis of mathematical-statistical criteria (coefficient of determination, standard error of regression coefficients and testing) and with the use of Statistica 10 software. The general form of the multiple linear regression model can be set out as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n + \varepsilon,$$

where

$y$  ... is the explained variable (successively total indebtedness; or long-term indebtedness; or short-term indebtedness),

$x_1, \dots, x_n$  ... are explanatory variables (determinants of capital structure: size, ROA, collateral value of assets, non-debt tax shield, retained profit, liquidity),

$\beta_0, \dots, \beta_n$  ... are unknown regression coefficients,

$\varepsilon$  ... is the stochastic (random) element including the errors of the model.

The quantification of the effect of the factors on the capital structure of businesses is conducted with the utilization of the STATISTICA statistical software. Individual regression parameters are estimated by way of the method of least squares. The linear model was utilized in parameters as well as in variables and it was not necessary to linearize it in any way (Cipra, 2008). The estimated regression parameters simultaneously represent the coefficients of flexibility of the individual variables. On the basis thereof, we can therefore deduce the average changes of a dependent variable upon a unit change of a selected variable with the constant effect of the remaining variables.

Multiple linear regression is calculated for each year separately (in the time line of 2004 - 2010), so that partial changes within individual years are explained, primarily as pertains to the direction of the dependence of individual determinants of capital structure. In each of the assessed cases, all three models of indebtedness are calculated. In the regression models, its assumptions were verified as pertained to the random element and, in general, multicollinearity between the selected determinants of capital structure. The presence of multicollinearity between explanatory variables is undesirable, as it can distort the estimated parameters. Meloun and Militký (2004), or Hušek (2004) consider multicollinearity to be harmful in the event that the correlation coefficient  $|r_{yx}| > 0.8$ . That means that in the event that any

Indicator	Determination*
Dependent Variables	<b>Total Debt</b> / <i>Total debt (BS85) / Total Assets (BS1)</i>
	<b>Long-term Debt</b> / <i>Long-term Debt (BS86+BS91+BS115) / Total Assets (BS1)</i>
	<b>Short-term Debt</b> / <i>Short-term Debt (BS102+BS116+BS115) / Total Assets (BS1)</i>

Note: \*) determination of Dependent Variables in relation to the balance sheet lines

Source: own processing

Table 2: Identification of dependent variables entering into regression models.

of the pair correlation coefficients exceeds such value, the model should be adjusted, or the structure of independent variables should be re-evaluated. In the event of the existence of multicollinearity, the relevant variable was then eliminated and the entire process of analysis was performed again.

## Results and Discussion

Firstly, the main determinants of the capital structure of agricultural businesses of legal entities were first identified, on the basis of professional studies focusing on such issues. Subsequently, by way of regression analysis, their effect on the selected indicators of indebtedness was quantified and discussed, including the interconnectedness of such results with the selected empirical studies. The analysis itself is performed for agricultural businesses of legal entities in the Czech Republic within the period of the years 2004 - 2010, whereby the object of assessment was 16075 businesses, which were divided up according to legal forms (joint stock company, cooperative, and limited liability company) and subsequently the relevant size group (six groups). In total, 18 groups of businesses were created, whereby the average balance and profit and loss account were drawn up for each group, on the basis of which the relevant calculations were conducted.

### 1. Identification of the main determinants of the capital structure of agricultural businesses

A large number of factors that affect the capital structure of agricultural businesses can be found. However, on the basis of the specifics of the sector of agriculture and individual professional studies, primarily the following can be considered to be the main determinants:

- size of the business – expressed by way of the size of revenues;
- profitability – expressed by way of the profitability of assets;

- tangibility – expressed by way of the share of tangible assets in total assets;
- non-debt tax shield – expressed by way of the proportion of deductions to total assets;
- retained profits – expressed by way of the sum of all retained profits within the business;
- liquidity – expressed by way of the proportion of current assets to current liabilities.

A detailed identification of the main determinants of capital structure is set out in the following Table 3.

### 2. Quantification of the effect of the main determinants of capital structure of agricultural businesses

The following text sets out and discusses the results of multiple regression analysis of sectional data, which describes the effect of individual determinants on capital structure. Three models are drawn up in all, in such a way so that the effect of such determinants on individual categories of indebtedness can be examined separately. Each of the tables set out below contains the basic characteristics of the analyzed groups of businesses in terms of individual categories of indebtedness within the analyzed period of 2004 - 2010 (the average of the values of the relevant category of indebtedness, the median of the values, the standard deviation), the basic characteristics of the quality of the created model (the coefficient of determination and the p-value), as well as the quantification of the effect of the main determinants (estimated parameters, p-value and direction of dependency) affecting the capital structure. As statistically significant were defined those determinants that showed a statistical significance at least at a level of significance of  $\alpha$  0.1 in more than half of the analyzed years (4 years).

Table 4 demonstrates that no great fluctuation

Dependent Variables	Size	Total sales
	Profitability	EBIT / Total Assets
	Tangibility	Tangible Assets / Total Assets
	Non-debt tax shield	Depretiation / Total Assets
	Retained profits	Reserve funds, Statutory reserve account for cooperatives and other retained earnings + profit/loss previous years + profit/loss current year
	Liquidity	Current Assets / Short-term liabilities

Source: own processing

Table 3: Identification of the main determinants of capital structure.

Indicator/Determinants of capital structure	Characteristic	Year						
		2004	2005	2006	2007	2008	2009	2010
Total debt	Average	0.528	0.521	0.508	0.497	0.491	0.499	0.472
	Median	0.527	0.497	0.503	0.477	0.464	0.484	0.427
	Standard deviation	0.173	0.166	0.146	0.154	0.137	0.168	0.171
Quality of model	Coefficient of determination	0.82278	0.94931	0.90846	0.80886	0.70089	0.8966	0.74629
	p- value	0.000355	0.000002	0.000008	0.001912	0.006739	0.000077	0.007975
Explanatory variables								
Size	Statistical significance	**	****	****	**	*	**	-
	Regression coefficients	0	0	0	0	0	0	0
	Direction of dependency	positive	positive	positive	positive	positive	positive	positive
Profitability	Statistical significance	eliminated	*	-	-	-	**	-
	Regression coefficients	eliminated	1.76012	1.76082	0.10375	1.43597	-2.07908	-0.23752
	Direction of dependency	eliminated	positive	positive	positive	positive	negative	negative
Tangibility	Statistical significance	*	****	***	-	*	-	-
	Regression coefficients	-0.84822	-1.64386	-1.98197	-0.86171	-1.31099	-0.5032	-0.84611
	Direction of dependency	negative	negative	negative	negative	negative	negative	negative
Non-debt tax shield	Statistical significance	***	-	-	-	-	-	-
	Regression coefficients	9.51133	1.2967	0.24874	-0.9601	-4.32154	6.93468	7.03469
	Direction of dependency	positive	positive	positive	negative	negative	positive	positive
Retained profits	Statistical significance	**	***	*	*	-	***	-
	Regression coefficients	0.00001	0.00001	0	0	0	0.00001	0
	Direction of dependency	positive	positive	positive	positive	positive	positive	positive
Liquidity	Statistical significance	***	*	eliminated	**	eliminated	****	***
	Regression coefficients	-0.18563	-0.0517	eliminated	-0.09868	eliminated	-0.25042	-0.15203
	Direction of dependency	negative	negative	eliminated	negative	eliminated	negative	negative

Source: own processing

Note: Statistical significance: -) coefficient is not significant, \*)  $\alpha = 0.1$ ; \*\*)  $\alpha = 0.05$ ; \*\*\*)  $\alpha = 0.01$ ; \*\*\*\*)  $\alpha = 0.001$

Table 4: Conclusions of analysis indebtedness of agricultural businesses of legal entities in the years 2004 - 2010, Model of total indebtedness – Model 1.

of the average values of total indebtedness occurred among the assessed groups of businesses. The highest average value was achieved in 2004, specifically a value of 0.528. The lowest average value was then achieved in 2010, when the average value of indebtedness fell to a level of 0.472. The result of indebtedness in 2004 is clearly associated with the entry of the Czech Republic

into the EU, when the opportunities of access to external sources of financing improved for agricultural businesses, primarily in the form of bank loans, and a significant effect was also caused by the support of investment activities from the EU, where specifically the motivation of the co-financing of investment activities played a significant role in the making of decisions regarding the application

of further external capital within the business.

The estimated parameters show that increases in size, profitability (ROA), non-debt tax shield and the amount of retained profits have a positive impact on the value of indebtedness. However, not all such dependencies apply without exception. A change in the effects of the determinant of profitability on the value of indebtedness is apparent in 2009 and 2010, and the negative effect of the non-debt tax shield is then apparent in 2007 and 2008. For further determinants, i.e. the collateral value of assets and liquidity, a clearly negative effect on indebtedness was established.

In terms of the theoretical level, the relationship between the size of the business and indebtedness is unclear. A positive relationship is in accordance with the trade-off theory, which assumes that large businesses have lower bankruptcy costs, are more diversified, and that affects their access to external capital. On the other hand, the pecking order theory assumes that larger businesses provide less asymmetrical information on financial markets and are able to issue more own capital as compared to small companies. Fama and Jensen (1983) assume that less asymmetrical information can appear about large companies, because such companies have a tendency to provide more information to external investors than smaller companies. That should increase their preferences for the utilization of own capital in terms of debt. As regards empirical studies, the relationship between the size of the business and indebtedness is also unclear. Very often, such fact is given by the statistical insignificance of this parameter and also by the various conclusions of empirical studies that confirm both a positive relationship as well as a negative relationship. However, the majority of empirical studies confirm a positive relationship between the size of the business and indebtedness (Rajan, Zingales, 1995; Weill, 2004; Song, 2005; Friend, Lang, 1988; Delcoure, 2007; Kayo, Kimura, 2011; Michaelas, Chittenden, Poutziouris, 1999; Hutchinson, Hall, Michaelas 1998; Chen, 2004), which are also in line with the results of the conducted analysis. From an economic standpoint, it can be stated that upon a change in the size of the business (revenues) by a unit, a nearly zero change in capital structure occurs. We can therefore deduce that within the analyzed set of businesses, a nearly zero increase in total indebtedness occurred upon an increase in revenues. Such fact is entirely logical from an economic standpoint, as an increase

in the market share provides a business with a better position and stabilizes its capital structure.

The **collateral value of assets** showed a clearly negative effect on total indebtedness. The negative effect of the collateral value of assets on indebtedness is in conflict with the theoretical assumptions of the trade-off theory, which defines a positive relationship between the collateral value of assets and indebtedness, as tangible assets represent a collateral value for creditors. In the event that financial distress occurs, the business is able to quickly monetize such type of assets. However, in the case of the analyzed sample of agricultural businesses of legal entities, such fact does not apply. However, such result does correspond to the pecking order theory, which assumes that businesses with a higher level of tangible assets do not have a tendency to face problems with asymmetrical information and the utilization of debt is less probable for them. In terms of empirical verification, conclusions primarily of a positive effect of the collateral value of assets on total indebtedness predominate (Rajan, Zingales, 1995; Song, 2005; Michaelas, Chittenden, Poutziouris, 1999; Delcoure, 2007; Kayo, Kimura, 2011; Chen, 2004; Friend, Lang, 1988; Bevan, Danbolt, 2002). However, some empirical studies also speak of a negative dependency (Weill, 2004; Chittenden, Hall, Hutchinson, 1996; Hutchinson, Hall, Michaelas 1998), which is in accordance with the ascertained results. From an economic standpoint, such phenomenon within the set of agricultural businesses can be interpreted as follows: after the entry of the Czech Republic into the EU, investment activity of the agricultural sector was supported in a significant manner as part of efforts to strengthen competitiveness, new buildings were constructed for animal production, and new and more efficient machinery and technologies were acquired. The increase in investments in businesses caused greater productivity of labor, better results of economic activity, and upon their accumulation in regard to the value of own capital, a decrease in indebtedness occurred thereby.

**Retained profit** showed a clearly positive effect on total indebtedness. Such relationship corresponds to the assumptions of the trade-off theory and also to the results of empirical investigations (Brav, 2009), which concur on a positive direction of dependence. In terms of the strength of dependence, it can be stated that upon a change in retained profit by a unit, a nearly zero change

in capital structure occurs. It can thus be deduced that, within the analyzed set of businesses, a nearly zero increase in total indebtedness occurred upon an increase of retained profits. From an economic standpoint, such result can thus be interpreted in such a way that, with an increase in the volume of retained profits, businesses are able to simultaneously stabilize and optimize their capital structure, without a significant increase in indebtedness.

**Liquidity** was established as a statistically significant factor, with a negative effect on indebtedness. Such result is in accordance with the pecking order theory, which assumes that after the deduction of current liabilities, businesses with greater liquidity achieve greater current assets, or working capital, which is a prerequisite for generating a greater value of profit. Therefore, businesses with greater liquidity can generate more profit and do not have to utilize external capital.

Such result is also in accordance with the results of empirical studies - Šarlija, Harc (2012), Frieder a Martell (2006), Lipson a Mortal (2009), Morellec (2001), Myers a Rajan (1998).

Table 5 demonstrates that for the assessed groups of businesses, there was no great fluctuation in the average values of long-term indebtedness. The estimated parameters show that an increase in size, profitability (ROA), non-debt tax shield and the amount of retained profits have a positive impact on the value of indebtedness. However, not all such dependencies apply without exception. A change in the effect of the determinant of profitability on the value of indebtedness is evident in the years 2006 and 2009, and a negative effect of the non-debt tax shield is seen in the years 2005 and 2008. For the collateral value of assets, a clearly negative effect on long-term indebtedness was established. For liquidity, a negative dependence predominates, whereby it shows a change

Indicator/Determinants of capital structure	Characteristic	Year						
		2004	2005	2006	2007	2008	2009	2010
Total debt	Average	0.302	0.314	0.294	0.298	0.274	0.265	0.298
	Median	0.322	0.33	0.322	0.316	0.305	0.306	0.28
	Standard deviation	0.127	0.116	0.098	0.116	0.085	0.086	0.198
Quality of model	Coefficient of determination	0.81543	0.8963	0.82964	0.83477	0.7897	0.72859	0.67097
	p- value	0.00045	0.00008	0.00028	0.0009	0.00094	0.01112	0.02818
Explanatory variables								
Size	Statistical significance	***	***	****	**	***	**	-
	Regression coefficients	0	0	0	0	0	0	0
	Direction of dependency	positive	positive	positive	positive	positive	positive	positive
Profitability	Statistical significance	eliminated	-	-	-	**	-	-
	Regression coefficients	eliminated	1.1325	-0.95622	0.9189	1.10469	-0.25528	2.58669
	Direction of dependency	eliminated	positive	<b>negative</b>	positive	positive	<b>negative</b>	positive
Tangibility	Statistical significance	***	****	***	-	-	-	*
	Regression coefficients	-1.26953	-1.13668	-1.44019	-0.87588	-0.21062	-1.08648	1.31163
	Direction of dependency	negativni	negativni	negativni	negativni	negativni	negativni	<b>positive</b>
Non-debt tax shield	Statistical significance	***	-	*	**	-	-	*
	Regression coefficients	8.09558	-0.4147	4.90613	6.30879	-0.79487	2.72399	3.50873
	Direction of dependency	positive	<b>negative</b>	positive	positive	<b>negative</b>	positive	positive
Retained profits	Statistical significance	***	***	***	**	**	**	-
	Regression coefficients	0.00001	0.00001	0	0	0	0	0
	Direction of dependency	positive	positive	positive	positive	positive	positive	positive
Liquidity	Statistical significance	-	-	eliminated	-	eliminated	-	***
	Regression coefficients	-0.01897	0.00526	eliminated	-0.05086	eliminated	0.00185	-0.17209
	Direction of dependency	negative	positive	eliminated	negative	eliminated	positive	negative

Source: own processing

Note: Statistical significance: -) coefficient is not significant, \*)  $\alpha = 0.1$ ; \*\*)  $\alpha = 0.05$ ; \*\*\*)  $\alpha = 0.01$ ; \*\*\*\*)  $\alpha = 0.001$

Table 5: Conclusions of analysis indebtedness of agricultural businesses of legal entities in the years 2004 - 2010, Model of long-term indebtedness - Model 2.

in the direction of dependency to positive in 2009.

In the long-term indebtedness model, **size**, collateral value of assets, non-debt tax shield and retained profit were shown to be the statistically most significant determinants. The dependence of total indebtedness on size (expressed by way of revenues) was also clearly established as positive in such model, within the entire assessed time period. In terms of theoretical assumptions, it is not possible to establish a clear conclusion regarding the direction of the effects of such determinant. The result is thus in accordance with the trade-off theory, which presumes that large businesses have lower bankruptcy costs, are more diversified, and that positively affects their access to external capital. At the level of empirical studies, the relationship between long-term indebtedness and the size of the business is also unclear. However, conclusions of the positive relationships between the size of the business and long-term indebtedness prevail (Michaelas, Chittenden, Poutziouris, 1999; Mateev, Poutziouris, Ivanov, 2012; Chittenden, Hall, Hutchinson, 1996; Hutchinson, Hall, Michaelas, 1998; Bevan, Danbolt, 2002). However, other authors predicate a negative affect (Song, 2005, Delcoure, 2007, Chen, 2004). The **collateral value of assets** showed a predominantly negative effect on long-term indebtedness in model 2, but in 2010 a positive effect was also seen. Such resulting impact on long-term indebtedness is in accordance with the pecking order theory, which assumes that businesses with a higher level of tangible assets do not have a tendency to face problems with asymmetrical information and the utilization of debt is less likely for them. In terms of empirical studies, the conclusion that they concur upon the positive effect of the collateral value of assets on long-term indebtedness applies (Prášilová, 2012; Song, 2005; Michaelas, Chittenden, Poutziouris, 1999; Delcoure, 2007; Mateev, Poutziouris, Ivanov, 2012; Chittenden, Hall, Hutchinson, 1996; Hutchinson, Hall, Michaelas, 1998; Bevan, Danbolt, 2002; Chen, 2004). The achieved result is thus in conflict with the conclusions of empirical studies. The **non-debt tax shield** rather tended to confirm a positive effect on the value of long-term indebtedness. Although a negative dependence was also shown in 2005 and 2008. Such result is in conflict with the trade-off theory, which assumes that the non-debt tax shield is a substitute of the advantages of debt financing. From that point of view, it is thus assumed that an increase in the non-debt tax shield will lead to a decrease in indebtedness. A positive relationship between

the non-debt tax shield and long-term indebtedness is also in conflict with the conclusions of empirical studies, which confirm primarily a negative relationship (Song, 2005; Michaelas, Chittenden, Poutziouris, 1999; Chen, 2004). **Retained profit** also showed a clearly positive effect in the case of long-term indebtedness. The theoretical assumption of the trade-off theory was thus confirmed. In terms of the economic significance of this determinant, the inflexible reaction of total indebtedness to such factor was also established, at a value of nearly zero.

It is apparent from the results of the model that the effect of the selected determinants on the value of short-term indebtedness is statistically significant only for liquidity. The other factors cannot be considered to be decisive in the development of short-term indebtedness (the p-value as compared to the selected level of significance).

The estimated parameters show similar results as in the case of model 2. An increase in size, profitability (ROA), non-debt tax shield and the amount of retained profits have a positive impact on the value of indebtedness. However, not all of these dependencies apply without exception. A change in the effects of the determinant of profitability on the value of short-term indebtedness is apparent in 2009, and the negative effect of non-debt tax shield is identified in 2006 - 2008. In the case of liquidity, a clearly negative effect on short-term indebtedness was established. In the case of the collateral value of assets, a negative dependency predominates, whereby in 2004, 2009 and 2010, it shows a change in the direction of dependency to positive.

For the model of short-term indebtedness, only liquidity was confirmed as the statistically most significant determinant. **Liquidity** was established as a statistically significant factor, with a clearly negative effect on indebtedness. The conclusion of model 1, which is in accordance with the pecking order theory, was thus confirmed once again. Greater liquidity means that more current assets (working capital) remain within the business after the deduction of current liabilities and such higher volume of working capital is a prerequisite for generating a higher value of profit. A business with greater liquidity thereby does not have to utilize external capital. In terms of the direction of the dependency of liquidity in relation to short-term indebtedness, the negative dependency is not an economic matter, but a mathematical matter, where current liabilities

Indicator/Determinants of capital structure	Characteristic	Year						
		2004	2005	2006	2007	2008	2009	2010
Total debt	Average	0.225	0.207	0.214	0.2	0.217	0.234	0.233
	Median	0.183	0.176	0.193	0.19	0.206	0.201	0.166
	Standard deviation	0.094	0.067	0.081	0.096	0.089	0.163	0.181
Quality of model	Coefficient of determination	0.74362	0.84703	0.77646	0.84895	0.75467	0.90525	0.83179
	p- value	0.00287	0.00061	0.00133	0.00057	0.00224	0.00005	0.00099
Explanatory variables								
Size	Statistical significance	-	-	-	-	-	-	-
	Regression coefficients	0	0	0	0	0	0	0
	Direction of dependency	positive	positive	positive	positive	positive	positive	positive
Profitability	Statistical significance	eliminated	-	**	-	-	**	-
	Regression coefficients	eliminated	0.78599	2.34875	0.01271	0.28049	-1.89858	0.09725
	Direction of dependency	eliminated	positive	positive	positive	positive	negative	positive
Tangibility	Statistical significance	-	-	-	-	***	-	-
	Regression coefficients	0.35082	-0.37154	-0.51585	-0.24396	-1.07136	0.61893	0.27243
	Direction of dependency	positive	negative	negative	negative	negative	positive	positive
Non-debt tax shield	Statistical significance	-	-	*	-	-	-	-
	Regression coefficients	1.2945	0.8602	-4.03021	-0.82408	-3.26495	4.62227	5.10462
	Direction of dependency	positive	positive	negative	negative	negative	positive	positive
Retained profits	Statistical significance	-	-	-	-	-	-	-
	Regression coefficients	0	0	0	0	0	0	0
	Direction of dependency	positive	positive	positive	positive	positive	positive	positive
Liquidity	Statistical significance	****	***	eliminated	***	eliminated	****	****
	Regression coefficients	-0.1534	-0.05778	eliminated	-0.09062	eliminated	-0.25452	-0.18685
	Direction of dependency	negative	negative	eliminated	negative	eliminated	negative	negative

Source: own processing

Note: Statistical significance: -) coefficient is not significant, \*)  $\alpha = 0.1$ ; \*\*)  $\alpha = 0.05$ ; \*\*\*)  $\alpha = 0.01$ ; \*\*\*\*)  $\alpha = 0.001$

Table 6: Conclusions of analysis indebtedness of agricultural businesses of legal entities in the years 2004 - 2010, Model of short-term indebtedness – Model 3.

enter into the denominator in the case of the indicator of liquidity, and simultaneously into the numerator in the case of the indicator of short-term indebtedness (current assets/current liabilities versus current liabilities/total assets). In terms of empirical theories, this result is in accordance with the conclusions of Mateev, Poutziouris, Ivanov (2012), Šarlija, Harc (2012), who assume a negative dependence between short-term indebtedness and liquidity.

## Conclusion

The capital structure of businesses, its monitoring and optimization represent a steadily current topic both on a theoretical level as well as on a practical level. A fundamental issue in the area of capital structure is also associated with its determinants, specifically with their identification and quantification. From a theoretical

point of view, there are currently a number of expert studies that focus on such issue. However, their conclusions are ambiguous, just as the results of empirical studies that verify such conclusions. Such situation is given primarily by the fact that there are many factors, whether external or internal, that affect the capital structure of businesses and whose spectrum is continually expanded by way of empirical studies.

The objective of this article was to identify and quantify the effect of the main determinants on the capital structure of agricultural businesses of legal entities in the Czech Republic within the period of the years 2004 – 2010. The analysis itself was based on extensive sectional data acquired from the Albertina database, supplemented with information from the publicly accessible SZIF database. The calculations were performed with the utilization of Statistica 10

statistical software.

Size, profitability, collateral value of assets, non-debt tax shield, retained profit and liquidity were selected as the main determinants of the capital structure of agricultural businesses. The effect of these determinants was quantified by way of regression analysis, whereby only some determinants were confirmed as statistically significant.

Three models in total were drawn up, within which the capital structure was expressed by way of three dependent variables, specifically total indebtedness, short-term indebtedness and long-term indebtedness. Regression analysis established size, the collateral value of assets, retained profit and liquidity as statistically the most significant determinants affecting total indebtedness of agricultural businesses. In terms of long-term indebtedness, size, the collateral value of assets, the non-debt tax shield, and retained profit were identified as the statistically significant determinants. In the case of short-term indebtedness, only liquidity was established as a statistically significant factor affecting this category of indebtedness.

The results of quantitative analysis further pointed out similar results in the assessment of individual categories of indebtedness and its determinants. Although the size and value of retained profit were confirmed as statistically significant determinants,

for both overall as well as long-term indebtedness, from an economic viewpoint the effect of those determinants on both categories of indebtedness is basically zero.

For the further examination of capital structure, it would be appropriate to focus in more detail on individual categories of indebtedness, i.e. long-term and short-term. In doing so, attention should be focused primarily on the identification of the determinants that directly relate to the development of those categories of indebtedness, as both theory and empirical studies are focused primarily on the examination of indebtedness as a whole. Primarily short-term indebtedness is in some studies also indicated as one of the determinants of capital structure as a whole and further examination in this area could thus bring new conclusions.

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## Operations Research in Agriculture: Better Decisions for a Scarce and Uncertain World

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### Abstract

Operations Research / Management Science (OR/MS) can be described as the discipline of applying advanced analytical methods to help making better decisions and has been around in the agricultural and forestry management sectors since the fifties, approaching decision problems that range from more strategic sector-level planning to farm operation issues and integrated supply chain management. In this paper insights are given on the use of OR/MS in agriculture, illustrating them with cases drawn from the literature on this topic while keeping the descriptions accessible to uninitiated readers.

The presence of OR/MS in Agriculture and Forest Management applications is already extensive but the potential for development is huge in times where resources are becoming increasingly scarce and more has to be done with less, in a sustainable way.

### Key words

Agriculture, Forest Management, Operations Research, Management Science, Decision Support Systems.

### Introduction

Although there is no “official” definition for Operations Research/Management Science (OR/MS), it is described at the EURO - The Association of European Operational Research Societies web site (<http://www.euro-online.org>) as a “scientific approach to the solution of problems in the management of complex systems (...) seeking to facilitate the choice and the implementation of more effective solutions which, typically, may involve complex interactions among people, materials and money.”.

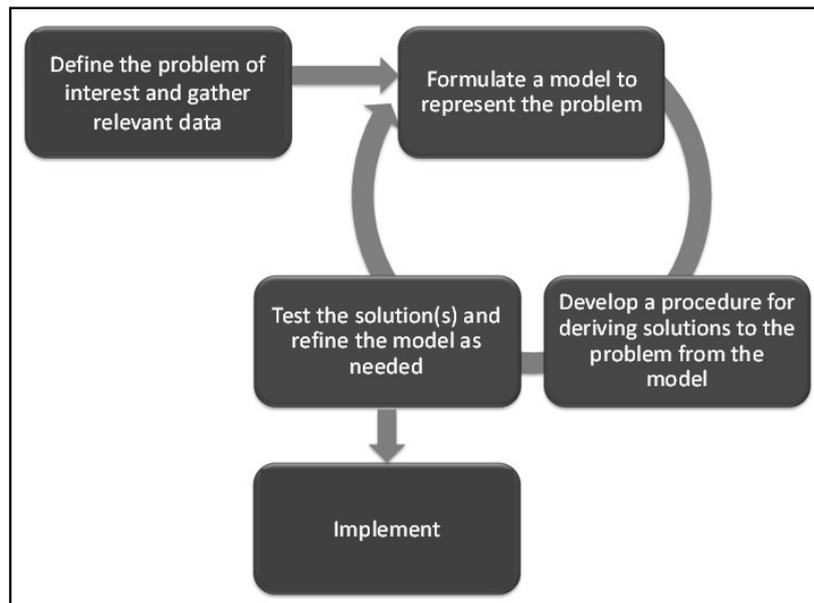
An alternative definition can be found at the INFORMS -- The Institute for Operations Research and the Management Sciences - web site (<http://www.scienceofbetter.org>) devoted to the presentation and dissemination of Operations Research: “Operations research is the discipline of applying advanced analytical methods to help make better decisions.”. OR/MS is an active field of research and practice all over the world, with a quite active Latin-American pan-association: “ALIO -- Asociación Latino-Iberoamericana de Investigación Operativa” (<http://www-2.dc.uba.ar/alio/>).

To try to overcome the lack of a unified definition

of this scientific discipline, in Figure 1 we present an illustration of the phases of the OR/MS method, when approaching the resolution of real-world problems.

OR/MS deals with structuring, modelling and solving problems related to decision processes. As an application-oriented scientific discipline, OR/MS practice requires not only interactions with the systems to be tackled but also with the agents that specify, design, build and operate those systems (i.e. with everyone that will have to make decisions, that will act as decision agent). On the other hand, OR/MS is characterized by a rational approach to decision processes, using quantitative methods whenever possible, that encompass a diversified sets of models, techniques and algorithms from different scientific areas, where Mathematics and Informatics play a fundamental role, but from where we cannot discard Sociology and Psychology. On the top of that, all technological application areas are necessarily involved.

In fact, OR/MS has been extensively used in Engineering, Economics, Management, Industry, Public Administration, Services and, of course, in Agriculture and Forest Management. This transversal nature of OR/MS, and its problem solving orientation, makes it a natural tool for every



Source: own processing

Figure 1: Phases of the OR/MS method when solving real-world problems.

application area. As we will discuss in this paper, its presence in Agriculture and Forest Management applications is already extensive and the potential for development is huge in times where resources are becoming increasingly scarce and more has to be done with less, in a sustainable way.

In the remaining of the paper we will survey the resources available in the scientific community concerning the application OR/MS in Agriculture and Forest Management, namely conferences, workshops and working groups on the theme. Afterwards, we will review some applications, published in the literature, representative of the planning horizons and scopes that can be addressed, from the more strategic decisions to the operational ones, and from governmental planning to farm running issues. At the same time we will try to offer an insight over the different methodologies and techniques, ranging from risk analysis and uncertainty modelling to performance evaluation or agriculture production optimization.

## Materials and methods

In this section we will discuss the resources available from the scientific community.

### 1. Conferences, Workshops and Streams in conferences

Agriculture is a topic always present in every major OR/MS conference. The largest OR/MS

conferences in the world are the EURO Conferences, organized by the OR/MS European Association, the INFORMS Conferences, organized by the North-American society, and the IFORS Conferences, organized by the world federation of OR/MS societies. Looking at the recent past and the near future, we can spot streams of sessions on “OR in Agriculture, Forestry & Natural Resources” and on “OR in Agriculture and Forest Management” in the 2009 EURO Conference, in Bonn and in the 2010 EURO Conference, in Lisbon with a lot of interesting and relevant communications, or a cluster of sessions on “Energy, Natural Resources & the Environment/Forestry” in the 2010 INFORMS Meeting, in Austin and a similar one at the last CLAIO Conference, in Buenos Aires. In the IFORS 2011 Conference, in Melbourne, a stream on “Forestry Applications” did also run.

However, probably more interesting because more focused, are the specialized meetings. Without trying to be thorough, we may mention a couple of past initiatives that are worthwhile of being followed-up in the future. In the first place, the “EURO Summer Institute 2009 OR in Agriculture and Forest Management”, Lleida, Spain, July 25<sup>th</sup> - August 8<sup>th</sup>, 2009, where for two weeks young PhD students and senior researchers met to discuss cutting-edge applications of OR/MS in the field. In the United Kingdom, the “OR50: Agriculture and Natural Resources Stream”,

University of York, September 9<sup>th</sup> - 11<sup>th</sup>, 2008. Of high relevance is also the annual meeting organized by the “EURO Working Group on Operational Research (OR in Agriculture and Forest Management (EWG-ORAFM)”. However, even in non-specialized congresses we can find important contributions for the field, as in the “International Congress on Modeling and Simulation, Modeling and Simulation Society of Australia and New Zealand - MODSIM 2011” where a session on the impact of climate change on agriculture has been held. Indeed, climate change is a hot topic for agriculture, and once more OR/MS may provide the tools to analyze, model, forecast, simulate and, ultimately, help to make better decisions.

## **2. Working groups**

Another important tool for the scientific development, and consequent improvement of the practice of OR/MS in agriculture, are the “Working Groups”.

The “EURO Working Group on OR in Agriculture and Forestry Management (EWG-ORAFM)” aims to encourage communication and research between people with different backgrounds (like industry, university, etc...) who are interested on OR methods and on its application in Agriculture and Forest Management in order to exchange ideas, experiences and research results.

The “OR Society Special Interest Group on Agriculture and Natural Resources (SIG-ANR)”, from the United Kingdom Operations Research Society, aims “to encapsulate the management of all of the biotic primary production industries (agriculture, forestry, fisheries, etc...) and their underpinning natural resources (soils, water, ecosystems, etc...), at policy, strategic and tactical levels. This definition includes the production of goods and [ecosystem] services as well as their related chains or webs of secondary industries and logistics. It is application orientated and not restricted to any particular method. (...) The governance and management of these industries place this area at the vanguard of operational research’s contribution to sustainability. This Special Interest Group offers a platform for those working on such issues.”.

In line with these objectives is the “INFORMS Section on Energy, Natural Resources, and the Environment (ENRE)”, organized “to promote the development and application of operations research / management science methods, techniques,

and tools to the solution of problems relating to energy, natural resources and/or the environment; encourage the exchange of information among practitioners and users in energy, natural resources, and environmental applications areas; and to promote the maintenance of high professional standards in the application of operations research/management science to problem areas in energy, natural resources, and/or the environment. (...) ENRE has three strong and active groups: Energy, Forestry and Mining.”.

Finally, again in the United Kingdom, the “Natural Resources Management Centre” was established as a result of Cranfield’s significant investment in research on natural resources. One of the specific focus of the center is “supporting the practice of urban, rural and agricultural development studies, including sustainable agriculture, rural livelihoods and agri-environmental systems.” with a strong contribute on “management of marketing systems, including sustainable supply chain management and its impact on the supply of food, fiber, bio-energy and countryside services, and the sustainable consumption of energy and materials in production and by consumers, and the recovery of waste, especially in the agriculture and food sectors.”.

Particularly interesting, as a repository of resources in the field, is the web site “OR4NR Operational Research for the natural resource industries” (<http://www.or4nr.interdisciplinary-science.net/>).

## **3. Journals**

Scientific results must be validated by the scientific community, and besides conferences, congresses and other meetings, and working groups, the traditional media to spread the acquired knowledge are the scientific journals. It may be said that if we want to know if a scientific area exists and has expression in the scientific community, we should look for the journals on that field. OR/MS and Agriculture and Forest Management passes with distinction that test. Special issues on the topic are regularly published in the top OR/MS journals, as for instance the special volume of “Annals of Operations Research: Operations Research in Forestry” that is edited (chair) by Andrés Weintraub (Universidad de Chile), but also specific journals are published by other scientific publishers.

“Agriculture, Ecosystems & Environment”, publicized as an International Journal for Scientific Research on the Interaction Between Agro ecosystems and the Environment,

aims at publishing “scientific articles dealing with the interface between agro ecosystems and the natural environment, specifically how agriculture influences the environment and how changes in that environment impact agro ecosystems“, with a strong focus on:

- Biological and physical characteristics of agro ecosystems including land, air, and water quality.
- Ecology, diversity and sustainability of agricultural systems.
- Relationships between agro ecosystems and the natural environment.
- Agro ecosystem and global environmental changes including climate change and air pollution.
- Ecological consequences of intensification, soil degradation, waste application, irrigation, and mitigation options.
- Environmental implications of agricultural land use and land use change.

The “Journal of Agricultural Science” publishes papers concerned with the advance of agriculture and the use of land resources throughout the world. It declares as specific topics of interest: “all aspects of crop and animal physiology, modelling of crop and animal systems, the scientific underpinning of agronomy and husbandry, engineering solutions, decision support systems, land use, environmental impacts of agriculture and forestry, impacts of climate change, rural biodiversity, experimental design and statistical analysis, the application of new analytical and study methods (including molecular studies)”.

“Agricultural Systems” is an international journal that “deals with interactions - among the components of agricultural systems, among hierarchical levels of agricultural systems, between agricultural and other land use systems, and between agricultural systems and their natural and social environments. (...) Papers generally focus on either methodological approaches to understanding and managing interactions within or among agricultural systems, or the application of holistic or quantitative systems approaches to a range of problems within agricultural systems and their interactions with other systems”.

Looking at the declared scope of the journal will help us to introduce the framework under which some examples of published works

on OR/MS application to Agriculture and Forest Management will be described in the next section. Topics concerning long term strategic decisions are tackled, when the journal speaks about eco-regional analysis of agriculture and land use, studies on natural resource issues related to agriculture, impact and scenario analyzes related to topics such as genetically modified organisms, multifunctional land use and global change. On the other hand, short and medium-term tactical and operational decisions, concerning producers, farms and local agencies, are dealt with when the journal welcomes contributions on the development and application of systems methodology, including system modelling, simulation and optimization, on approaches to analyzing and improving farming systems, and on technology transfer in tropical and temperate agriculture.

The room for applications of OR/MS methodologies and techniques to agriculture is very large and in the next section a few examples of successful contributions of OR/MS for better decisions in agriculture will be presented.

## **Results and discussion**

In this section we will present some examples of successful applications of OR/MS to problems in agriculture, trying to cover the three levels induced by time scope (strategic, tactical, and operational). These levels are strongly connected to the kind of decision-maker present in the problem. Strategic problems involve usually decisions that have to be made by governments or global financing agencies, while at the operational level decision-makers are usually farm managers, producers or local associations of farmers. Somehow transversal to all time horizons is sustainability. Usually looked at as an environmental issue, involving habitat protection of species, chemical fertilizers abuse or soil protection, it is nowadays tackled together with the economic and social dimensions, originating even more complex systems to analyze and harder decisions to make. Therefore, sustainability is present from the long-term decisions to the day-by-day livestock rations choice. Finally, forestry is for a long time an important OR/MS application sector. In fact what differentiates forest management from the agriculture sector is mainly the time scale, but that is a huge difference. If every day decisions are also present in forest management, even medium-term decisions have impact only dozens of years afterwards, given the time needed to

species to grow. Long-term decisions impacts may be measured in a scale of hundreds of years.

Risk and uncertainty have been present in farmer's life since ever. Modern man can neither eliminate risk and uncertainty, nor can he control nature, but we are capable of making rational decisions even under scenarios of great uncertainty, controlling and diminishing the risk.

Finally, from the OR/MS toolkit point of view, the selected set of papers is also representative. In some cases the techniques are more normative, by applying optimization models and algorithms, and propose the best decision. Other times, the concept of better decision does not even exist as there are multiple conflicting ways of evaluating a decision, that is, there are decisions that are better for a given criterion and worse for another, and others where the effects are reversed. We resort there to multi-criteria analysis. Other situations exist in which we just need to understand who is performing better. It is not trivial to compare unit's performance when the resources used are not the same, or the intensity with which they are used is dramatically different. Data Envelopment Analysis points the most efficient units by properly trading-off the results with the inputs consumed. Finally, in many circumstances, even the generation and evaluation of several scenarios generation, and there OR/MS can help with Decision Analysis and Simulation.

In the following sections some recent examples on how OR/MS was used to help solving decision problems in agriculture and forestry will be presented.

### **1. Applications in agriculture at the farm level**

Dos Santos et al. (2010) consider a production problem, in which one must meet a known demand of crops while respecting ecologically-based production constraints. The problem has two decision levels. Firstly the division of the available heterogeneous arable areas in plots has to be determined, so that the demand is met, and secondly it is necessary to determine, for each plot, the appropriate crop rotation schedule. Ecological-based constraints, such as the interdiction of certain crop successions, and the regular insertion of fallows and green manures, are considered for the generation of the rotation plans. The problem resolution is modelled by a linear program and solved by means of a column-generation approach. The authors run a set of computational tests using real data of up to 24 crops and report very good

performance for this approach.

Still within the optimization framework, Detlefsen and Jensen (2007) also deal with the optimal rotation crop for a given selection of crops on a given piece of land, with sustainability goals. A network modelling approach is followed, proving that special algorithms for solving network problems can be developed and applied to solve the crop rotation problem. This can save computation time and make it tractable to implement crop rotation in whole-farm models. The authors claim that the chosen modelling approach is more strategic than operational, as it does not consider specific fields. One could imagine that the above model came up with a solution that would require part of a field to be grown with one crop and the other part grown with another crop.

A different type of approaches assumes the intrinsically multi-objective nature of these decision problems and tries to deal with it. Hayashi [2000] reviews multi-criteria analysis applied to agricultural resource management. The main goal of the author is to collect, classify and evaluate which criteria are usually used for modelling agricultural systems and to identify the difficulties for practitioners in applying the methodology. As expected, the authors conclude that a multi-criteria analysis brings more expressivity to the problem definition, although it decreases the normative level of the proposed decisions.

Another multi-objective approach is presented by Annetts and Audsley (2002). They consider the problem of identifying the best cropping and machinery options which are both profitable and result in improvements to the environment, depending upon the farm situation of market prices, potential crop yields, soil, and weather characteristics. It is assumed that profit and environment protection are antagonist objectives and therefore a multi-objective optimization model is required. The authors claim that the model is rather flexible, allowing to choose the machinery, timing of operations, crop rotations and levels of inputs and show, for a United Kingdom scenario, that large reductions in environmental impact can be achieved for reductions in farm profit which are insignificant relative to the annual variation due to yields and prices.

Frequently the data that feed the models are not known with precision, either because it has not been collected in the past or because it refers to the future. In both cases, estimations have

to be made and used, bringing an additional level of uncertainty to the decision making process. In this context, Biswas and Pal (2005) revisit the land-use planning problem for optimal production of several seasonal crops in a planning year, but describe the utilization of total cultivable land, supply of productive resources, aspiration levels of several crop productions as well as the total expected profit from the farm with fuzzy theory elements. As a case study, the District Nadia region, West Bengal, India is considered. The obtained solution is compared with the existing cropping plan of the District as well as with another solution for the problem, obtained by using previous solution techniques. The authors conclude that the main advantage of the proposed approach is that the decision for proper allocation of cultivable land for production of seasonal crops can be made on the basis of the need to society, even in an environment of uncertainty.

Moschini and Hennessy (2001) also deal with uncertainty and risk. In their paper, the authors address the sources of agricultural risk, production uncertainty, price uncertainty, technological uncertainty and policy uncertainty, and provide an exposition of expected utility theory and of the notion of risk aversion. The article also addresses the agricultural insurance theme, with emphasis on the moral hazard and adverse selection problems that arise in the context of crop insurance.

In line with Moschini and Hennessy, Gómez-Limón [2003] addresses the attitude of farmers when facing risk. It is well known from the literature on multi-criteria decision making the categorization of decision makers in risk-adverse, risk-neutral and risk-seekers. The authors claim that farmers are, in general, risk-adverse decision makers and this characteristic determines their decisions in both the short and long run. In fact, if farmers were risk-neutral, it would be irrelevant to consider risk in their decision-making process, since their responses could be represented by the maximization of the expected profit. However, farmers' generalized risk aversion results in decisions that conflict with those that would be regarded as optimal from a social point of view. The authors present a methodology, based on multiple criteria mathematical programming to obtain relative and absolute risk aversion coefficients. Afterwards they apply multi-attribute utility theory to elicit a separable additive multi-attribute utility function and estimate the risk aversion coefficients of farmers of an irrigated area of Northern Spain. The results

show a wide variety of attitudes to risk among farmers, who mainly exhibit decreasing absolute risk aversion and constant relative risk aversion. Based on these conclusions agricultural economists try to enhance stabilization features of agricultural policies aimed at reducing farming risk.

## **2. Applications in agriculture at the sector level**

Leaving the farm level, multi-criteria decision-making is still a powerful tool to model situations in which conflicting objectives arise. It is the case described by Van Huylenbroeck (2001) where the impact of policy changes in the behavior and reactions of the farmers is studied. A multi-criteria decision-making methodology is used to analyze shifts in the utility function of farmers. The change from price support to direct income support has decreased the relative importance of the risk objective, while the environmental objective is gaining importance. The multi-objective methodology can be a useful framework for a better understanding of farmers' reactions on policy reforms.

When positioning ourselves at the sector level, comparing different farms performance is unavoidable. Farms do not perform equally, and measuring how different are really the performances, discarding all the non-controllable factors, as the size, understanding the reasons for the different performances and determining what should be done to perform as well as the best (benchmark units) is something that Data Envelopment Analysis can help to do. Dhungana et al. (2004) analyze a sample of 76 Nepalese rice farmers, revealing average relative economic, allocative, technical, pure technical and scale inefficiencies of 34, 13, 24, 18 and 7 per cent, respectively. The significant variations in the level of inefficiency across sample farms are attributed to the variations in the 'use intensities' of resources such as seed, labor, fertilizers and mechanical power. The conclusions of this work show that, operating at best practice, farmers could release resources that could be used to purchase new technologies such as improved seeds, fertilizers and for land improvement.

Another study involving farm efficiency comparison was run in Andalusia, Spain, and is reported by Amores and Contreras (2009). The aim of this study is to help government to define objective criteria to assign European Union (EU) subsidies to olive-growing farms in Andalusia. EU regulations demand objective criteria for the subsidy allocation

system and in a sector where more than 60% of the farms would have negative returns without the EU agricultural subsidies, it is difficult to access the real efficiency of the farms. A new Farm Efficiency index is calculated by decomposing overall DEA Scores, by means of internalizing the positive and negative externalities of agricultural activity. The index was tested in a study carried over a sample of 3000 real farms, with data taken from the administrative subsidy database. More important than different decisions concerning the subsidies attribution, the study highlighted areas where there is lack of information to allow proper and grounded decisions.

Also dealing with farm efficiency analysis, Garcá-Alonso et al. (2010) resort to artificial neural network models to compute the farms gross margin, which is a basic element in agrarian programs for sustainable development and directly used by the European Union to assign financial subsidies to the sector. However, the process of farm gross margin determination is complicated and expensive because it is necessary to find the value of all the inputs consumed and outputs produced. With the research described in this paper it was possible to select a representative and reduced set of easy-to-collect descriptive variables to estimate the gross margin of a group of olive-tree farms in Andalusia and validate the best mathematical model obtained for gross margin prediction by analyzing realistic farm and farmer scenarios.

A different OR/MS intervention area, in agriculture, is forecasting. Bhattacharya (2005) develops a pre-harvest forecast of sugarcane yield. The forecast employs a goal programming formulation to estimate the pre-harvest yield of sugarcane on the basis of measurements on biometrical characters of the plant such as plant height, girth of cane, number of canes per plot and width of third leaf from the top. When compared with conventional forecasting methods (regression model using least square technique) this methodology has the advantage of not needing so strong assumptions, allowing, for example, for an estimate of the sugarcane yield 3 months before harvest in situations where the assumptions of conventional regression analysis are violated.

### **3. Applications in forest management**

Decisions on Land use is one of the common applications of OR/MS in forestry planning. Oliveira et al. (1993) tackle an afforestation problem in Denmark, which has the goal of increasing

the amount of forest compartments in the country. In this problem there is a set of disjoint potential afforestation areas, areas where actual forest already exist and areas, also disjoint, where afforestation is not recommended. The goal is to locate and design a given number of new forests, with an area equal or bigger than a given value, by merging existing forests and potential afforestation areas, so that the total area where afforestation is not recommended and is included in the new forests, is minimized.

However, as Darek J. Nalle et al. (2004) state, production of marketed commodities and protection of natural systems often conflict and the authors claim their “intent was to continue to bridge the gap between economics and ecology through integration of modelling techniques”. A focus on only one goal can result in large losses in other goals and may result in inefficient and unsustainable outcomes. In this paper the authors develop a dynamic method to evaluate land use decisions and find acceptable alternatives both from the economic and ecological points of view. The method is tested and validated using timber production and species conservation on a forested landscape over a 100-year planning horizon. The results are better than current practice and that a static reserve approach.

Another important OR/MS application area is the forestry supply chain design, planning and operation. The forestry supply chain involves all activities concerning the flow of fiber from the forest to the customer. D’Amours et al. (2008) present an overview of problems arising in this supply chain, ranging from the long-term strategic rotations of forest growth, that can span over more than 80 years, to the very short-term operational problems, as the lumber cutting stock problem, truck routing problems or finished product distribution. In the middle we have tactical planning that deals with the detailed operative planning and closes the gap between the strategic and the operational levels by globally analyzing the supply chain and creating the framework where operations will take place.

Forestry supply chain management and optimization is also the goal of Carlsson and Ronnqvist (2005). Looking at the wood-flow, starting with standing trees in forests, continuing with harvesting, bucking, sorting, transportation to terminals, sawmills, pulp mills, paper mills and heating plants, conversion into products such as pulp, paper, lumber, and ending at different customers, the authors conclude

that many planning problems arise, over different time horizons, whose coordination is vital for the companies in the sector. Another important remark of these authors is that there is a systematic and endemic lack of data that prevents a better exploitation of the techniques that OR/MS has to offer to the sector.

However, more operational problems are also dealt with in forestry management, and solved by optimization techniques. Gunnarsson et al. (2004) propose a mixed integer linear programming model to decide when and where forest residues are to be converted into forest fuel, and how the residues are to be transported and stored in order to satisfy demand at heating plants. Additionally, decisions include whether or not additional harvest areas and saw-mills are to be contracted. In parallel they consider the flow of products from saw-mills and import harbors, and decide which terminals to use. The solution approach is tested with data from a large Swedish supplying company.

#### **4. Surveys and overviews**

In the previous sections we have tried to point out some recent applications of OR/MS techniques to agricultural and forestry problems, with the objective of being illustrative but not exhaustive. However, very good surveys and overviews on this area have been published. The first survey we would like to refer to is authored by Andrés Weintraub, from the Department of Industrial Engineering of the University of Chile, which, together with Mikael Rönnqvist from the Department of Finance and Management Science of the Norwegian School of Economics and Business Administration, are two of the most prominent researchers on applications of OR/MS to agriculture and forest management. Weintraub and Romero (2006) analyze the use of OR/MS to assess the past performance of its models in this field and to highlight current problems and future directions of research and applications. They divide the agriculture planning problems into farm level and regional-sector level and go through the application of several OR/MS techniques. In what concerns forestry planning the division is on strategic, tactical and operational levels and, once again, the authors go through the application of several techniques to problems of each one of the levels, pointing out the increasing importance of environmental issues. In terms of trends, dealing with uncertainty and risk are definitely the next big challenges for the sector. In the forestry sector, planning and operating the supply chain as a whole will be the tendency for the next years. Audsley

and Sandars (2009) go through a similar survey, with as focus on the United Kingdom and with an insight on the need of an holistic approach to the problems of the sector.

Especially interesting is also the book edited by Romero and Rehman (2003). In the first part of the book the MCDM approach is introduced and discussed, while in the second part more advanced topics are presented, including techniques to deal with uncertainty and risk. The third and final part of the book presents three very interesting case studies. The first one is about the evaluation of the agrarian reform program in Andalusia, Spain, the second addresses the livestock ration problem and the final case is about a diet problem for cattle.

### **Conclusions**

In this paper we have tried to give an overview of the potential of application of OR/MS to agricultural and forestry decision problems. As stated in Weintraub and Romero (2006), "Agriculture is one of the fields in which OR models were first used and have been most widely applied." To the best of our knowledge, the first paper with an application of OR to agriculture was published in 1954 (Heady, 1954) in the *Journal of Farm Economics*, where Earl Heady demonstrates the use of linear programming for land allocation on crop planning problems. Nowadays the OR/MS community devoted to agricultural decision problems is big and quite active, with an increase on the use of OR/MS models, mainly because of the development of personal commercial software programs (Weintraub and Romero, 2006).

The future is even more promising, as scarce resources and environmental pressures will demand for better decisions that should be technically better grounded and better explained. Because we have only one world to feed an increasing number of people, and fertile land is limited and scarce, Operations Research / Management Science will be in a near future a fundamental science for everyone needing to make decisions in the agricultural sector.

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## Economic Evaluation of Intensive Growing of Selected Crops

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### Anotace

Předložený příspěvek na téma „Ekonomické hodnocení intenzivního pěstování vybraných plodin“ se zabývá ekonomickým zhodnocením pěstování vybraných plodin řepky ozimé, pšenice ozimé a cukrové řepy v Agro Žlutice a.s., kde jsou využívány intenzivní pěstitelské technologie. Dosahované výsledky jsou srovnávány s výsledky v rámci České republiky, které představují průměrné hodnoty pro uvedené plodiny. Agro Žlutice a.s. se nachází v řepařské výrobní oblasti v okrese Jičín a hospodáří na 1902 ha zemědělské půdy, z čehož je 1742 ha orná půda. Rozhodující předmět podnikání zde tvoří rostlinná výroba, živočišná výroba a ovocnářství. V příspěvku se hodnotí intenzita a ekonomika pěstování řepky ozimé, pšenice ozimé a cukrové řepy v letech 2010, 2011 a 2012. Řepka ozimá je z tržního hlediska důležitou plodinou pro vybraný podnik i české zemědělství. Při vhodném pěstování výrazně přispívá ke kladnému hospodářskému výsledku. U pěstování pšenice ozimé z hlediska konkurenceschopnosti je důležité snižování technologických vstupů, které nevede k poklesu výnosu a má prokazatelný ekonomický přínos při posuzování nákladů na jednotku produkce. Příznivá ekonomika pěstování této plodiny je dosahována, jak při intenzivní pěstitelské technologii v daném podniku, tak i za průměrných podmínek pěstování. Základním předpokladem, zda pěstovat cukrovou řepu, je možnost podniku dodávat tuto surovinu ke zpracování ať už pro výrobu cukru či bioetanolu. Tato plodina v uvedeném podniku i v rámci celostátním vykazuje příznivou rentabilitu. Dosažené pěstitelské i ekonomické výsledky podniku Agro Žlutice a.s. při využívání intenzivních pěstitelských technologií jsou příznivější v porovnání s průměrnými výsledky za celé odvětví zemědělství.

Poznatky prezentované v článku jsou výsledkem řešení výzkumného záměru MŠM 6046070906 „Ekonomika zdrojů českého zemědělství a jejich efektivní využívání v rámci multifunkčních zemědělskopotravinářských systémů“.

### Klíčová slova

Řepka ozimá, pšenice ozimá, cukrová řepa, hektarový výnos, náklady přímé, realizační cena, tržby, provozní zisk, rentabilita.

### Abstract

The submitted paper on the topic: “Economic Evaluation of Intensive Growing of Selected Crops” deals with an economic evaluation of growing of selected crops – winter oilseed rape, winter wheat, and sugar beet in Agro Žlutice a.s. where intensive growing technologies are used. Reached results are compared with results in the framework of the Czech Republic which represent average values for the mentioned crops. Agro Žlutice a.s. is situated in sugar beet production area in district Jičín and it farms on 1902 ha of agricultural land of which 1742 ha is arable land. A decisive subject of business here is plant production, animal production, and fruit growing. In the paper, an intensity and economics of growing of winter oilseed rape, winter wheat, and sugar beet in 2010, 2011 and 2012 is evaluated. Winter oilseed rape from a market view-point is an important crop for the chosen enterprise and Czech agriculture. In suitable growing it significantly contributes to a positive economic result. In winter wheat growing, from a view-point of competitiveness, it is important to reduce technological inputs which does not lead to decrease in yield and has provable economic benefit in evaluation of costs per a production unit. A favourable economics of growing of this crop is reached both in the intensive growing technology in the given enterprise, and within average growing conditions. A basic presumption whether to grow sugar beet is a possibility of the enterprise to supply this raw-material for processing either for sugar or bio-ethanol production. This crop in the mentioned enterprise and in the nationwide framework shows a favourable profitability.

The reached growing and economic results of the enterprise Agro Žlunice a.s. in use of intensive growing technologies are more favourable in comparison with average results over the whole sector of agriculture.

Pieces of knowledge introduced in this paper resulted from solution of an institutional research intention MSM 6046070906 „Economics of resources of Czech agriculture and their efficient use in frame of multifunctional agri-food systems.

## **Key words**

Winter oilseed rape, winter wheat, sugar bet, yield per hectare, direct cost, realization price, revenues, operational profit, profitability.

## **Introduction**

In the framework of plant production in the Czech Republic, cereals, oil plants and row crops belong among decisive groups of crops. An economic evaluation is focused on one significant crop of each group. It is dealt with winter oilseed rape, winter rape, and sugar beet. The Czech Republic ranked after the accession in the European Union among the biggest European rape growers. A large-area growing of the best line and hybrid varieties was a base of a very good quality of domestic raw material in which there is a big interest abroad.

From an economic point of view, growing of oilseed rape has a double effect for management of agricultural enterprises:

- direct – a production and sale of rape seed,
- indirect – as a foregoing crop it increase yield of cereals (an interrupter of cereal succession), improves soil structure by which it influences nutrition management in the soil (Baranyk, Fábry at al., 2007).

A correct crop rotation system is cheapest and economically the most efficient, biologically and ecologically the most correct intensification measure in winter oilseed rape growing. Oilseed rape has an importance also as weeding plant. An influence of oilseed rape on soil structure is very significant (Vašák at al., 2000).

A success of rape growing is considerably dependent on a care which a grower gives to its nutrition. In nutrient consumption, rape is ranked among very demanding crops. An above-ground bio-mass takes for a good yield 4 t per hectare following amount of basic nutrients: 208 – 236 kg of nitrogen, 160 – 200 kg of potassium, 120 – 152 kg of calcium, 44 – 72 kg of phosphorus, 16 – 24 kg of magnesium, 48 – 64 kg of sulphur (Balík, 2007).

From a market viewpoint, one of the most important

plants for Czech agriculture is winter oilseed rape. Seed of winter rape is a very demanded and appreciated commodity in a long term. Rape in reasonable, economical growing significantly contributes to creation of a positive economic result and stabilizes economic situation of enterprise.

The cultivation of oilseed rape poses no particular problems for its good adaptability to different soil and climatic conditions (Zegada-Lizarazu, Monti, 2011). Besides the market use itself rape significantly influence its preceding-crop and economic efficiency of other plants, mainly of cereals. Thereby, its importance for Czech agriculture significantly increases at time of narrowed cropping patterns. Rape growing from economic view-point has a double effect for management of agricultural enterprises. A direct, understand production and sale of rape seed, and an indirect, rape as preceding crop increases yield of cereals and improved soil structure by which it influence nutrient management in soil. Rape growing is a very demanding and costly business and requires very good knowledge. A perfect knowledge of growing technology is important, but the same importance is given to knowledge of economic problems, especially cost items. For business economics it is fundamental a financial result of economic activity. Security of positive operating results can be reached the best by optimization of production for given growing conditions (Baranyk, Fábry et al, 2007).

Winter wheat is in the Czech Republic the most important field crop grown approximately on a quarter of arable land. It belongs among so called cash commodities which positively influence economy of most agricultural enterprises. It is grown practically in all production areas. For comparison, the largest wheat producer and consumer in the world is China where wheat is widely distributed from the Arctic to the equator and from lowlands to highlands (Jing-Jong, Guang-Sheng, Xing-Hua, 2012). Favourable profitability rate is

reached above all in site conditions of sugar beet, maize, and partially also grain production area, even if a certain part of food wheat production came, mainly in the last years, also from potato production area, and its growing was generally profitable (Křen, 2001).

Winter wheat is the most demanding cereal regarding preceding crop because it substantially changes soil environment and qualities important both for the growth of plants, and for the creation of yield and quality. In choice of preceding crop it is necessary to take into account conditions of the production area, requirements of varieties, and the final use of production. The best preceding crops are clover, legumes, oil crops (winter oilseed rape), and vegetable – organically fertilized crops (Zimolka et al, 2005).

Fertilization, above all by nitrogen, can influence more or less creation of growth and thereby also the final effect – the yield and quality of grain. With yield around 6 t of grain and approximately the same yield of straw, about 144 kg of N, 30 kg of P, 108 kg of K, 24 kg of Ca, and 12 kg of Mg is drawn from the soil (Vaněk et al., 2007).

In minimization technologies of wheat growing it is possible to save labour which reduces costs. Also costs for fuels and use of machines, which have a smaller number of passages, are lower. However, in minimization technologies we have to count on higher costs for liquidation of weeds by the help of herbicides. Costs for herbicides will than show themselves in the total costs (Horák, 2005).

Economic reasons play the main role in every business, in the current agriculture they lead to narrowing of assortment of grown crops, to a simplification of cropping pattern, an enlargement of area under crops in which minimization technology secures achievement of comparable yields. A permanent rise in a diesel price, but also a labour price increases differences in costs among conventional technologies using in various rate minimization elements (Hůla, Procházková, 2008).

Sugar beet is the most productive crop of temperate zone and in our territory has been grown to a greater extent already for 180 years. Sugar beet belongs among stabilizing crops of our fields. In recent two years, yields of sugar beet moved at a high level in the Czech Republic. The year 2011 enrolled in history of sugar industry as record when average yields of our growers converted to 16 % sugar content exceeded a border

70 t/ha. Sugar beet succeed also in 2012 when yields with 16 % sugar content at average moved again above 70 t/ha. However, there were obvious large differences among areas. While growers in Bohemia harvested at average roughly 80 t/ha of tubers, in Moravia yields fluctuate between 50-70 t/ha in dependence on weather course. A ten-year average of the Czech Republic amount approximately 61 t/ha (Honsová, 2013). In comparison with other crops sugar beet is not characterized by self-regulated, but only compensatory ability, due to which the average weight of plant corresponds in a certain extent to a land area which the plant keeps at disposal during its life (Pulkrábek et al., 2007).

The yield structure is composed of:

- a number of plants per hectare
- a weight of tubers
- an amount of sugar in a tuber (Hřivna et al., 2004).

Sugar beet is an important cash crop. From a view-point of economics of its growing, decisive is achievement of appropriate yield in standard quality. The yield and quality of sugar rape is created during the whole vegetation and a significant role is plaid here by agri-ecological factors: course of weather, conditions of the site, a level of agronomical activity etc. One of possibilities to influence significantly the yield and quality of production is an application of controlled nutrition. Fertilization with nitrogen and other macronutrients is decisive. However, sugar beet also a plant very well responsive to extra-root nutrition. Therefore, also “leaf fertilizers”, eventually growth substances can be used successfully (Hřivna, Pecková, 2013).

Sugar beet is highly nutrients intensive crop; therefore it is possible to grow it only on fertile land with sufficient fertilization. Nevertheless, we can secure the right nutrition of sugar beet by a suitable combination of fertilization with manure and mineral fertilizers. Dosage of nutrients for sugar beet are determined in a system based on soil analyses on operative determination of spring nitrogen reserve in soil, and on plant analyses (Vaněk et al., 2007).

In a high yield of biomass sugar beet takes also a huge amount of nutrients from the soil. However, any luxury uptake of nutrients (it is an intake higher than must) is harmful; it deteriorate economy, and especially it complicates processing to sugar.

So, the fertilization is above all the matter of optimization, finding of the best combination between favourable and undesirable effects of fertilizers (Chochola, 2004).

The most suitable organic fertilizers are manure and compost. Recently, a green fertilization has been used. A manure dosage is about 40 tonnes per hectare. However, the term of ploughdown is always more important than the dosage. The most suitable for conversion of manure and for creation of soil structure is ploughdown in September. Slurry with straw is a suitable organic fertilizer, if it is applied equally in the same terms as manure (Pulkrábek et al., 2007).

The economic position of Czech producers related to the most considerable commodities of Czech agriculture through 2 indicators, profitability without supports (R-S) and profitability with supports (R+S). There was proved that profitability R+S in the period I was positive for most plant commodities while it was negative for most animal commodities. In connection with the membership of the CR in the EU, agricultural supports significantly increased for nearly all commodities as the consequence of applying the Common Agricultural Policy (CAP) on Czech agriculture. Therefore, there were monitored in the period II important positive changes of the indicator R+S for most commodities. For the average of the Czech Republic, there were obtained the following values of R+S in the period I, resp. period II: wheat 2.6%, resp. 24.9%, barley 27.7%, resp. 39.8%, rapeseed -18.0%, resp. 23.4%, sugar beet 9.1%, resp. 41.4%, potatoes 10.5%, resp. 2.5% (Foltýn, Kopeček, Zedníčková, Vávra, 2009).

An aim of the paper is evaluation of intensive growing of crops of an agricultural enterprise Agro Žlunice a.s. in comparison with average results within the Czech Republic. The work focuses on selected crops: winter oilseed rape, winter wheat and sugar beet. These crops are the third most important cash crops for the mentioned farm and other agriculture enterprises in the same natural conditions which significantly contribute to achievement of positive economic result. The paper contains an evaluation of growing level in 2010, 2011 and 2012.

## **Materials and methods**

As a resource of supporting data a business registration on plant production is used, as well as

economic data obtained from internal annual reports of the enterprise and registered operating results. For comparison of results of Agro Žlunice with results of the Czech Republic, information from statistics provided by the Ministry of Agriculture of the CR and the Institution of Agricultural Economics and Information Prague (IAEI) was used.

A detailed analysis of natural and economic results is elaborated over the whole economic years 2010, 2011 and 2012. Regarding to recording economy over calendar year, a term calendar-economic year is used also for evaluation of results in the plant production. The paper shows cost calculations for growing of evaluated crops. An influence of intensification factors is investigated in details in the form of costs for seeds, fertilizers and plant protection.

Efficiency of growing of selected crops is evaluated on base of comparison of costs and achieved revenues from sale. The economic result of growing of winter oilseed rape, sugar beet, and winter wheat is expressed in the form of operational profit, i.e. a profit before interest and taxation (EBIT).

### **Characteristics of the enterprise**

The joint-stock company Agro Žlunice, a.s. came into being on the 6<sup>th</sup> of October, 1998. The company domicile is Žlunice, the region Jičín. The enterprise has been found for indeterminate duration.

Žlunice is situated in altitude 250 meter above the sea level. The company manages in the area of rape production type. A soil type is pararendzina on terraced broken stones and gravel sands from acid material. The soil is slightly acid to neutral; a content of phosphorus is 71 mg.kg<sup>-1</sup>, of potassium 173 mg.kg<sup>-1</sup> and of magnesium 147 mg.kg<sup>-1</sup>. A climatic region: BZ – mild warm area, mild dry, with mild winter. The average yearly air temperature is 7 – 9 °C in this area and the average yearly rainfall totals 500 – 600 (650) mm (in the vegetation period /i.e. April – September/ is 380 mm. The site is plane.

The acreage of agricultural land on which Agro Žlunice, a.s. manages, is 1902 ha, of it 1742 ha is arable land.

The main subject of enterprise is agricultural production including purchase of non-processed agricultural products in the view of further processing and sale. Other subjects of enterprise are repair and production of agricultural machines, fruit growing, bee-keeping and others. Plant production is focused on growing of cash crops like: winter

wheat, winter oilseed rape, pea, sugar beet, spring and winter barley.

## Results and discussion

### Development of areas under crops and yields per hectare

Areas under the monitored crops develop with growing tendency in the enterprise Agro Žlunice a.s. because winter oilseed rape, winter wheat and sugar beet are significant crops for the farm. They take a considerable part of arable land. In 2012 it was 60 % of the area. A similar development is shown also by areas under crops of from the nationwide perspective.

The enterprise uses a traditional growing technology in growing of winter oilseed rape. A medium-deep ploughing is suitable with an immediate adjustment in order to disintegrate arising clods. If the preceding crop, eventually course of vegetation allows, a part of this procedure is stubble ploughing. A “chemical stubble ploughing” with Roundup is costly (use mainly in minimization technology of establishment of stands) and postpones sowing of rape. It liquidate above all the first wave of weeds, however, usually other application of herbicides and graminicides is necessary.

The used growing technology is characterized by higher amount of inputs in production – a number of treatments of plants against diseases and pests where moreover the second growth regulation appears. At the same time also higher dosages of mineral fertilizers are applied here – higher intensity of nitrogen fertilization in amount of c. 210 kg/ha.

### Growing technology

In terms of variety composition of winter oilseed rape, in 2/3 hybrid varieties are used like for example NK Petrol, NK Linus, Sherpa and a rest of line variety like ES Bourbon, NK Smart.

In winter wheat growing, a stubble ploughing is carried out according to a preceding crop.

A depth of ploughing moves in a range of 25 – 28 cm, or a shallow soil cultivation is used.

NPK is used for autumn fertilization, a regenerative fertilization in early spring, and other fertilization with a preparation DAM 390 during spring. The total dosage of nitrogen moves in amount of 190 – 200 kg/ha. Herbicidal and insecticidal protection runs during autumn part of vegetation and continues according to the state of growths during the spring and in next period of vegetation. Also a growth regulation against lodging is carried out. For growing varieties of foods wheat are used like Pannonia, Genius, Magister and others.

Growing of sugar beet is prepared by application of organic manure on stubble after cereals in a dose 40-50 t/ha which is ploughed under. Ploughing is carried out in depth 30-35 cm. In spring before sowing, nitrogenous, phosphate and potash fertilizers are ploughed under. Leaf fertilizers are applied during vegetation we well as herbicidal treatment. From a varietal composition, Pohoda, Viktor, Talenta and others are used.

In 2012, they succeeded to harvest already increased area under winter oilseed rape, from 358 ha. The acreage of winter wheat has been moving always in range 505-580 ha in recent years while area under sugar beet has been increased by c. 70 ha. The increase in areas has been influenced by growing of sugar beet determined for bio-ethanol production.

Regarding to favourable climatic conditions, by a choice of quality varieties and intensive growing technology higher yields were always achieved in the enterprise Agro Žlunice a.s. in the monitored years than averages of the Czech Republic show. A record yield of winter oilseed rape 5.59 t/ha was reached in the economic year 2011 which represented a double of the average CR yield which was at the level 3 t/ha. A decrease in yields of sugar beet in 2012 was caused by a high sum of rainfalls at the beginning of vegetation. In the same year, deep frosts affected an area of 50 ha under winter wheat which caused

Year/crop	Winter oilseed rape	Winter wheat	Sugar beet
2010	306	542	230
2011	303	576	248
2012	358	507	257

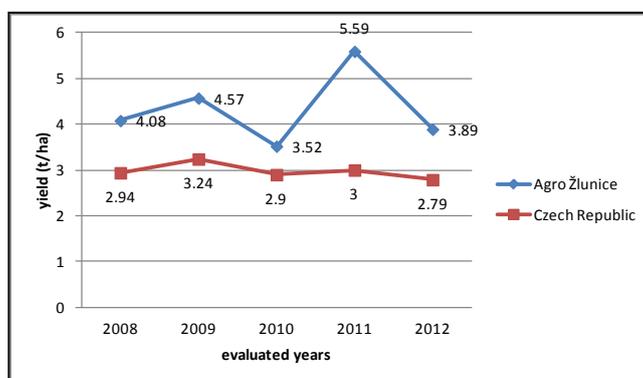
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Table 1: Development of acreages of Agro Žlunice a.s. (ha).

a decrease in yield in this crop.

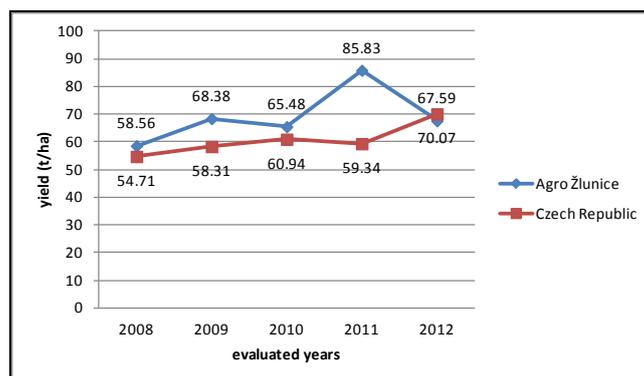
Graphs 1, 2 and 3 compare yields of particular crops of Agro Žlunice a.s. with average yields achieved in the Czech Republic throughout the period

of 5 years. From the graphic expression it is obvious a higher level of crop growing intensity in the evaluated enterprise in comparison with average values over the whole agriculture.



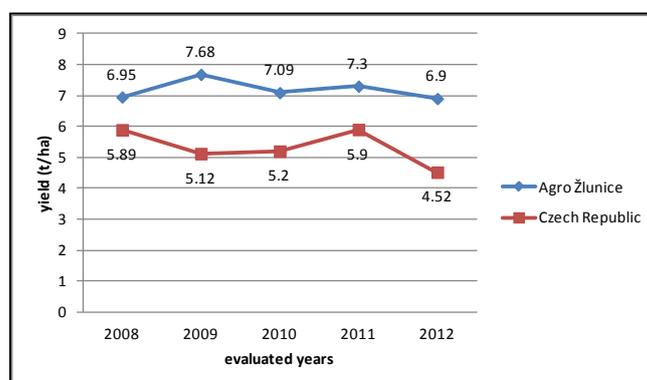
Source: own processing, eAGRI

Graph 1: Comparison of yield averages in winter oilseed rape in the period of five years (t/ha).



Source: own processing, eAGRI

Graph 2: Comparison of yield averages in sugar beet in the period of five years (t/ha).



Source: own processing, eAGRI

Graph 3: Comparison of yield averages in winter wheat in the period of five years (t/ha).

### Cost for crop growing

Cost represents a consumption of production factors which is financially expressed. A significance of their monitoring is unquestionable because costs in the form of various indicators show demandingness of production and thereby in some extent also a presumption of competitiveness of products. The cost monitoring is carried out for particular crops which represent calculation sections. Particular cost items are ranked according to a general calculation figure which enables to catch correlative cost items. These particular items are further classified into: Seed consumption, Fertilizer consumption, Consumption of chemical protective means, Transport charges, Field works and other services, Insurance of operating property, Administrative enterprise expenses, Production expenses of plant production, Tractor works, Combined works.

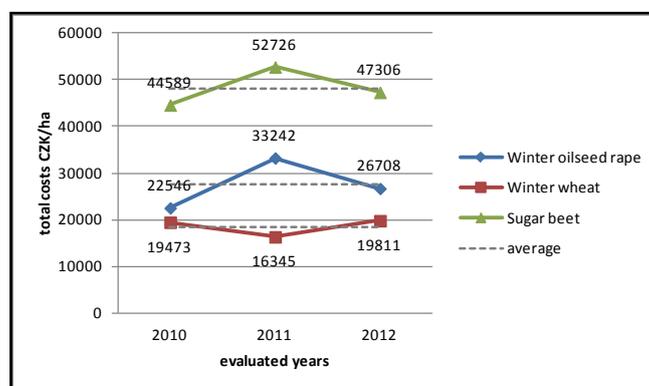
The graph 4 shows total costs for particular crops over the monitored period and an arithmetic mean of these costs per 1 ha of growing of the monitored crops is calculated. The highest total costs in winter oilseed rape were expended in 2011 (33 254 CZK/ha) and vice versa the lowest in 2010 (22 546 CZK/ha). The average cost of the three monitored seasons amounted to 26 549 CZK/ha. The highest costs in winter wheat were spent in 2010 (19 473 CZK/ha) and the lowest in 2011 (16 345 CZK/ha). The average cost amounted to 17 785 CZK/ha. In sugar rape, the highest costs were spent in 2011 (52 726 CZK/ha) and vice versa the lowest 2012 (33 573 CZK/ha). The average cost amounted to 43 629 CZK/ha)

The table 2 shows a cost structure of particular

crops. Values are recounted in CZK/ha and a share of cost items is expressed. The biggest part of spent costs is created by direct material costs. Growth of costs in seed depends on a structure of purchased seed (e.g. winter oilseed rape – a share of hybrid and line varieties and representation of novelties on the market).

The enterprise uses a higher growing intensity which is given by higher dosages of fertilizers and thereby also higher costs spent for them. Also a growing commodity prices has a big influence and thereby also directly proportionally growing price of fertilizers. Without chemical protective means it is not possible to secure the required quality and quantity and a goods health state of plants.

The group "labour costs" includes tractor works and work of self-propelled loaders. In impossibility of direct determination of labour costs these items are included in the productive overhead. The most important item of the group "other costs" (costs of auxiliary works) is property insurance. In the structure of total costs the item "overhead costs" takes a considerable share. It includes productive overhead and administrative expense. The productive overhead represents mainly costs for depreciation of multipurpose buildings and machines (sowing machines, sprinklers, machines for soil preparation) and other costs arisen in production which were not able to classify to particular crops grown in plant production. The administrative expense is given by an appropriate share of costs connected with administration and organization of the enterprise. Overhead costs are included in costs of particular calculation sections by the help of scheduling units. It is possible



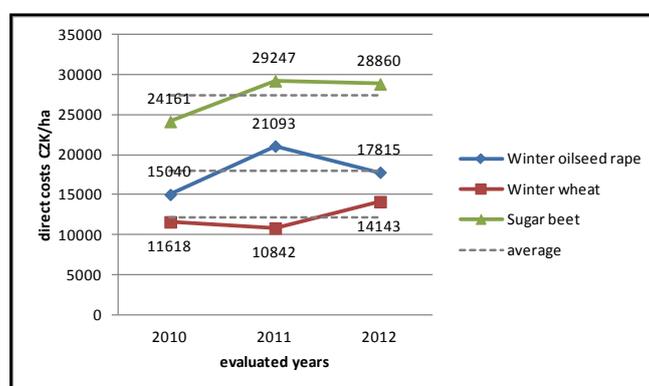
Source: own processing

Graph 4: Total and average costs of Agro Žlutice a.s. in monitored crops (1ha).

Indicators/crops in years	Winter oilseed rape			Winter wheat			Sugar beet		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Direct material costs in total	12 922	18474	16292	9974	10422	13043	16811	21286	21790
	57.30%	55.60%	62.30%	51.20%	63.80%	64.40%	37.70%	40.40%	45.20%
of it:									
Seeds	1691	1722	1530	2158	1848	2110	5495	5802	5507
	13.10%	9.30%	9.20%	21.60%	17.70%	16.20%	32.70%	27.30%	25.30%
Fertilizers	5127	6885	6931	4437	5369	6818	2034	2998	4315
	39.70%	37.30%	42.70%	44.50%	51.50%	52.20%	12.10%	14%	19.80%
Chemical means	6104	9867	7831	3379	3205	4115	9282	12486	11968
	47.20%	53.40%	48.10%	33.90%	30.80%	31.60%	55.20%	58.70%	54.90%
Other direct costs and services	2118	2619	1523	1644	420	1100	7350	7961	7070
	9.60%	7.90%	5.80%	8.40%	2.60%	5.40%	16.50%	15.10%	14.70%
Total labour cost	1949	2716	1454	1651	356	573	4031	4026	4006
	8.60%	8.20%	5.60%	8.50%	2.20%	2.90%	9%	7.60%	8.30%
Other costs	3246	3116	2300	2490	1817	1995	5673	4871	3983
	14.30%	9.30%	8.80%	12.80%	11.10%	9.90%	12.50%	9.20%	8.20%
Overhead costs	2311	6317	4559	3714	3321	3525	10724	14582	11370
	10.20%	19%	17.50%	19.10%	20.30%	17.40%	24.10%	27.70%	23.60%
Total costs/ ha	22546	33242	26128	19473	16345	20236	44589	52726	48219
Total costs/ t	6405	5947	6716	2747	2239	2933	681	614	713

Source: own processing

Table 2: Development and structure of costs of particular crops in Agro Žlutice a.s. in evaluated seasons (CZK/ha, %).



Source: own processing

Graph 5: Total direct costs in particular crops in the monitored period.

to set them according to harvest areas in the plant production.

The graph 5 shows items of direct costs (seeds, fertilizers, chemical means and other direct costs). There is obvious inter-seasonal increase of direct costs which is connected with a growing price of inputs (seeds, fertilizers and so on). Further the graph indicates average values of these costs over the monitored season in particular crops. The other direct costs and

services includes costs for transport charges, field works (combine harvest), aerial works, ground rent and services. The ground rent has a big influence on costs for growing because it still increases. The rent moves in at intervals 1 550 – 2 950 CZK/ha/year according to BPEJ (Evaluated Land Ecological Unit).

Table 3 compares direct material costs of the enterprise Agro Žlutice a.s. with average direct costs of enterprises of a sample monitored by

Indicator/ crop	Rape Agro Žlutice	Rape CR average	Wheat Agro Žlutice	Wheat CR average	Sugar beet Agro Žlutice	Sugar beet CR average
Seeds	1691	1423	2158	1032	5495	5533
Fertilizers	5127	4219	4437	2980	2034	3418
Chemical means	6104	5486	3379	2381	9282	7351
Total material costs	12922	11128	9974	6393	16811	16302
Other direct costs	2118	2407	1644	2396	7350	7402

Source: own processing, IAEI Prague

Table 3: Comparison of direct costs in Agro Žlutice a.s. with CR average in 2010 (CZK/ha).

Indicator/crop in years	Rape			Wheat			Sugar beet		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Costs (CZK/ha)	22546	33242	26128	19473	16345	20236	44589	52726	48219
Costs (CZK/t)	6405	5947	6716	2747	2933	2542	681	614	713
Yield (t/ha)	3.52	5.59	3.89	7.09	7.3	6.9	65.48	85.83	67.59
Price (CZK/t)	7742	11145	12397	4391	2993	3252	1018	795	954
Evaluation									
Revenue /ha (CZK/ha)	27252	62301	48224	31132	21849	22439	66659	68235	64481
Operating profit (CZK/ha)	4706	29059	24364	11659	5504	2203	22070	15509	16262
Operating profit (CZK/t)	1338	5198	6263	1644	754	319	337	181	240
Rate of cost return	20.90%	87.40%	93.30%	59.80%	33.70%	10.90%	49.50%	29.50%	33.70%

Source: own processing

Table 4: Evaluation of economics in Agro Žlutice a.s. (CZK/ha, CZK/t).

UZEI Prague. For comparison, the year 2010 was chosen; it was the most economically beneficial year in the monitored period. From the table it is evident a use of intensive inputs in Agro Žlutice a.s. which positively shows in the achieved yields in the monitored crops.

#### Evaluation of economics of growing

In evaluation of efficiency we take into account spent expenses (inputs) and achieved yields (revenues from sale). The results is revenue (CZK/ha), operation profit (EBIT) in CZK/ha, and a production return rate (%). An aim of the enterprise is achievement of operating profit in crop growing (Table 4).

The biggest price increase was caused by a high demand for commodities in winter oilseed rape and winter rape in the last three years. The high demand was invoked on base of a lower crop against foregoing years.

Revenues of the enterprise Agro Žlutice a.s. were highest in winter oilseed rape and in sugar

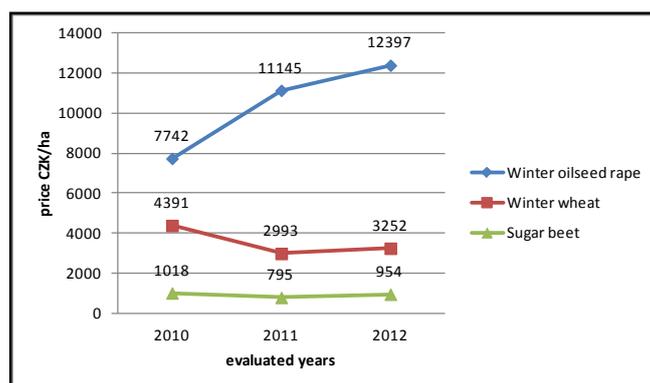
beet in 2011 which was caused by record yields in these crops. In winter wheat the highest revenues were reached in 2010 because this commodity was successfully sold for a bargain sale price. A possibility to use storage spaces and waiting for the highest possible sale price showed favourably.

A steady high yield together with fixed price secures to the enterprise achievement of a continual operating profit from sale of sugar beet. The return rate is influenced by the yield and the price in the monitored commodities.

The following graphs 6 and 7 shows a development of realization prices of the monitored crops and also a development of operating profit in the enterprise Agro Žlutice a.s. in the monitored period.

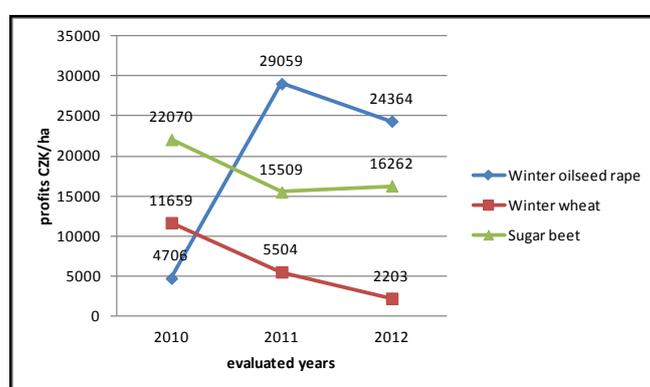
Table 5 compares revenues, prices and yields per hectare in the enterprise Agro Žlutice a.s. with averages reached in the CR.

From comparison of data, higher yields, higher realization prices and higher level of revenues in all



Source: own processing

Graph 6: Development of realization prices in Agro Žlunice a.s. (CZK/ha).



Source: own processing

Graph 7: Operating profit in Agro Žlunice a.s. (CZK/ha).

Indicator/ crop	Rape Agro Žlunice	Rape CR average	Wheat Agro Žlunice	Wheat CR average	Sugar beet Agro Žlunice	Sugar CR average
Revenues from sale of products CZK/ha	27252	22208	31132	18210	66659	44120
Realization price CZK/t	7742	7658	4391	3502	1018	724
Yield per hectare t/ha	3.52	2.9	7.09	5.2	65.48	60.94

Source: own processing, IAEI Prague

Table 3: Comparison of direct costs in Agro Žlunice a.s. with CR average in 2010 (CZK/ha).

monitored crops in Agro Žlunice a.s. are evident as well as their better evaluation than the mentioned CR averages are.

The company Agro Žlunice a.s. chooses carefully its customers and takes into account a solvency, a payment discipline, and catchment area of trade and manufacturing capacities in closure of contracts. The main consumer of mercantile winter wheat and winter oilseed rape is the company ZZN Polabí which takes c. 70 %

of these two commodity production. An exclusive customer of sugar beet is a sugar refinery TTD Dobruvice.

## Conclusion

The most important crops included in the cropping pattern in the agricultural enterprise Agro Žlunice a.s. are: winter oilseed rape, winter wheat, and sugar beet. Similarly this also applies for other

agricultural enterprises in comparable natural conditions. Therefore, these crops have been grown on a considerable part of area in the nationwide measure already for many years. In 2012, the evaluated enterprise succeeded to harvest already increased area under winter rape seed oil, it was from acreage 358 ha. The acreage of winter wheat has moved always at intervals 505-580 ha in recent years, which is given by the cropping pattern. Recently, the area of sugar beet has been increased. It was dealt with 70 ha within the last ten years. This increase was influenced by growing of sugar beet determined for bio-ethanol production.

Agro Žlunice a.s. manages in favourable climatic conditions of rape production area, therefore they achieve above-average high yields in comparison with the average of the Czech Republic. The results are amplified by intensive agronomical practices of growing and a selection of quality varieties in the monitored crops. A record yield was reached in winter oilseed rape in 2011. It amounted to 5.6 t/ha which was almost double of the average CR yield, i.e. 3 t/ha. The highest yield of winter wheat was achieved in 2011, 7.3 t/ha. This yield was by 1.4 t/ha higher than the CR average was in this year. Similarly also sugar beet reached the highest yield 85.8 t/ha in this year. The CR average yield was at the level of 59.3 t/ha.

The enterprise Agro Žlunice a.s. shows higher costs for the monitored crops against the sample of enterprises. It is caused by use of intensive agronomical practices of growing of agricultural crops and by a selection of quality varieties. The biggest part of spend expenses are represented by direct material costs. It is dealt with use

of higher doses of fertilizers and preparations for plant protection which leads to high expenses spent for them. Also the growing price of commodities has an influence and thereby also directly proportionally growing price of fertilizers and pesticides.

The revenues of the enterprise Agro Žlunice a.s. were highest in 2011 in winter oilseed rape and in sugar beet. It was caused by record yields and a very favourable realization price of these commodities. The highest revenues in winter wheat were reached in 2010 because they succeed to sale this crop for the highest realization price. A possibility to use storage spaces and waiting for the highest possible sale price showed favourably.

The return rate of grown crops is influenced by the reached yield, spent costs, and the realization price of the monitored commodities. The plant production of the enterprise Agro Žlunice, a.s. reaches favourable results in all above mentioned areas, therefore the growing of evaluated crops was cost-effective and profitable in the whole monitored period. The enterprise achieves also a higher value of operating profit in the evaluated crops in comparison with the average over the whole sector.

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## Modelling the Efficiency of Agri-Environmental Payments to Czech Agriculture in a CGE Framework Incorporating Public Goods Approach

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### Anotace

Multifunkčnost zemědělství zaměstnává ekonomy již více než dekádu. Na jedné straně lze registrovat četné snahy o zahrnutí environmentální funkce zemědělství v komoditních modelech a na straně druhé jsou evidentní pokusy fundovaně odhadnout environmentální přínosy a hodnotu krajiny pomocí kontingenčních metod. Tento článek se pokouší spojit oba vědecké proudy inkorporací nabídky a poptávky po krajině jako veřejném zboží do CGE modelu, přičemž nabídka krajiny je modelována pomocí Leontievy produkční funkce a poptávka po krajině je řešena zahrnutím ochoty platit za krajinu (WTP) do poptávkového systému domácností. Tento přístup je testován ve čtyřech scénářích, které jsou detailně analyzovány.

### Klíčová slova

Veřejné zboží, tvorba krajiny, agri-environmentální politika, CGE model.

### Abstract

Capturing agricultural multifunctionality has been a challenge to agricultural economists for more than a decade. On one hand, researchers increasingly include the provision of environmental protection and landscape maintenance in their commodity based models; on the other hand, there are efforts as contingent valuation to assess the economic value of environmental benefits provided by agriculture. This paper tries to merge both research streams by incorporating supply and demand of landscape as a public good in a CGE framework. The former is done by including an explicit sector of joint commodity and non-commodity production in the model structure; the latter by extending the household demand system of willingness to pay for landscape. The approach is tested on four scenarios which are extensively compared.

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### Key words

Environmental public goods, landscape provision, agri-environmental policy, CGE models.

### Introduction

Capturing agricultural multifunctionality has been a challenge to agricultural economists for more than a decade. This is, of course, associated with the turn of agricultural policy from market intervention to the support of public goods such as environmental conservation; i.e., the turn from commodity support to non-commodities support. On one hand, researchers

increasingly include the provision of environmental protection and landscape maintenance in their commodity based models; on the other hand, there are efforts as contingent valuation to assess the economic value of environmental benefits provided by agriculture. Concerning the former, most of the EU-based research has tended to address multifunctionality by integrating bio-physical, land use and economic models, such as works of Uthes, Ittersum and Sieber (2010), Renting, Rossing

and Ittersum (2009), Rossing, Zander and Josiem (2009), Parra-Lopez, Groot, Torres et al. (2009). Using either single or integrated model approaches, partial or general equilibrium models, the research concentrates almost exclusively on the cost of public good provision omitting completely the economic value of the benefit. This unfortunately leaves cost benefit sides unbalanced and supports the view that agriculture is a pure consumer of taxpayer money.

This paper and the corresponding research intends to overcome this problem by linking both research streams together. The research particularly draws on the works of Cretegny (2002), and Rødseth (2008), aiming at Swiss and Norwegian agriculture respectively, who conceptualised supply and demand of landscape as a public good in the CGE framework.

The objective of the paper is to assess the efficiency of the agri-environmental (AE) payments directed to permanent grasslands (meadows and pastures), whose maintenance is a key element of cultural landscape conservation in the Czech Republic as well as in many other European countries. This objective has been translated into three research questions: i) what landscape provision would correspond to actual willingness to pay (WTP) of households and what will be the “socially optimal” subsidy rate, ii) what is the value of “landscape” provided by farmers and iii) what would be the effect of removing a certain proportion of AE payments starting in 2014.

This research paper contributes to the current discussion on the methodological challenges connected to the evaluation of public goods provided by the agricultural sector. According to Slee and Thompson (2011), there are particular aspects of public goods that make the evaluation challenging. First of all, the level of the provision of public goods is very diverse across Europe and its value might be perceived higher in urban areas with limited countryside. Secondly, environmental public goods are also associated with the provision of non-use values which are not captured by the standard contingent valuation methods. Therefore, the scenarios applied in this paper take into account both the use and the non-use values of the provision of landscape. Whereas the use-values are attributed to the internalized demand of households, the non-use values are associated with the additional agri-environmental payments.

The paper is structured as follows: the CGE model and the methodology of incorporating supply and demand of environmental public goods are outlined in the next section, and the results of the simulations are presented in Chapter 4; we discuss the outcomes of the exercise and draw conclusions in Chapter 5.

## **Material and methods**

In order to assess the efficiency of the agri-environmental policy, a Computable General Equilibrium (CGE) model is applied. The choice of this approach is supported by various arguments. According to Piermartini (2006), general equilibrium models (CGE models) provide a consistent, rigorous and quantitative way of assessing economic policies and they serve as supporting tools in the decision making process. Decreaux and Valin (2007) further emphasize that CGE models are based on robust and generally accepted behavioural patterns of the economic agents. Concerning the area of public goods modelling, the CGE models are capable of internalizing public goods into markets by capturing their jointness with commodity production and by incorporating them into the consumption pattern of households or government (Rødseth, 2008).

At the very beginning of the research we assumed to utilize the survey on Czech citizens willingness to pay (WTP) for agricultural public goods (landscape) conducted by UZEI in 2009 (Majerova, Wollmutova, Prazan, 2009). However, in the course of the work it became apparent, that the survey was more sociologically oriented and thus that it lacked a clear reference to the extent of public good in terms of what landscape area and what landscape features it covered. Therefore, the survey could only provide indicative information, which had to be complemented by literature studies and by expert consultations.

The exercise has been restricted to only public goods (landscape) stemming from extensive beef production on permanent grasslands. Actually, the measure “Support to the Maintenance of Grasslands” is by far the largest agri-environmental measure, and grasslands are further supported by a set of agri-environmental measures including the support to organic livestock farming (MA, 2007). Concentrating on only one agricultural sub-sector enables us to incorporate

the jointness of production between a concrete commodity and an environmental non-commodity and to capture the competition for land between extensive and intensive farming.

### 1. Description of the CGE model for the Czech Republic

The presented CGE model has been developed for the economy of the Czech Republic with a specific focus on agricultural policy simulations. The national economy is modelled in a disaggregation into 13 production sectors, of which 8 represent specific agricultural sectors and the other represent the sectors of industry and services (Table 1).

The production side of the economy is modelled following a standard CGE model structure (see Lofgren, 2002). It is assumed, that the total gross production is a fixed factor Leontief combination of intermediate consumption and value added under perfect competition and constant returns to scale, which can be expressed by a nested production structure (for the schematic production structure as well as for more details on the model description see Křístková, 2010 b).

Sector	Land employment	Description
sec1	Yes (Secland)	Cereals
sec2		fruits and vegetables
sec3		Oilseeds
sec4		sugar beet
sec5		Cattle
sec6		pigs and poultry
sec7		Milk
sec8		other agriculture
sec9	No (Secnlan)d	forestry and fishing
sec10		food industry
sec11		other industry
sec12		R&D
sec13		other services

Table 1: Production sectors in the CGE model.

Two groups of production sectors are distinguished in the modelling of value added (Table 1): sectors that use land as a production factor (secland) and sectors that use only labour and capital stock (secland). At the first level, the value added of all sectors is formed by the combination of labour ( $L_i$ ) and capital-land bundle ( $KD_i$ ) based on the CES I production function (equation 1):

$$VA_i = aF_i \cdot (\chi F_i \cdot KD_i^{-\rho F_i} + (1 - \chi F_i) \cdot L_i^{-\rho F_i})^{-1/\rho F_i} \quad (1)$$

where  $aF_i$  is the efficiency coefficient and  $\chi F_i$  a  $(1 - \chi F_i)$  are the distribution parameters of the production function. Parameter  $\rho F_i$  in the exponent is derived from the elasticity of substitution  $\sigma F_i$  between the production factors  $KD_i$  and  $L_i$ .

There is a second level for the sectors deploying land, in which the optimal combination of capital stock ( $K_i$ ) and land ( $D_i$ ) is modelled with the use of the CES II production function (Equation 2):

$$KD_i = aG_i \cdot (\chi G_i \cdot K_i^{-\rho G_i} + (1 - \chi G_i) \cdot D_i^{-\rho G_i})^{-1/\rho G_i} \quad (2)$$

Total gross production per sector is computed as a sum of intermediate consumption, value added, net taxes on production and the depreciation of capital, which is calculated as a fixed proportion of the current level of capital stock.

The behaviour of households in the Czech economy is simulated by introducing two representative households – farmer households and other households, which optimise their utility subject to a budget constraint. Whereas the microeconomic theory provides numerous suggestions, the standard Stone-Geary Linear Expenditure System (LES) has been chosen for modelling households' behaviour (Equation 3). Due to the lack of empirical evidence on the income elasticities of agricultural households, it is assumed that both types of households follow the same consumption behaviour, based on the following utility function:

$$U = \prod_j (C_j - \mu H_j)^{\alpha HLES_j}, \quad \sum_j \alpha HLES_j = 1 \quad (3)$$

where  $U$  is the consumer's utility,  $C_j$  is the amount of consumption of the j-th commodity,  $\mu H_j$  represents the subsistence level of consumption of each j-th commodity and  $\alpha HLES_j$  is a preferential parameter of the respective j-th commodity in the consumer basket.

The household consumption budget is given by the net value of household income after taxation and transfers, reduced by its savings. The distribution of factor incomes differs for each type of household: whereas labour income of farmer households comes solely from agriculture, other households receive wages from the remaining sectors of the economy. The capital and land rent from agriculture is shared jointly between both

types of households.

The government maximizes utility modelled by the Cobb-Douglas utility function subject to the disposable budget which is derived from incomes received on basis of tax collections:

$$U = \prod_j CG_j^{\alpha CG_j} \sum_j \alpha CG_j = 1 \quad (4)$$

where  $CG_j$  is government consumption of a commodity  $j$  and  $\alpha CG_j$  represents a preference parameter in the government's consumption basket

The closure of the governmental account is arranged by fixing a ratio of governmental consumption to GDP. Governmental savings are thus adjusted to the difference between governmental incomes and expenditures.

Total supply in the market is represented by a composite commodity consisting of the bundle of domestically produced goods supplied to domestic markets and imports. The composite commodity is a result of two simultaneous forces in the model: first the intention of producers to find the most profitable combination of supply between foreign and domestic markets, modelled with a Constant Elasticity of Transformation (CET) function, and second the intention of the consumer to find an optimal combination of imported and domestically produced commodities, modelled with a CES Armington function. Two non-domestic institutions are assumed to be the EU and the Rest of the World (RoW).

The model applies six closure and factor market assumptions: i) supply of labour and land is fixed, and capital stock grows at the rate of net investments; ii) capital is fully employed in all sectors, whereas land is employed only in agriculture; iii) the labour force is not fully employed, and unemployment is determined by the Phillips curve; iv) the model follows a standard macroeconomic balance of savings and investment; v) export and import prices are fixed; vi) both foreign sector closures (for the EU and the RoW) assume fixed foreign savings and endogenously adjusting exchange rates.

The CGE model follows a recursive form of dynamisation with a Tobin's Q investment function, which allocates investments to the sectors according to their ratio of profitability to the user costs (for a detailed description, see Křístková, 2010a). The recursive dynamic linkage enables

the growth of the capital stock based on the level of investments carried out in the previous period, which are determined by total savings generated in the economy. Savings of households are determined by a fixed marginal propensity to save, whereas foreign savings are set exogenously in the balance of payment equation.

Concerning the implementation of policies it is worth to mention direct payments. Due to the fact that the direct payment rate per hectare highly exceeds the land rent in the Czech Republic, modelling direct payments solely as land subsidies is not possible (see also Gohin, 2006). In order to address this problem, only a part of the direct payments is allocated to land and the rest is modelled as a production subsidy. In the Czech Republic, direct payments are distributed in the regime of SAPS and the rate is uniform per hectare of agricultural land. However, the production subsidy rates applied in the model are sector-specific, as the subsidy share in gross agricultural production per each specialization differs (Table 2). For the sectors of pigs and poultry, the subsidy rate was calculated with the use of feedstuff conversion coefficients.

All agricultural subsidies received from the EU budget are recorded in the balance of payments. For the subsidies in the second pillar of the CAP which are co-financed, the flows are also recorded in the equation of governmental expenditures.

The CGE model is implemented in the GAMS programming language and solved in MCP format using the Path solver.

Description	Order in the model	Subsidy rate as a share of Gross Prod.
cereals	sec1	-0.26
fruits and veg	sec2	-0.02
oilseeds	sec3	-0.21
sugar beet	sec4	-0.26
intensive livestock	sec5	-0.38
pigs and poultry	sec6	-0.05
milk	sec7	-0.13
extensive livestock	sec14	-0.02

Note: negative sign of producer subsidy rate indicates that received subsidies exceed paid taxes.

Source: author's calculation

Table 2: Production subsidy rates applied in the CGE model (base year).

## 2. The Social Accounting Matrix and exogenous variables

The Social Accounting Matrix (SAM) is based on National Accounts data published by the Czech Statistical Office for the year 2006 (CSO, 2010a). Given the need to conduct agricultural policy analyses and simulations, the agricultural production and commodity accounts have been disaggregated in 8 sub-sectors/commodities on the basis of commodity balance calculations and cost survey tables provided by the Institute of Agricultural Economics and Information (UZEI). In addition, the agricultural households are separated from the other households. This split in two household accounts is based on the Statistics of Household Accounts (CSO, 2010b).

The expected growth rates of the exogenous variables were obtained from various official sources: the prediction of GDP EU is based on the Economic Forecasts of the European Commission (EC 2010); world prices and world GDP are taken from the IMF predictions (IMF, 2010); and the growth rates of the domestic exogenous variables, such as transfers or the GDP deflator, are taken from the Czech Ministry of Finance (MF 2010). In general, external economic conditions are considered prosperous with the average world annual GDP growth 4.5%.

## 3. Incorporation of public goods into the CGE model

### Supply of grassland linked landscape

As mentioned before, the extensive livestock farming sector is added to the SAM. It is assumed that this sector produces jointly a private commodity (beef meat) and a public commodity (cultural landscape). The total domestic production of beef thus consists of the production of intensive livestock farming (sector 5 in the CGE model) and of extensive farming (sector 14 in the CGE model). It is assumed that there is no qualitative difference between the two beef commodities.

Following Cretegnny (2002), the extensive farming sector produces jointly a public and a market commodity, where the area of extensive grasslands is the quantity of public goods and the value of beef production with the concentration of 0.3 LU/ha is the private good. Concerning the production function of the extensive farming sector, the linear form is preferred over the CES production function used in the other production sectors,

as it impedes substitution between land and capital, which is characteristic for extensive farming. Appendix 1 shows the nested production structure used in the CGE model including extensive livestock.

	Intensive livestock (sec5)	Extensive livestock (sec14)
Intermediate Consumption	4 688	2 099
Labour	1 861	403
Capital	265	199
Land	73	889
Total subsidies	-2 009	-2 477
Gross Capital Depreciation	302	182
Gross-gross production	5 180	1 295

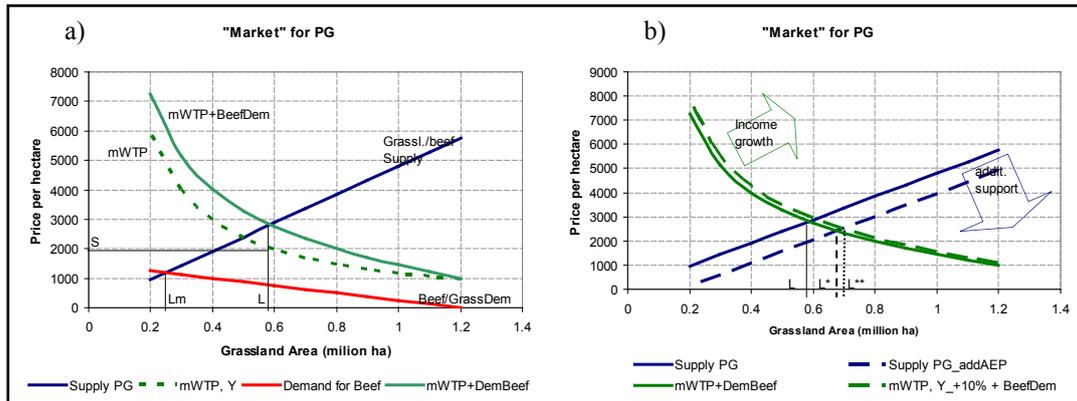
Table 3: Cost structure of intensive and extensive livestock farming (2006) in mln CZK.

As for the other agricultural sectors, the cost survey carried out by UZEI is utilised for the specification of the extensive livestock sector in the SAM. Table 3 demonstrates the differences between the cost structure of the extensive livestock sector and the intensive one. It is obvious that the extensive livestock sector must get additional revenues if it is to survive, since the production costs highly exceed market revenues.

### Demand for public goods

The last comment on the costs of extensive beef production implies in turn that public goods associated with extensive livestock production on grasslands will be under-supplied under market conditions. This situation is also depicted in Figure 1, where the area of grasslands is marked as Lm.

In the absence of a market for public goods, it is the government that can purchase the socially demanded amount of grasslands landscape. Actually, the government provides funds to subsidise extensive livestock production on grasslands. Figure 1a) illustrates that the socially optimal supply of grasslands (L) is given by the intersection of the joint beef and public good demand curves with grasslands-beef supply curve (the marginal cost of pastoral beef production per hectare of grasslands). The corresponding optimal subsidy rate (payment per hectare - S) equals marginal WTP (mWTP) at the point L (see also Rødseth (2008)).



Source: own illustration following Rødseth (2008).

Figure 1: Market for public goods (grassland – landscape).

Figure 1b) shows what happens with the optimal provision of grasslands landscape if the household income grows and/or there are additional subsidies paid to extensive beef farmers.

Following this, the Czech CGE model was extended by assuming that the public good (landscape) produced by the extensive livestock farming sector is consumed directly by households. Therefore, landscape is incorporated into the Linear Expenditure System of both types of households. In order to maintain the original benchmark equilibrium, the consumption of landscape is introduced in the SAM by separating it from demand for services.

Although the original intention was to use the results of UZEI's contingent valuation of landscape, for reasons stated earlier, we finally determined the parameters of mWTP (represented in the LES form) by assuming that the provision of grassland landscape (area of grasslands) was at its optimum in 2006 and that income elasticity of WTP equals 1.2. These are strong assumptions which are only weakly supported by the evidence - no other valuation of landscape has been conducted in the Czech Republic recently.

In the assessment of the efficiency of agri-environmental payments to the extensive livestock sector, we internalize the “market” of agricultural landscape with the use of the WTP function (as described above). The price of the public good corresponds to the household marginal WTP. The demand for landscape depends on household income and the prices of commodities; with growing real household income, households are willing to pay more for landscape and vice versa. The analytical form of the LES function

for landscape, derived from the Stone-Geary utility function is provided in equation 5:

$$P_{com14} \cdot C_{com14} = P_{com14} \cdot \mu H_{com14} + \alpha HLES_j \left( CBUD - \sum_j^{13} \mu H_j \cdot (1 + tc_j) P_j \right) \text{ where } j=1,2,\dots,13 \quad (5)$$

where  $P_{com14}$  and  $C_{com14}$  represent the price and consumption of landscape,  $CBUD$  is the consumer budget,  $tc_j$  are indirect taxes charged on other prices of commodities, and  $\mu H_j$  and  $\alpha HLES_j$  are the parameters of the utility function, as specified in equation 3.

In the model, the landscape production competes for land with other agricultural sectors; land is converted into extensive grassland production as long as the total income from extensive production is higher than from the intensive one. A summary of the main characteristics of the model is presented in Table 4.

	Model description
Gross production of the extensive livestock sector	Represented by the gross production of the private commodity (beef) + public commodity (landscape)
Landscape supply	Modelled as a fixed share of the total gross production of sector 14
Landscape demand	Explicitly included in the households expenditure system (LES)

Source: author's proposal

Table 4: Main features of the modelling approach.

#### 4. Description of Scenarios

To show the capacity of the extended model, three scenarios on the implementation of landscape have been prepared and calculated.

*Scenario 1* aims at simulating the provision of permanent grassland landscape under the simulated “market” for public goods, where no specific (additional) governmental support directed to the extensive livestock sector is assumed. Nevertheless, the sector still receives direct payments. This simulation is performed without further policy changes for the whole period 2007- 2020. In order to maintain the governmental balance, the removed subsidies are transferred to both types of households, proportionally to their size.

*Scenario 2* models a parallel existence of landscape markets where households are the direct purchasers of landscape, and the additional governmental support to the production of landscape. The total revenue of the extensive farming sector thus consists of market revenues from the private commodity represented by beef production, the revenue from the public good market, direct payments and the additional subsidy revenue of various policy measures related to grasslands and beef production included in the agri-environmental payments.

*Scenario 3* aims at illustrating changes in the optimal landscape provision if the additional supports (except for direct payments) are removed from 2014 onwards and also transferred directly to both types of households.

## Results and discussion

The primary purpose of this research is to analyse the provision of public goods from the supply and the demand side, including consumption effects. Since the aim is not to investigate potential impacts of considered policies, there is no baseline

scenario introduced. Scenarios are first interpreted with respect to the development dynamics and afterwards compared each to other.

For the simulations we applied the actual amount of supports directed to landscape maintenance for the period 2006-2010 (Table 5), assuming that the support will continue at the 2010 level until 2020. The considered income elasticity of the “landscape good” is supposed to be equal to the income elasticity of services (1.2). The LES is calibrated to the 2006 figures as the entire model.

The results are presented in terms of the landscape value, grasslands area under extensive livestock, the landscape value based on WTP and beef production figures for both the extensive and intensive farming. Furthermore, the effects on the whole agricultural sectors as well as the national economy in terms of GDP are analyzed.

### 1. The provision of agricultural landscape under different policy options

The provision of landscape under the scenarios is presented in Table 6 and Figure 2 below. The numbers relate to the area of grasslands under extensive livestock farming – absolute figures in the graph and annual growth rates in the table. In the benchmark period, the size of grasslands that were operated in the extensive livestock farming amounted 889 thousand hectares. The simulation of Scenario 1 shows that the extent of grasslands would be gradually increasing in the following periods, which can be explained by an increasing real income of households and thus their increasing willingness to pay for the landscape. Furthermore, it can be expected that the grassland size would stabilize at 1,200 thousand ha at the end

CZK millions	2006	2007	2008	2009	2010
Maintenance of meadows and pastures	1 866.5	1 777.2	1 766.3	1 445.7	1 462.2
Other AEP directed to grasslands	34.1	279.2	286.4	739.9	766.7
Total	1 900.5	2 056.4	2 052.7	2 185.6	2 228.9

Source: SZIF (2011)

Table 5: Agri-environmental payments directed to grasslands 2006-2010.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 1	9%	-1%	2%	4%	3%	5%	0%	4%	-1%	3%	-1%	2%	-2%	2%
Scenario 2	13%	10%	-2%	15%	3%	2%	1%	1%	0%	0%	0%	-3%	2%	-1%
Scenario 3	13%	10%	-2%	15%	3%	2%	1%	-15%	1%	1%	1%	1%	0%	0%

Source: own calculations

Table 6: Growth rates of land employed in the extensive livestock sector.

of the analyzed period.

In Scenario 2 when the revenue from the beef and “landscape” markets is complemented by additional government support, the amount of land employed in the extensive livestock sector grows substantially, especially in the first half of the analysed period. The sudden fall of grasslands’ size in 2009 is attributed to the GDP decline which occurred as a result of the ongoing economic and financial crises and has a repercussion on household demand and thus on the demand for landscape. In 2020, the size of the landscape stabilizes at 1,300 ha, which is 100 thousand hectares larger compared to Scenario 1, indicating a positive impact of additional governmental support on extensive farming.

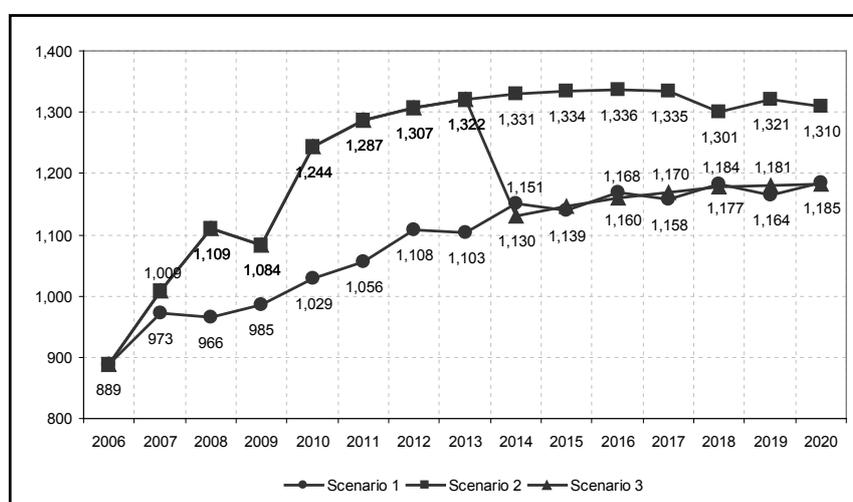
Scenario 3 provides the extent of grasslands if the additional agri-environmental subsidies are removed from 2014 and the support of the landscape provision is determined only by households’ willingness to pay. As the figure shows, it is possible to expect a 20% decline in the amount of land employed in the extensive livestock sector. The size of grasslands would fall from 1,322 thousand ha to

only 1,130 thousand. However, in the consequent periods, the size of grasslands will slightly recover and converge to the level in Scenario 1.

The decline of the grassland area after 2014 in Scenario 2 can be attributed to the fact that high supports capitalise in the land price. Table 7 shows the development of the land price indexes of all scenarios. Between 2006-2013 land prices grow faster in Scenarios 2 and 3 than in Scenario 1, due to the effect of additional subsidies. Such growth of land prices signalizes high pressures on the land market due to stimulated demand for land. This can have a reverse effect on the profitability of the extensive livestock sector. It can be also noted that after 2013, the land price index falls in Scenario 3 as a result of the subsidy removal. Thus, in 2020 land prices in Scenarios 1 and 3 converge.

## 2. Demand for landscape and the optimal subsidy rates

In the benchmark equilibrium, the WTP for the landscape is set equal to the agri-environmental payments, reaching CZK 1.976 billion.



Source: own calculations

Figure 2: Land employed in the extensive farming sector ('000 ha).

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 1	1	1.1	1.6	1.6	2.2	2.2	2.4	2.5	2.8	3	3.3	3.6	4	4.2	4.7
Scenario 2	1	1.2	1.9	1.8	2.8	2.8	3	3.2	3.4	3.8	4	4.4	4.5	5.1	5.5
Scenario 3	1	1.2	1.9	1.8	2.8	2.8	3	3.2	2.7	3	3.3	3.6	3.9	4.3	4.7

Source: own calculations

Table 7: Development of the annual land price indices.

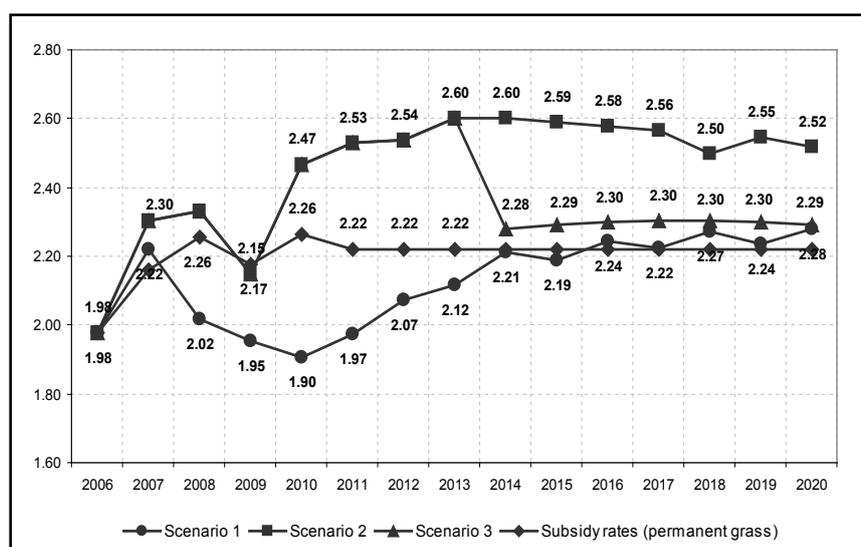
The demand for landscape is determined by the LES function which depends on the households' income and the landscape price, corresponding to the marginal willingness to pay. With growing income, the households are willing to pay more for the landscape and their demand increases. This behaviour can be observed particularly in the second half of the period (Figure 3). Between 2007-2010, a considerable decline of the demand for landscape is noticed, which reflects the combination of two different forces, firstly the demand driven decline due to the economic crisis and second, the supply driven decline due to a loss of the grassland sector's competitiveness, induced by the land market development. As a response to the economic revival, between 2009 and 2010, the land price index increases by 33% and this increase has serious impact on the profitability of extensive farming. The development of landscape demand in Scenarios 2 and 3 implies that the additional agri-environmental support can substantially divert the decline in profitability.

Figure 3 allows a comparison of the landscape value determined solely by the market and the landscape

value corresponding to actual governmental subsidy rates. In the first half of the period (2007-2013), real subsidy rates were actually exceeding implicit demand for landscape driven by households. After 2013, the economic growth will return the demand by households to the levels corresponding to the governmental subsidy rates. Based on this finding, it can be speculated that in the absence of governmental support, the extensive farming sector would lose competitiveness compared to other agricultural sectors. We can also assert that the current Agri-environmental programme has defined the payment rates in line with the expected demand around 2015, and that the payments will need to be revised in the programming period if they should meet the demand of 2020.

The subsidy effect is further clearly demonstrated in case of Scenario 3 where the demand for landscape suddenly falls by 12% and afterwards tends to converge to the level of Scenario 1.

It can also be seen from Figure 3 that with the (additional) targeted supports to grasslands, the demand for the landscape considerably increases.



Source: own calculations

Figure 3: Demand for landscape by households (bln. CZK).

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 1	1	1	1.15	1.19	1.24	1.24	1.25	1.3	1.3	1.39	1.41	1.49	1.52	1.62	1.65
Scenario 2	1	0.96	0.99	1.07	0.95	0.96	1.01	1.05	1.1	1.16	1.22	1.28	1.38	1.41	1.49
Scenario 3	1	0.96	0.99	1.07	0.95	0.96	1.01	1.05	1.26	1.32	1.38	1.44	1.5	1.57	1.65

Source: own calculations

Table 8: Evolution of landscape price indexes.

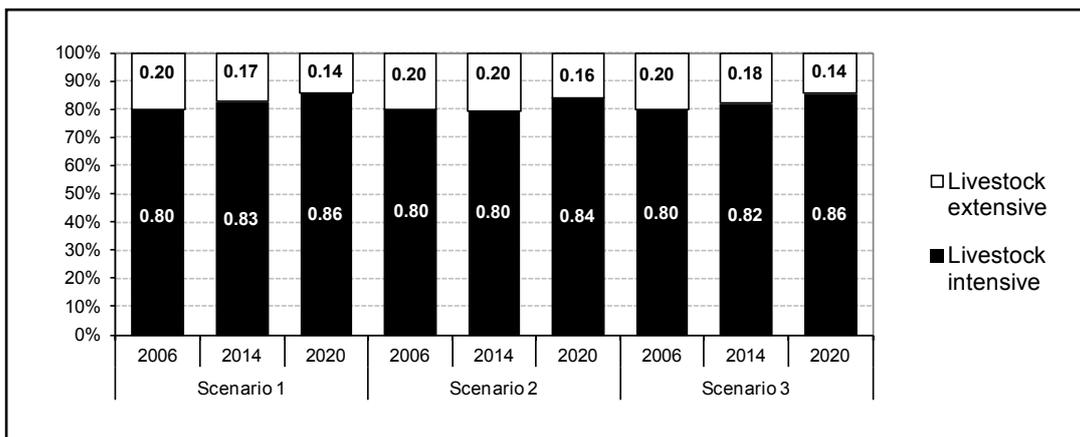
With some caution, it can also be interpreted that supporting “other environmental values” of grassland conservation including those which are not necessarily recognised or appreciated by domestic households, domestic households will benefit since they will also get more and cheaper “landscape”. This is also documented in Table 8 which shows that if the sector of extensive livestock is not supported by other subsidies than the price of public good (corresponding to the marginal WTP for landscape), the price of landscape is higher than in Scenario 2 where this support is present.

### 3. The effects on the extensive and intensive livestock production

The changes in the provision of landscape are closely related to the production of beef on grasslands, as these commodities are complements to each other

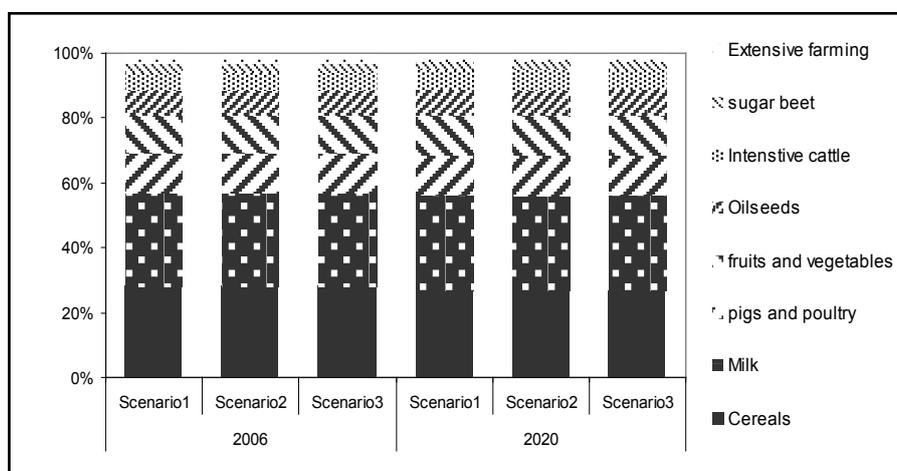
in the production process. Moreover, the different policy options concerning grassland landscape have also simultaneous impacts on the production of beef in the intensive livestock sector, because of the single commodity market. Figure 4 illustrates the impact of the scenarios on the production of both extensive and intensive livestock sectors.

In the benchmark equilibrium, the value of beef produced in the intensive farming sector represents 80% of total beef production. The scenarios clearly show that this relation can be changed in favour of either farming sector, depending on the level of support to the extensive production. Concerning Scenario 1, due to the absence of the agri-environmental subsidies, the total demand for the provision of landscape declines, which is further translated in the decline



Source: own calculations

Figure 4: Gross production of beef in extensive and intensive livestock farming (% share).



Source: own calculations

Figure 5: Structure of value added as a share of GDP.

of beef produced in the extensive farming sector. The decline in profitability of the extensive livestock sector leads to a reallocation of resources to the sector of intensive livestock farming. In Scenario 2, the proportion of beef produced in the extensive farming is higher, as the subsidies cover the production costs and contribute to lower the prices of beef meat. Scenario 3 converges with Scenario 1 and shows that the long term size of the extensive beef production would be stabilized around the level of 14%, which is 6 percentage points less than in the initial period.

#### **4. The effects on structure value added in agriculture as a share of GDP**

Figure 5 provides an overview of the structure of value added in the agricultural sectors considered, measured as a share in total GDP. It can be noted that changes in the structure of the agricultural sector produced by the scenarios are almost negligible. Even more negligible is the share of the extensive farming sector in total GDP which also explains why the analysed scenarios produce almost no effects on the macroeconomic balance of the Czech Republic.

## **Conclusions**

By incorporating the provision of landscape into a CGE model, it was possible to assess the efficiency of agri-environmental payments. It has been found out, that in the absence of these payments, the area devoted to the grasslands could be about 20% lower. However, it was also shown that in the period 2007 – 2013, the subsidy rates supporting the provision of landscape were above the optimum rates derived from household demand.

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Furthermore, the analysis revealed the necessity to revise the agri-environmental subsidy rates for 2020.

Although the research suffered from a lack of credible information on the willingness of households to pay for the provision of landscape associated with extensive livestock production, it proved that incorporating public goods in the CGE model has an important capacity to improve the analysis of agri-environmental policies. If we are able to estimate or calibrate the marginal WTP function, we will also be able to value the non-commodity production of agriculture. It was also shown that such an extended model can provide a rich analysis of the interlinkage between commodity and non-commodity production and policies.

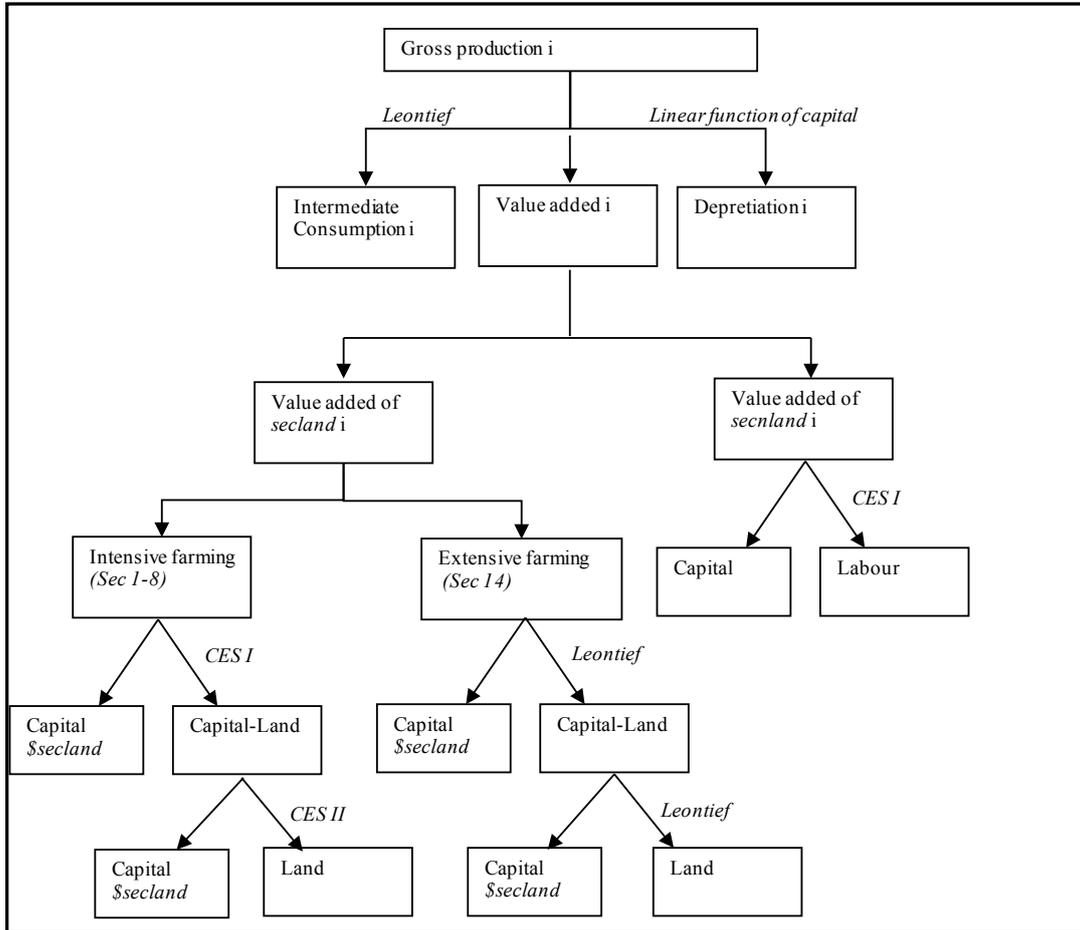
Besides the necessary improvement on the WTP surveys as an input to modelling, there are at least two other directions how to improve the analysis: the first is straightforward - by including more than one sector of multifunctional activities. The other improvement will be using a similar approach to split the beef markets and to internalise some of the environmental attributes of the production in the value of the commodity (bio-beef).

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## Appendix



Appendix 1: Nested production structure in the CGE model.



## World Sugar Market – Basic Development Trends and Tendencies

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### Anotace

Zpracovaný článek se věnuje problematice světové produkce cukru a cukrodárných plodin (cukrová řepa a cukrová třtina) a dále pak je analyzován i vývoj globálního obchodu s cukrem. Hlavním cílem článku je vymezit základní vývojové trendy a tendence ovlivňující současný vývoj trhu s cukrem a cukrodárnými plodinami a dále pak poukázat na proces postupného profilování světového trhu s těmito komoditami. Článek identifikuje nejvýznamnější hráče/subjekty operující na světovém trhu a to jak z pohledu produkce, tak i z pohledu obchodu. Článek rovněž identifikuje nejen nejvýznamnější subjekty globálního trhu z pohledu realizovaného objemu produkce a obchodu, ale i z pohledu disponibilních komparativních výhod a dynamiky růstu realizovaného objemu produkce a obchodu. V neposlední řadě příspěvek poukazuje na výrazné difference existující v jednotkových cenách realizovaných exportních a importních toků v případě jednotlivých zemí a regionů. Z výsledků zpracovaného článku vyplývá, že světový trh s cukrem je extrémně koncentrovaný, omezený počet subjektů lokalizovaných zejména v Latinské Americe, jihovýchodní Asii a v Evropě a Severní Americe ovládá většinu světové produkce cukrové řepy a cukrové třtiny. Dále pak z výsledků analýzy vyplývá, že produkce a export cukru jsou logicky úzce spjaty s regiony produkujícími cukrodárné plodiny z čehož opět vyplývá, že omezený počet subjektů ovládá většinu globálního trhu s cukrem – v současné době tomuto trhu dominují zejména Latinsko americké země a jihovýchodní Asie společně s Evropou.

### Klíčová slova

Cukr, cukrodárné plodiny, cukrová řepa, cukrová třtina, produkce, obchod, regiony, země, konkurenceschopnost, cena, vývoj, trend.

### Abstract

This article is devoted to the issues of the world's sugar production and cultivation of sugar crops (sugar beet and sugar cane). It also analyzes the development of the global sugar trade. The main aim of this paper is to define the basic developmental trends and tendencies that affect the current situation on the market for sugar and sugar crops and then outline a process of gradual profiling of the world markets for these commodities. The article identifies the most important players operating in the global market, both in terms of production and in terms of trade. It also identifies not only the most important subjects of the global market from the viewpoint of the realized volume of production and trade, but also in terms of available comparative advantages and growth dynamics of the realized volume of production and trade. Finally, the paper highlights the significant differences existing in unit prices of the realized export and import flows in individual countries and regions. The results of this study show clearly that the world sugar market is extremely concentrated. A narrow group of entities localized mainly in Latin America, Southeast Asia, Europe and North America controls most of the world production of sugar beet and sugar cane. Furthermore, the results of the analysis show that the production and export of sugar are logically closely linked with the regions cultivating sugar crops, which again suggests that a limited number of entities controls most of the global sugar market. Currently, this market is dominated mainly by Latin American countries and Southeast Asia together with Europe.

### Key words

Sugar, sugar crops, sugar beet, sugar cane, production, trade, regions, countries, competitiveness, price, development, trend.

## **Introduction**

Sugar is a very important commodity that contributes towards feeding the mankind. It is also a very significant component of the global food market, on which it plays an irreplaceable role. The world market for sugar and sugar-containing products is constantly evolving (Pokorná, Smutka, Pulkrábek, 2011). Its present form is being very markedly shaped especially by the process of liberalization of the world market for agricultural commodities.

In this respect it should be noted that although in recent years the markets for agricultural commodities - including sugar - have dramatically opened up, it remains clear that the trade in agricultural produce in general, and sugar in particular, represent one of the most distorted markets in the world. This is due mainly to the protectionist policies of many governments. Production and trade in sugar are also very closely linked with the policies of sustainable development (Smutka, Rumánková, Pulkrábek, 2013).

Economics of the production of and trade in sugar is greatly influenced by the developments in the area of the cultivation and trade in sugar crops. Their cultivation, trade and prices have been in recent years considerably influenced by the attitudes of many governments of the world towards the issue of renewable sources of energy. The economy of not only sugar crops cultivation, but also of the actual production of sugar and sugar-containing products are thus dramatically affected by the increase in demand for biofuels, which has been growing very dynamically in recent years.

At this point it should be mentioned that biofuel production is linked to the cultivation of both sugar beet and sugar cane - the two most important sugar crops (Smutka, Pokorná, Pulkrábek, 2011). Due to the dynamic growth of the global production of sugar and then also the production of biofuels, the worldwide cultivation of sugar crops has increased considerably in recent years. The sugar beet and sugar cane production volumes have increased by 2.5% and 2.7% per annum respectively over the past five years (FAO, 2013). The increase in the extent of cultivation was accompanied by increased production of sugar, which has reached the rate of almost 0.8% per year in the period of 2008/2009 - 2011/2012.

From the above it follows that a considerable volume of the sugar crops production was not

used for the manufacture of sugar but mainly for the needs of the biofuels production the volume of which grew during the years of 2006 - 2012 in the case of biodiesel from 1700 million to nearly 5700 million gallons, and in the case of bioethanol from 10 000 million to almost 23 000 million gallons (USDA, 2013).

Nevertheless, given the long-term evolutionary trend, a comment could be made that over time the world sugar market is a dynamically evolving quantity. In the years of 1966 - 2012 alone the worldwide sugar production had increased from 66 million tonnes to over 172 million tonnes (FAO, 2013). These figures thus show that on average the volume of the global production during the observed period rose by 2% per year.

The average annual production increase during the observed period amounted to around 2 300 thousand tons of sugar. During the same period the volume of the sugar stockpiles also increased sharply. In the years of 1966 - 2012 it increased from approximately 22 million tons to nearly 50-60 million tons (USDA, 2013). The production growth over time is constantly becoming more dynamic and over the past five years alone, ie 2008/2009 - 2012/2013, the world's sugar production has increased on average by 4.6% per year.

The sugar market is undergoing very significant changes that very dramatically modify its character. The process of liberalization and globalization of the world market (Jeniček, 2012) for agricultural and food products, which began in the nineties of the 20<sup>th</sup> century through the Uruguay Round of GATT, weakened the position of some major players on the world sugar market (notably the European Union and the USA) and, by contrast, it reinforced the production and trading positions of especially the Latin American countries and also of some countries located in Southeast Asia and the Pacific Region (Devadoss, Kropf, 1996; Poonyth, Westhoff, Womack, 2000).

The global market has been developing very dynamically in recent years, both in terms of sugar production and in terms of cultivation of sugar crops (mainly sugar cane), which, as mentioned above, are increasingly being used for the conversion into biofuels (Janda, Kristoufek, Zilberman, 2012). Prices of sugar and sugar crops have recorded a very strong growth over the past decade. However, the character of this growth has varied in different regions of the world.

The sugar prices that were previously relatively stable had started to significantly oscillate in either direction (Rumánková, Smutka, Pulkrábek, Benesova, 2012a). After a long period of growth, it is now possible to register their gradual reduction. However, it is worth noting that as a result of the increasing use of sugar crops for non-food purposes, the growth in the global demand for sugar (owing to population growth, rising purchasing power, etc.) and the stagnation in the world's sugar stockpiles, we can expect further price increases for this key commodity (Rumánková, sadness, Pulkrábek, Benesova, 2012b).

The sugar market is very competitive (Smutka, Pokorná, Pulkrábek, 2012a). It is, therefore, not surprising that more and more profiles are constantly being created (Smutka, Pokorná, Pulkrábek, 2011b). On the other hand, it is still valid that the sugar market is greatly distorted by a number of protectionist policies pursued by a number of countries (Neundoerfer, 2011; Dillen, Demont, Tollens, 2008; Smutka, Pokorná, Pulkrábek, 2011b) such as the EU, the Commonwealth of Independent States (CIS), China etc. In the future, we can expect that the global sugar market will continue to evolve and the changes will affect not only the territorial structure of exports and imports, but also the deployment of the production capacities around the world.

## **Materials and methods**

The aim of this paper is to define the basic development trends and tendencies that have been affecting the development of the world sugar market in recent years. It also defines the major players operating in the global sugar market. In this regard, it lists the most important producers and traders of sugar and sugar crops. The article also outlines the distribution of comparative advantages in the global market and identifies the positions of the major countries and then of individual regions of the world market. Finally, the paper points out the differences existing in kilogram prices of exports and imports between individual countries and regions.

This article examines mainly the development of the worldwide production, consumption and trade in the years of 2008/2009 - 2012/2013. Emphasis is placed primarily on the period of 2012/2013. The databases of the USDA, UN Comtrade and FAOSTAT served as the primary data sources for processing individual analyses. The analyses

have been processed in metric tonnes and at current dollar prices (USD).

In terms of content, this study covers production (data are processed in the raw sugar equivalent) and trade (the analysis is processed by means of the accumulation of the commodity HS 1701 aggregation, ie refined and raw sugar together). Individual analyses are processed at the level of individual regions and countries. The availability of data in some cases was limited, thus the analysis includes results for only about 140 countries. However, based on the above mentioned reputable statistics, these countries should represent more than 95% of the world production and trade in sugar.

The overall analysis includes several parts. The basic trends were calculated for the observed period by means of chain indices, which were then averaged by the geometric mean to obtain the average increase/decrease in production, consumption and trade. The analysis of kilogram prices was carried out by simply dividing the declared value of traded goods and their mass. The competitiveness of individual countries and regions in relation to trade flows realized between a given entity and its external environment was assessed by the LFI index (includes only transactions that took place between the countries/regions and the external environment), and the RCA index (which analyzes the comparative advantages of export of a given country/region in relation to the globally implemented exports).

The analysis of the competitiveness of individual countries and regions in white sugar trade has been carried out in relation to the commodity aggregation (HS 17 - Sugar and sweets). In respect to the various above-mentioned indices, their design and interpretation follows next. The actual comparative or competitive advantage of individual entities is analyzed at the national/regional level in relation to the total volume of traded sugar on the world market via the RCA index. The concept of the RCA index itself is based on the so-called Balassa index of 1965 (Balassa, 1965).

The RCA Index of the obvious comparative advantage (comparative advantage – global/regional level

$$RCA = (X_{ij}/X_{nj})/(X_{it}/X_{nt})$$

where:

X is export

- i is the analysed country  
 j is an analysed sector of economics (industry sector or commodity)  
 n represents a group of countries or the world  
 t represents the sum of all sectors of economics or the sum of all commodities or the sum of all branches

The RCA1 index analyzes the export commodity „j“ for a country „i“ in relation to the total exports of the country and the corresponding total export of the analyzed group of countries or the whole world. A comparative advantage in such cases is demonstrated if the value of the RCA1 index is greater than 1. However, if the resulting value of the calculated index is less than 1, then we can say that the given country has a comparative disadvantage in the case of a given commodity or a group of commodities.

Competitiveness of the realized export flows in relation to the import flows (only at the level of the actually realized transactions between a given country/region and its external environment) is realized by means of the LFI index (Lafay, 1994). The LFI index makes it possible to analyze the status of each specific product within the foreign trade structure of each specific analyzed country or group of countries (Fidrmuc, Grozea-Helmenstein, Wörgötter, 1999; Burianová, Belova, 2012; Zaghini, 2005). For a given country „i“ and for each analyzed product or group of products „j“ the LFI index is defined in the following form:

$$LFI = \left( \frac{x_j - m_j}{x_j + m_j} - \frac{\sum(x_j - m_j)}{\sum(x_j + m_j)} \right) \frac{x_j + m_j}{\sum(x_j - m_j)} 100$$

where:

$x_j^i$  a  $m_j^i$  represent exports and imports of the product „j“ implemented by a country or a group of countries „i“, in relation to the rest of the world or in relation to the selected trading partner (partner country). „N“ is the number of analyzed items. A positive LFI index indicates the existence of a comparative advantage within the framework of a given analyzed traded aggregation or a group of aggregations. The higher the resulting value of the index, the higher the degree of specialization of the given country in the case of trade involving a given item or a group of items. On the other hand, a negative value of the LFI index signals the lack of specialization and subsequently also of the comparative advantage (Zaghini, 2003).

## Results and discussion

The growth of the world sugar production relies on the increase in the sugar crops cultivation. In the years 2008/2009 - 2011/2012 alone the worldwide sugar beet production reached nearly 272 million tons, with an average growth rate of production standing at about 2.5% per year. In the case of sugar cane, during the same period its production reached the level of about 1 794 million tons, and the rate of the production growth achieved an average of 2.7% per year. From these figures it is clear that the main volume of sugar crops production is made up primarily of sugar cane. While sugar beet is grown in about 50 countries (see details in Table 1), the sugar cane is cultivated in about one hundred countries (see details in Table 2).

Table 1 shows that the main producers of sugar beet are mainly Russia, France, Germany, USA, Ukraine and Turkey (i. e. Europe and North America dominate). The share of these countries in the global production is more than 60%. The highest growth rate of the production is shown particularly in the countries of Eastern Europe. In respect of sugarcane Table 2 indicates that the most significant producers are mainly Brazil, India, China and Thailand (these countries represent more than 70% of the production of sugar cane in the world). In summary, the world sugar cane production is currently dominated mainly by Latin America and Asia, with the highest growth rates shown the countries located in South America and then in Southeast Asia.

From the above it follows that the global production of sugar cane and sugar beet continues to expand over time. This growth is stimulated, among other things, by the growing demand for sugar. Its production is realized in about one hundred and twenty countries. However, the fact is that the world sugar market has long been dominated by a small group of very powerful producers that we find mainly in the Asia-Pacific Region (about 38% of the world sugar production), and then in the area of North and South Americas (26% and 8% respectively of the world sugar production) and also in Europe (about 15% of the world production).

The world market is highly concentrated. At present, it is possible to include as the most important players on the global sugar market the following countries: Brazil, India, China, Thailand, USA, EU, Mexico, Russia, Pakistan and Australia. The share of these countries in the global

Country	(1000 tonnes)	Share 2011	Growth rate GEOM	Country	(1000 tonnes)	Share 2011	Growth rate GEOM	Country	(1000 tonnes)	Share 2011	Growth rate GEOM
Colombia	21.4	0.01%	1.179	Switzerland	1828.2	0.67%	1.038	Canada	703.1	0.26%	0.980
Azerbaijan	252.9	0.09%	1.155	Europe	195652.8	72.03%	1.034	Poland	11674.2	4.30%	0.980
Russian Federation	47643.3	17.54%	1.134	France	37259.1	13.72%	1.029	Romania	660.5	0.24%	0.969
Egypt	7486.1	2.76%	1.082	Asia	37213.8	13.70%	1.027	Serbia	2821.9	1.04%	0.969
Slovakia	1160.7	0.43%	1.082	Ukraine	18740.0	6.90%	1.025	Central Asia	593.2	0.22%	0.960
Czech Republic	3898.9	1.44%	1.078	World + (Total)	271644.9	100.00%	1.025	Americas	28852.2	10.62%	0.958
Syrian	1805.2	0.66%	1.072	Lithuania	877.8	0.32%	1.024	Iraq	15.0	0.01%	0.955
Eastern Europe	89707.3	33.02%	1.068	Eastern Asia	14278.0	5.26%	1.019	Japan	3547.0	1.31%	0.953
Austria	3456.2	1.27%	1.068	Mali	4.0	0.00%	1.017	Northern America	26855.4	9.89%	0.952
Western Asia	18210.8	6.70%	1.068	Western Africa	4.0	0.00%	1.017	USA	26152.3	9.63%	0.951
Turkey	16126.5	5.94%	1.068	Western Europe	78810.5	29.01%	1.016	Spain	3966.1	1.46%	0.948
Chile	1951.1	0.72%	1.065	Netherlands	5858.0	2.16%	1.015	Southern Europe	11884.3	4.37%	0.935
South America	1996.8	0.74%	1.065	European Union	118329.7	43.56%	1.008	Italy	3548.0	1.31%	0.934
United Kingdom	8504.0	3.13%	1.060	Kyrgyzstan	158.8	0.06%	1.005	Iran	4095.7	1.51%	0.933
Northern Africa	9922.0	3.65%	1.057	Ecuador	3.9	0.00%	1.003	Southern Asia	4131.8	1.52%	0.931
Africa + (Total)	9926.0	3.65%	1.057	Finland	675.7	0.25%	1.001	Croatia	1168.0	0.43%	0.927
Net Food Importing	9982.6	3.67%	1.055	Albania	40.0	0.01%	1.000	Kazakhstan	200.4	0.07%	0.897
Belarus	4485.1	1.65%	1.055	Turkmenistan	234.0	0.09%	1.000	Hungary	856.0	0.32%	0.843
Northern Europe	15250.7	5.61%	1.049	Germany	25000.0	9.20%	0.999	Greece	324.4	0.12%	0.782
China	10731.0	3.95%	1.047	Venezuela	20.5	0.01%	0.997	Armenia	10.0	0.00%	0.780
Denmark	2700.0	0.99%	1.046	Morocco	2435.9	0.90%	0.995	Pakistan	20.9	0.01%	0.707
Afghanistan	15.2	0.01%	1.042	Moldova	588.6	0.22%	0.990	Lebanon	1.2	0.00%	0.424
Sweden	2493.2	0.92%	1.039	Belgium	5409.0	1.99%	0.985	Portugal	8.0	0.00%	0.421

Source: Data processed by author, Faostat, 2013

Table 1: World production of sugar beet, 2011.

sugar market today exceeds 76%. In particular, the shares of Brazil, India, China and Thailand, compared to the total world production, amount to amazing 51%.

The world market is concentrated not only from the point of view of production, but also in terms of the sugar trade and the possession of available stocks. The world's largest exporter with a share exceeding 45% in the period of 2012/2013 was, undoubtedly, Brazil. Other major players were then Thailand (13% of world exports), Australia (about 5.6%), India (almost 4%), Guatemala (approximately 3%). A mere five of these mentioned countries currently control 70% of world exports of sugar.

It is very interesting to track the stocks of sugar and see who deals with these stocks. It can be seen that the global ownership of this key commodity stocks is also very concentrated. The largest holders of the world's reserves of sugar are, undoubtedly, India (17.3%) and China (about 12.7%), followed

by the EU (about 8.7%), Thailand (8%) and the USA (about 5.3%). The share of these countries in the available stocks at the end of 2012 was as high as about 55%. The world production, export and supply are concentrated. The sugar consumption and its import are relatively concentrated in a similar way.

The largest importers of sugar are currently Asian countries, the Middle East and African countries. The share of these regions in imports of sugar is hovering high above 70%. A specific feature of the world sugar market is its consumption. Quite logically, the majority of sugar is consumed in Asia (more than 42% of the world consumption). The most important consumers are China with India - together about 25% of the world sugar consumption. Other major consumers are then South America, Western Europe and North America. The cumulative share of these regions on the world sugar consumption is at the level of more than 75% of global consumption.

Country	(1000 tonnes)	Share 2011	Growth rate GEOM	Country	(1000 tonnes)	Share 2011	Growth rate GEOM	Country	(1000 tonnes)	Share 2011	Growth rate GEOM
Western Asia	11.9	0.00%	1.882	Mali	360.0	0.02%	1.013	Myanmar	9400.0	0.52%	0.993
Lao PDR	1222.0	0.07%	1.394	Papua N. Guinea	335.0	0.02%	1.012	Southern Asia	411599.9	22.94%	0.992
El Salvador	9899.0	0.55%	1.189	Guadeloupe	825.0	0.05%	1.011	India	342382.0	19.08%	0.991
Cameroon	1450.0	0.08%	1.117	Nepal	2718.2	0.15%	1.011	Nigeria	1450.0	0.08%	0.991
Thailand	95950.4	5.35%	1.105	Argentina	25000.0	1.39%	1.011	Dominican R.	4644.5	0.26%	0.990
Zambia	3500.0	0.20%	1.096	Guatemala	18951.8	1.06%	1.008	USA	26655.8	1.49%	0.990
Mozambique	2800.0	0.16%	1.080	Zimbabwe	3100.0	0.17%	1.008	Northern America	26655.8	1.49%	0.990
Brazil	734006.0	40.91%	1.075	Asia + (Total)	710938.6	39.62%	1.007	Mexico	49735.3	2.77%	0.989
Cuba	15800.0	0.88%	1.073	Senegal	860.0	0.05%	1.007	Indonesia	24000.0	1.34%	0.988
Nicaragua	5937.5	0.33%	1.073	Kenya	5338.6	0.30%	1.006	Sri Lanka	729.0	0.04%	0.982
Paraguay	5339.0	0.30%	1.068	Uganda	2400.0	0.13%	1.005	Burundi	164.5	0.01%	0.981
Honduras	7818.9	0.44%	1.065	Angola	510.0	0.03%	1.005	Egypt	15765.2	0.88%	0.981
Cambodia	365.6	0.02%	1.063	China	115123.6	6.42%	1.003	Cape Verde	25.0	0.00%	0.981
South America	823067.2	45.87%	1.060	Burkina Faso	460.0	0.03%	1.003	Venezuela	8907.7	0.50%	0.979
Afghanistan	92.5	0.01%	1.057	Pakistan	55308.5	3.08%	1.003	Bolivia	5869.6	0.33%	0.979
Americas	972689.7	54.21%	1.052	Haiti	1110.0	0.06%	1.002	Martinique	206.7	0.01%	0.978
South-Eastern Asia	183203.2	10.21%	1.051	Côte d'Ivoire	1650.0	0.09%	1.002	Africa	83455.0	4.65%	0.978
Panama	2095.0	0.12%	1.050	Eastern Asia	116123.6	6.47%	1.002	EU	5.1	0.00%	0.976
Middle Africa	5285.0	0.29%	1.049	Viet Nam	17465.2	0.97%	1.001	Europe	5.1	0.00%	0.976
Oman	1.2	0.00%	1.048	American Samoa	0.0	0.00%	1.000	Southern Europe	5.1	0.00%	0.976
Congo	650.0	0.04%	1.047	Bahamas	57.5	0.00%	1.000	Sudan	6728.0	0.37%	0.974
Peru	9884.9	0.55%	1.047	Bhutan	13.3	0.00%	1.000	Saint Vincent	18.0	0.00%	0.974
Benin	48.0	0.00%	1.044	Central African R.	95.0	0.01%	1.000	Guyana	2762.3	0.15%	0.972
Rwanda	115.0	0.01%	1.043	Chad	390.0	0.02%	1.000	Southern Africa	21800.0	1.21%	0.969
Réunion	1888.2	0.11%	1.043	Djibouti	0.1	0.00%	1.000	South Africa	16800.0	0.94%	0.961
French Guiana	4.0	0.00%	1.038	Dominica	4.8	0.00%	1.000	Malaysia	800.0	0.04%	0.958
Madagascar	3000.0	0.17%	1.036	French Polynesia	3.0	0.00%	1.000	Costa Rica	3418.2	0.19%	0.956
DR Congo	1950.0	0.11%	1.036	Ghana	145.0	0.01%	1.000	Bangladesh	4671.4	0.26%	0.949
Somalia	230.0	0.01%	1.036	Grenada	7.2	0.00%	1.000	Melanesia	2086.0	0.12%	0.926
Guinea-Bissau	6.3	0.00%	1.035	Guinea	283.0	0.02%	1.000	Niger	176.7	0.01%	0.926
World	1794359.2	100.00%	1.027	Liberia	265.0	0.01%	1.000	Barbados	258.8	0.01%	0.925
Eastern Africa	34166.5	1.90%	1.024	Malawi	2500.0	0.14%	1.000	Belize	844.0	0.05%	0.916
Sierra Leone	77.0	0.00%	1.024	Portugal	5.1	0.00%	1.000	Fiji	1751.0	0.10%	0.914
Caribbean	24267.0	1.35%	1.024	Samoa	0.0	0.00%	1.000	Oceania	27270.9	1.52%	0.913
Ethiopia	2400.0	0.13%	1.022	Suriname	120.0	0.01%	1.000	Australia	25181.8	1.40%	0.912
Gabon	240.0	0.01%	1.022	Swaziland	5000.0	0.28%	1.000	AUS + NZ	25181.8	1.40%	0.912
Uruguay	314.0	0.02%	1.017	Wallis and Futuna	0.0	0.00%	1.000	Jamaica	1334.6	0.07%	0.907
Iran	5685.1	0.32%	1.017	Polynesia	3.1	0.00%	1.000	Morocco	632.3	0.04%	0.907
Philippines	34000.0	1.89%	1.015	Mauritius	4230.2	0.24%	1.000	Japan	1000.0	0.06%	0.904
Central America	98699.7	5.50%	1.015	Western Africa	5806.0	0.32%	0.998	Northern Africa	16397.5	0.91%	0.896
Tanzania	2500.0	0.14%	1.013	Ecuador	8131.8	0.45%	0.993	Colombia	22727.8	1.27%	0.877

Source: Data processed by author, Faostat, 2013

Table 2: World production of sugar cane, 2011.

Production		Import		Export		Consumption		Stock	
1,000 metric tons									
World	172310	World	48538	World	55144	World	163614	World	163614
Share in world									
Asia - Oceania	38.4%	Asia - Oceania	36.5%	World	48.245%	Asia - Oceania	42.2%	Asia - Oceania	52.1%
South America	26.3%	Middle East	19.9%	South America	45.336%	India	15.3%	India	17.3%
Brazil	21.8%	Africa	16.7%	Brazil	26.427%	South America	12.1%	China	12.6%
India	14.9%	North America	8.9%	Asia - Oceania	13.601%	Western Europe	11.4%	Western Europe	11.9%
Western Europe	9.7%	Western Europe	8.7%	Thailand	6.186%	EU-27	11.0%	EU-27	11.4%
EU-27	9.5%	EU-27	7.9%	Africa	5.622%	North America	10.1%	North America	8.7%
China	8.5%	Indonesia	6.6%	Australia	5.279%	China	9.4%	Thailand	7.9%
North America	8.2%	United States	6.1%	Central America	5.246%	Middle East	8.1%	Africa	6.9%
Thailand	5.8%	Eastern Europe	4.4%	India	3.990%	Africa	8.0%	South America	6.9%
Eastern Europe	5.1%	China	4.1%	Middle East	3.817%	Brazil	7.2%	Middle East	6.6%
Africa	4.9%	South America	3.9%	Guatemala	3.128%	United States	6.9%	United States	5.2%
United States	4.6%	Japan	3.2%	North America	3.085%	Eastern Europe	6.4%	Eastern Europe	4.3%
Mexico	3.5%	Canada	2.6%	Western Europe	2.811%	Russia	5.8%	Pakistan	3.4%
Middle East	3.2%	Egypt	2.4%	EU-27	2.720%	Indonesia	3.4%	Mexico	2.8%
Central America	2.8%	Russia	2.4%	Mexico	2.488%	Mexico	3.1%	Ukraine	1.8%
Russia	2.8%	India	1.9%	Eastern Europe	2.234%	Pakistan	2.9%	Central America	1.7%
Pakistan	2.7%	Caribbean	1.0%	Caribbean	1.949%	Egypt	2.7%	Japan	1.4%
Australia	2.5%	Colombia	1.0%	Colombia	1.587%	Thailand	1.8%	Indonesia	1.4%
Guatemala	2.0%	Mexico	0.7%	Cuba	1.269%	Turkey	1.6%	Brazil	1.3%
Philippines	1.4%	Australia	0.4%	South Africa	0.907%	Central America	1.4%	Philippines	1.0%
Ukraine	1.4%	South Africa	0.3%	Egypt	0.725%	Japan	1.2%	South Africa	0.9%
Colombia	1.4%	Dominican Rep.	0.2%	Russia	0.544%	Ukraine	1.2%	Colombia	0.9%
Turkey	1.3%	Ukraine	0.1%	Pakistan	0.544%	Philippines	1.2%	Caribbean	0.9%
South Africa	1.3%	Turkey	0.03%	Philippines	0.544%	Argentina	1.2%	Argentina	0.8%
Caribbean	1.3%	Thailand	0.01%	United States	0.452%	Colombia	1.1%	Russia	0.8%
Argentina	1.2%	Argentina	0.01%	Argentina	0.399%	South Africa	1.1%	Canada	0.7%
Indonesia	1.2%	Cuba	0.0%	Dominican Rep.	0.390%	Caribbean	1.1%	Turkey	0.6%
Egypt	1.2%	Guatemala	0.0%	Canada	0.145%	Australia	0.9%	Egypt	0.6%
Cuba	1.1%	Central America	0.0%	Turkey	0.109%	Canada	0.8%	Cuba	0.4%
Japan	0.8%	Brazil	0.0%	China	0.080%	Guatemala	0.7%	Guatemala	0.4%
Dominican Rep.	0.4%	Pakistan	0.0%	Ukraine	0.063%	Cuba	0.5%	Australia	0.2%
Canada	0.3%	Philippines	0.0%	Japan	0.002%	Dominican Rep.	0.4%	Dominican Rep.	0.2%

Source: Data processed by author, USDA, Faostat, 2013

Table 3: The distribution of forces on the world sugar market in the period of 2012/2013 (in the raw sugar equivalent)  
- The volume of production, trade, consumption and stocks over the period of 2012/2013.

Table 3 can more than confirm the high degree of concentration of the world market in terms of distribution of the available capacity in production, stocks and realized export. It also shows that the process of concentration of the world market continues. The concentration in this respect concerns mainly areas associated with the shares held by individual players related to the world trade and then also in association to the ownership of the world's supply of sugar.

The focus on the analysis of the dynamics of the growth rate of world production, consumption

and trade, reveals that the world production during the recent years of 2008/2009 - 2012/2013 was growing at an average rate of 4.6% per year, the volume of trade was rising at 4.2% per year on average, the annual sugar consumption was increasing at about 1.5% , and the volume of world reserves grew by about 5.8% per year. There are significant differences between various regions of the world in terms of the growth dynamics of production, consumption and trade.

Production and trade are growing particularly in the Asia-Pacific region (6.3% and 8.6%

per annum respectively). In general, the high growth rate (above world average) is maintained in the production of the Middle East and Eastern Europe. High dynamics in the production growth is sustained particularly in Canada, India, Russia, Ukraine, Thailand, Pakistan and Egypt. In regard to export, the above-average growth rate of the realized volume is maintained especially by Indonesia, Turkey, India, Egypt, Pakistan, USA, Russia, Colombia, Thailand, Canada and the Philippines.

Sugar consumption has been growing very dynamically in recent years, especially in Thailand, Canada, Turkey, Dominican Republic, South

Africa, Colombia, Indonesia, Australia, USA, EU 27, Egypt and India. In regard to the regions, apart from the Asian-Pacific area, a high rate of consumption exists also in Africa, Central America and, in general, also in Western Europe. In recent years the stocks have been increasing especially in North and South Americas, the Caribbean, and Western European countries. The most important sources of accumulation of reserves include mainly China, USA, Cuba, Indonesia, Mexico, the European Union, Pakistan, Ukraine, the Dominican Republic and South Africa.

In addition to the growth in production and consumption of sugar, it is clear that sugar trade is

Country Mktg Year	Production	Country Mktg Year	Imports	Country Mktg Year	Exports	Country Mktg Year	Stocks
Canada	1.220	Cuba	N/A	Indonesia	N/A	Brazil	N/A
India	1.126	Guatemala	N/A	Turkey	1.861	Argentina	N/A
Russia	1.086	Central America	N/A	India	1.770	South Africa	1.855
Ukraine	1.084	Brazil	N/A	Egypt	1.414	Dominican Republic	1.503
Thailand	1.084	Thailand	N/A	Pakistan	1.414	Ukraine	1.323
Pakistan	1.074	Pakistan	N/A	United States	1.193	South America	1.298
Eastern Europe	1.073	Philippines	N/A	Russia	1.107	Pakistan	1.242
Asia - Oceania	1.063	Dominican Republic	1.414	Colombia	1.106	EU-27	1.183
Egypt	1.057	Colombia	1.244	Middle East	1.101	Western Europe	1.159
Middle East	1.054	China	1.167	Thailand	1.091	Mexico	1.142
World	1.046	Mexico	1.070	Asia - Oceania	1.086	Indonesia	1.127
Brazil	1.042	EU-27	1.049	Canada	1.084	North America	1.106
United States	1.040	Canada	1.046	Philippines	1.075	Cuba	1.099
EU-27	1.040	Western Europe	1.045	World	1.042	United States	1.096
Western Europe	1.039	South America	1.043	Brazil	1.038	Caribbean	1.072
North America	1.039	Asia - Oceania	1.043	Eastern Europe	1.037	China	1.064
Philippines	1.034	Africa	1.041	South America	1.034	World	1.058
Mexico	1.034	World	1.026	EU-27	1.030	Canada	1.051
South America	1.033	North America	1.024	Western Europe	1.030	Philippines	1.047
Central America	1.027	Middle East	1.020	Central America	1.028	Thailand	1.046
Turkey	1.023	United States	1.013	North America	1.022	Asia - Oceania	1.039
China	1.023	Caribbean	1.003	Guatemala	1.011	Eastern Europe	1.036
Dominican Republic	1.021	Turkey	1.000	Japan	1.000	India	1.030
Cuba	1.015	Japan	0.994	Mexico	0.999	Africa	1.029
Caribbean	1.011	Egypt	0.955	Dominican Republic	0.998	Japan	0.996
Guatemala	1.010	South Africa	0.938	Cuba	0.991	Middle East	0.984
Africa	1.010	Eastern Europe	0.889	Ukraine	0.986	Central America	0.897
Colombia	1.004	Russia	0.804	Caribbean	0.984	Russia	0.885
Indonesia	0.998	India	0.779	Africa	0.973	Turkey	0.833
South Africa	0.990	Ukraine	0.662	Australia	0.969	Egypt	0.694
Australia	0.972	Argentina	0.556	China	0.875	Guatemala	0.631
Argentina	0.964	Australia	0.416	South Africa	0.806	Australia	0.600
Japan	0.955	Indonesia	0.099	Argentina	0.784	Colombia	-0.053

Source: Data processed by author, USDA, Faostat, 2013

Table 4: Basic development trends in the areas of production, trade, consumption and stockpiles of sugar in the years of 2008/2009 – 2012/2013 (average annual growth rate).

also growing very dynamically. Many countries are not able to meet the growth in the domestic demand through increasing their own production volumes and some countries are unable to compete in price with cheaper sugar from the areas which are more production-equipped. The growing consumption of sugar is the engine that drives the expansion of imports of sugar in certain regions of the world. Imports are rising very significantly especially in Western Europe and in some Latin American countries, as well as in the Asia-Pacific region, Africa and North America. The main importers of sugar include China, Mexico, Colombia, Dominican Republic, EU and Canada.

Regarding the development of the global sugar reserves - despite the currently declining stock levels, the long-term growth rate of sugar stored

in individual countries and regions is increasing. During the observed period alone, the growth rate of stock volumes amounted to nearly 6% per year and in a number of countries (Brazil, Argentina, South Africa, Dominican Republic, Ukraine, Pakistan, Mexico, Indonesia, Cuba, USA and China) and regions (South America, EU and Western Europe, North America and the Caribbean) this rate was even higher.

From the above data it is unambiguously clear that the world market or the production and trade are completely controlled by a limited number of entities/subjects. The predominance of these entities is also further confirmed by the following analysis of the distribution of comparative advantages. The results of the analysis show that in an inter-regional comparison the comparative advantages

Country	LFI	Country	LFI	Country	LFI	Country	LFI
Panama	40.47	Rep. of Moldova	4.39	Saudi Arabia	-0.77	Tunisia	-7.01
Costa Rica	34.67	Portugal	4.34	Netherlands	-1.01	Kazakhstan	-7.88
Paraguay	33.4	Peru	4.21	Yemen	-1.12	Russian	-8.5
Philippines	30.45	Uganda	4.14	Tanzania	-1.34	Oman	-8.55
Serbia	24.67	Germany	3.83	Malta	-1.37	Finland	-8.63
France	22.95	Singapore	3.78	Albania	-1.38	Hong Kong	-9.53
Barbados	22.66	Belarus	3.42	Bolivia	-1.49	Ireland	-10.4
Mexico	19.45	Mauritius	3.07	Cyprus	-1.57	Chile	-10.9
Nicaragua	18.72	Niger	2.18	Kyrgyzstan	-1.64	Namibia	-11.22
Dominican Rep.	18.23	Luxembourg	2.05	Colombia	-1.69	Ecuador	-11.94
South Africa	16.45	Guyana	2.02	Senegal	-1.76	Switzerland	-12.57
Croatia	14.68	Romania	1.58	United Kingdom	-1.93	Hungary	-12.68
Cambodia	13.76	Madagascar	1.5	Ghana	-2.17	New Zealand	-13.22
El Salvador	12.91	Montenegro	1.42	Bahrain	-2.28	Egypt	-13.48
Austria	10.44	Bosnia Herzegovina	1.32	Nepal	-2.37	Bulgaria	-13.62
Zimbabwe	10.14	Brazil	1.02	Norway	-2.44	Co'te d'Ivoire	-14.39
Czech Rep.	10.08	Armenia	1.01	Belgium	-2.63	Indonesia	-15.19
Denmark	10.01	Algeria	0.85	Argentina	-2.95	EU-27	-17.19
Guatemala	9.41	Saint Kitts and Nevis	0.81	Lithuania	-2.97	Macedonia	-17.63
Zambia	9.21	Turkey	0.74	Latvia	-2.97	Lebanon	-19.46
Australia	8.3	St. Vincent, Grenad.	0.67	Estonia	-3.05	USA	-20.66
Viet Nam	7.77	New Caledonia	0.2	Iceland	-3.22	Israel	-20.67
Sweden	7.7	Suriname	0.01	Greece	-3.46	Italy	-21.43
Azerbaijan	7.45	Bahamas	0	Slovakia	-3.93	Botswana	-23.03
Mozambique	7.01	Burkina Faso	0	Rep. of Korea	-5.46	Iran	-23.84
Poland	6.99	Venezuela	0	Slovenia	-5.54	Spain	-23.94
Malawi	6.21	Rwanda	-0.04	Jordan	-6.2	Canada	-24.96
Thailand	6.14	Aruba	-0.09	Malaysia	-6.29	Ukraine	-34.08
India	5.9	Sri Lanka	-0.55	Cameroon	-6.88	Pakistan	-35.45
Belize	5.55	Nigeria	-0.71	Japan	-6.94	China	-40.95

Source: Data processed by author, UN Comtrade, 2013

Table 5: Distribution of comparative advantages on the sugar market on bilateral basis (at the level of HS 1701 aggregation in relation to HS 17 aggregation) – LFI index, 2012.

are possessed only by Latin America and then also by the Southeast Asian countries. At the country level, comparative advantage is held by approximately 52 countries (see Table 5.). In this regard, it should be noted that not all countries have comparative advantages at the global market, but they achieve comparative advantages in relation to a particular region or only in relation to a particular group of countries. Comparative advantage is then usually not determined by the competitiveness of a given region in relation to the global market, but by a given region/country/group of countries applying some form of protectionist policies that enable an expansion of their products into the markets of other countries (as an example can be mentioned the European Union and its member countries, as well as the USA, CIS countries - especially Russia, and some Asian countries).

When we focus on the analysis of the overall comparative advantages achieved by individual countries or regions or groups of countries in relation to the development of the value and volume of the global sugar market, regardless of bilateral trade exchanges, then we can say that comparative advantages are possessed especially by Latin America, Africa and some Southeast Asian countries. In relation to the various countries of the world, it can be stated that exports, which involve more than one hundred and twenty countries of the world, are marked by comparative advantages for about 46 countries (see details in Table 6).

The analysis of the RCA index largely confirms the results associated with the analysis of the LFI index. In this regard, it can be seen that the countries which acquire comparative advantages

Country	RCA	Country	RCA	Country	RCA	Country	RCA
Bahamas	1.45	Panama	1.28	Poland	0.78	Hong Kong	0.23
Burkina Faso	1.45	Romania	1.27	Lithuania	0.76	Israel	0.23
Malawi	1.45	Bosnia Herzegovina	1.24	Denmark	0.72	Cyprus	0.21
Cambodia	1.45	Guatemala	1.24	Australia	0.7	Italy	0.19
Saint Kitts and Nevis	1.44	Dominican Rep.	1.24	Cameroon	0.68	Turkey	0.18
Madagascar	1.44	Saudi Arabia	1.24	Czech Rep.	0.67	Namibia	0.15
Azerbaijan	1.44	Costa Rica	1.23	Hungary	0.67	Lebanon	0.15
Algeria	1.43	France	1.21	Oman	0.66	USA	0.14
Brazil	1.43	Suriname	1.19	Tunisia	0.65	Sri Lanka	0.13
Barbados	1.43	South Africa	1.19	United Kingdom	0.65	Ireland	0.12
Paraguay	1.42	Peru	1.17	Estonia	0.63	Nigeria	0.11
Uganda	1.42	Philippines	1.16	EU-27	0.59	Canada	0.11
Saint Vincent	1.41	Tanzania	1.11	El Salvador	0.56	Bahrain	0.09
Niger	1.41	Yemen	1.1	Belgium	0.54	Switzerland	0.09
Mauritius	1.41	Singapore	1.07	Bolivia	0.53	Macedonia	0.09
Belize	1.39	Malaysia	1.01	Sweden	0.53	Venezuela	0.08
Belarus	1.38	Greece	0.99	Argentina	0.52	China	0.06
Mozambique	1.37	Colombia	0.98	Germany	0.52	Pakistan	0.06
Montenegro	1.37	Senegal	0.97	Luxembourg	0.5	Aruba	0.05
Armenia	1.36	Mexico	0.95	Finland	0.48	Japan	0.05
Zimbabwe	1.36	Rwanda	0.94	Russia	0.44	Norway	0.04
Thailand	1.36	Rep. of Moldova	0.93	Spain	0.35	Malta	0.03
Croatia	1.35	Egypt	0.92	Ecuador	0.34	Ukraine	0.03
India	1.34	Bulgaria	0.89	Jordan	0.32	Nepal	0.02
Nicaragua	1.31	Austria	0.89	Iran	0.32	Kyrgyzstan	0.01
Zambia	1.31	Rep. of Korea	0.89	Kazakhstan	0.29	Botswana	0.01
Portugal	1.3	Slovakia	0.88	Co'te d'Ivoire	0.28	Indonesia	0.01
Guyana	1.28	Slovenia	0.87	Togo	0.27	Ghana	0.01
Serbia	1.28	Latvia	0.87	Netherlands	0.27	Chile	0
New Caledonia	1.28	Viet Nam	0.85	New Zealand	0.24	Albania	0

Source: Data processed by author, USDA, 2013

Table 6: Distribution of comparative advantages on the sugar market in relation to the global market – RCA Index, 2012.

in relation to the world market and, at the same time, also in relation to bilateral trade exchanges, are more or less the same ones. An exception in this respect is made only by Malaysia, Saudi Arabia, Yemen and Tanzania, which, although they do not have bilateral comparative advantages, possess comparative advantages in relation to the world market - this points to a disproportionate share of sugar in trade with the HS17 aggregation.

Additionally, there is a specific position held by countries such as Australia, Czech Republic, Denmark, El Salvador, Luxembourg, Mexico, Germany, Moldova, Poland, Sweden, Turkey and Vietnam, which, although not having comparative advantages on the world market, they have comparative advantages in terms of bilateral trade exchanges in relation to selected countries. This refers to their ability to find partners

within the framework of the global market over which these countries have the upper hand, or carry out trade within a specific environment that is different from the global market - this applies particularly member countries of the EU. In relation to the development in the world sugar market it should be pointed out that although sugar is a perfectly homogeneous product - its price across the world is not uniform. There are very significant price differences between individual regions, which are determined by different policies of the involved countries towards sugar industry.

Another factor affecting the price of sugar and its variations at the international and inter-regional levels is the fact that different countries are able to produce sugar with different costs. There is a significant difference between the efficiency and profitability of sugar production in the countries

Country	Export USD/kg	Country	Export USD/kg	Country	Export USD/kg	Country	Export USD/kg
Malta	4.39	Bolivia	0.99	Hong Kong	0.83	India	0.7
Bahamas	3.98	New Zealand	0.99	Germany	0.82	Ukraine	0.7
Ghana	3.61	Chile	0.99	Czech Rep.	0.82	EU-27	0.7
Nigeria	3.34	Greece	0.99	Suriname	0.82	Bahrain	0.69
Sri Lanka	3.29	Jordan	0.99	Belgium	0.82	Cambodia	0.68
Aruba	3.26	Co'te d'Ivoire	0.98	Italy	0.82	Iran	0.67
Norway	2.66	Kazakhstan	0.97	New Caledonia	0.82	Australia	0.67
Palestine	2.25	Romania	0.96	Israel	0.81	Yemen	0.65
Luxembourg	2.18	Poland	0.95	Rep. of Korea	0.81	Iceland	0.65
Albania	1.77	Tunisia	0.95	Saint Kitts,Nevis	0.81	Dominican Rep.	0.64
Gambia	1.68	Netherlands	0.95	Belarus	0.8	Viet Nam	0.63
Slovakia	1.68	Canada	0.95	Denmark	0.8	Costa Rica	0.63
Switzerland	1.61	Croatia	0.95	Armenia	0.8	Guyana	0.62
Cyprus	1.49	Spain	0.93	Algeria	0.8	Philippines	0.61
Japan	1.34	Egypt	0.93	Oman	0.79	USA	0.6
Indonesia	1.32	Lebanon	0.92	Turkey	0.78	Brazil	0.59
Singapore	1.29	Senegal	0.91	Saudi Arabia	0.78	Pakistan	0.59
Ireland	1.27	Rep. of Moldova	0.91	Malawi	0.78	Tanzania	0.58
Latvia	1.21	Azerbaijan	0.9	Ecuador	0.78	Nicaragua	0.57
Namibia	1.2	Panama	0.87	Peru	0.77	Zambia	0.57
Kyrgyzstan	1.19	China	0.86	Russian	0.76	El Salvador	0.56
Estonia	1.18	Mexico	0.86	France	0.76	Thailand	0.56
Slovenia	1.15	Bosnia Herzeg.	0.85	South Africa	0.75	Guatemala	0.5
Bulgaria	1.14	Austria	0.85	Malaysia	0.74	Zimbabwe	0.49
Paraguay	1.13	United Kingdom	0.84	Uganda	0.74	Barbados	0.46
Rwanda	1.12	Sweden	0.84	Madagascar	0.74	Niger	0.46
Hungary	1.09	Lithuania	0.84	Mauritius	0.73	Mozambique	0.44
Macedonia	1.05	Finland	0.84	Argentina	0.72	Venezuela	0.2
Portugal	1.02	Serbia	0.84	Montenegro	0.72	Nepal	0.28
Cameroon	1	Qatar	0.83	Colombia	0.7	Belize	0.23

Source: Data processed by author, UN Comtrade, 2013

Table 7: Worldwide sugar prices – declared export prices (at the level of HS 1701), 2012.

that produce this commodity from the processing of sugar beet and in those which process sugar cane.

Sugar cane provides higher yields of sugar per hectare of cultivated land, allows more efficient use of sugar mills, the sugar campaign duration can be several times longer than that of the beet campaign, and so on. Overall, the cane sugar is much more competitive on the world market than the beet sugar. In this respect, it is necessary to point out one more - a very significant comparative advantage that cane sugar has compared with beet sugar.

Sugarcane is produced in regions where the cost of the production factors (labour, land, capital) are significantly lower than in the countries dominated by sugar beet. Another fact which is

disadvantageous for sugar beet compared with sugar cane is that the environmental, social, labour, technical and other standards in many countries (especially the developed ones) make the economics of beet sugar production very much more expensive.

Regarding the prices of sugar, Table 7 demonstrates that the differences existing between countries and regions are really very great. For example, while Malta exports one kilogram of sugar for more than 4 USD, Botswana does the same for less than 10 cents. In respect to individual regions, it can be observed that the highest sugar prices are generally those in the OECD countries, especially in European countries, and there are also high prices in the countries of the CIS and Africa.

Country	Import USD/kg	Country	Import USD/kg	Country	Import USD/kg	Country	Import USD/kg	Country	Import USD/kg
Costa Rica	x	Philippines	0.91	Ecuador	0.84	Russian Federation	0.74	Belize	0.6
Brazil	x	Saint Vincent	0.91	Ireland	0.83	Belarus	0.74	Ukraine	0.6
Panama	x	Germany	0.91	Romania	0.83	Bosnia Herzeg.	0.74	Armenia	0.59
Bahamas	4.25	Czech Rep.	0.91	Cameroon	0.83	Guyana	0.73	Co'te d'Ivoire	0.58
Guatemala	2.87	Kyrgyzstan	0.9	Senegal	0.81	Colombia	0.73	Iran	0.57
Zambia	2.59	Vanuatu	0.9	Italy	0.81	Mauritius	0.73	Bhutan	0.54
Malawi	2.56	S Palestine	0.9	Rep. of Moldova	0.81	Algeria	0.72	Malaysia	0.54
El Salvador	1.79	Serbia	0.89	Bahrain	0.81	Samoa	0.72	Azerbaijan	0.53
Nicaragua	1.76	Cape Verde	0.89	Greece	0.8	United Kingdom	0.72	Burkina Faso	0.53
Luxembourg	1.58	Estonia	0.88	Poland	0.8	Ethiopia	0.72	Namibia	0.5
Montserrat	1.48	Malta	0.87	Georgia	0.8	Bermuda	0.71	Afghanistan	0.4
Slovakia	1.43	Switzerland	0.87	Montenegro	0.79	New Zealand	0.71	Chile	0.4
Aruba	1.41	France	0.87	Croatia	0.79	Dominican Rep.	0.71	Niger	0.38
Greenland	1.36	Paraguay	0.87	Saint Kitts Nevis	0.79	Portugal	0.71	Nepal	0.38
Turkey	1.18	Barbados	0.86	Madagascar	0.79	Egypt	0.7	Cambodia	0.37
Oman	1.07	Bolivia	0.86	Rwanda	0.79	Viet Nam	0.7	Venezuela	0.34
New Caledonia	1.06	Uganda	0.86	Suriname	0.78	Saudi Arabia	0.7	Mozambique	0.32
Tonga	1.03	Jordan	0.86	Tunisia	0.78	Lithuania	0.7	Gambia	0.2
Slovenia	1.01	Denmark	0.85	Yemen	0.77	South Africa	0.7	Togo	0.17
Nigeria	1	Spain	0.85	Botswana	0.77	Indonesia	0.7	Mauritania	0.12
Norway	0.97	Lebanon	0.85	Finland	0.77	Israel	0.69		
Maldives	0.97	Albania	0.85	Austria	0.76	Canada	0.69		
Latvia	0.96	Zimbabwe	0.85	Japan	0.76	Thailand	0.69		
Iceland	0.96	Hungary	0.84	Hong Kong	0.76	Rep. of Korea	0.68		
Cyprus	0.95	Cent. Afric. Rep.	0.84	Peru	0.76	Tanzania	0.67		
Kiribati	0.94	Kazakhstan	0.84	Australia	0.75	Ghana	0.67		
Polynesia	0.94	Mexico	0.84	EU-27	0.75	China	0.67		
Bulgaria	0.94	Argentina	0.84	Singapore	0.74	Belgium	0.66		
Sweden	0.93	USA	0.84	Pakistan	0.74	Turks, Caicos	0.64		
Netherlands	0.92	Macedonia	0.84	Sri Lanka	0.74	India	0.61		

Source: Data processed by author, USDA, 2013

Table 8: Worldwide prices of sugar – declared import prices, 2012.

By contrast, relatively lower export prices can be found in the countries of Southeast Asia and Latin America.

When we speak about the price variations in the global trade = there are very significant differences even in terms of the declared import prices of sugar. Table 8 demonstrates the fact that the world prices of imported sugar (the average prices of raw and refined sugar) differ considerably between countries and regions and range from 0.12 cents per kilogram up to about 4 USD per kilogram.

In respect to regions, on average the highest import prices are implemented in the EU member states and North America. High prices are generally shown by the OECD member countries. By contrast, the lowest declared minimum import prices can be found in the countries of Asia and especially in the countries of Latin America.

## **Conclusions**

The worldwide production of sugar crops, or the entire market with sugar crops products – particularly sugar and biofuels – is growing at a very rapid dynamic pace over time. It should be noted that both the volume and value of the production and trade have risen unusually quickly in recent years. The volume of the sugar crops - mainly sugar cane, but also sugar beet - have increased considerably. Over the past five years alone the volume of sugar beet and sugar cane has grown on average by 2.5% and 2.7% per annum respectively.

In respect of the current increase in the global production and consumption of sugar crops, it should be noted that mainly due to intensive promotion of the biofuel production in recent times, most of the growth in the volume of the sugar crops production - especially sugar beet – is transformed into biofuels - whose volume and consumption is rising sharply worldwide. Only about one-third of the increase in the sugar crops production is utilized for the manufacture of sugar as such.

When analyzing the global production of sugar crops, it quickly becomes obvious that its production is very strongly concentrated. In the case of sugar beet Russia, EU, Turkey and the USA represent about three quarters of its world production. Likewise, in the case of sugar cane Brazil, Thailand, China, India and Pakistan account for almost three quarters of its world production volume.

The above comments and results relating to the aims of this article clearly indicate that the global cultivation of sugar cane and sugar beet is concentrated within a limited segment of countries. The results of the processed analysis also demonstrate that the actual worldwide sugar market is also highly concentrated and the concentration process is constantly continuing. The world sugar production and trade are dominated by a limited number of entities that maintain their control over the volume of production and trade.

From the point of view of production and trade the most dominant regions currently include mainly Southeast Asia and Latin America. The key sugar producers in the world are Brazil, India, China and Thailand (their cumulative share of the world production exceeds 50%). An important role is also played by Europe and North America, which contribute about 20% of the global production.

In relation to the global trade, it is necessary to highlight the extreme predominance of Brazil, Thailand, Australia and India. These export-oriented countries participate in the global sugar exports by nearly 75%. From this it is clear that a mere four countries control more than ¾ of the worldwide sugar trade. And just like the sugar production and trade are concentrated so are the world sugar stockpiles of which almost 60% are controlled by China, India, the European Union, Thailand, USA, Pakistan and Mexico

It is appropriate to point out the fact that the worldwide sugar consumption is also concentrating. Currently, most of the sugar used in the world is consumed in India, EU, China, Brazil, USA, Russia, Indonesia, Mexico and Pakistan (in total this amounts to more than 60% of the world sugar consumption). It is important to note that as the market is concentrating so are also the comparative advantages in relation to the sugar trade. At present the comparative advantages in relation to the global market are possessed especially by the Latin American region and Southeast Asia.

To a limited extent, the comparative advantages in relation to the sugar trade are possessed by approximately forty to fifty countries around the world. However, most of these countries do not have a comparative advantage in relation to the global market as a whole, but they possess comparative advantages on a regional basis - i.e. a comparative advantage is determined

by a specific situation that prevails on the market within the framework of a given region, for instance, the existence of bilateral or multilateral trade agreements, the existence of a free trade zone, customs union, the single market, etc.

The countries that have comparative advantages on a regional rather than global basis, include CIS countries, the member countries of EU and, for example, some member countries of NAFTA, as well as some African and Asian countries. The obvious comparative advantages in relation to the global market are possessed particularly by countries producing sugar from sugar cane, especially those located mainly in South Asia, in Central and South America and then also some African countries.

It is important to mention the fact that because the world sugar market is still not fully liberalized, there are significant barriers that prevent the development of global trade in sugar. A wide range of markets is insulated against the influence of the worldwide market by the protectionist policies of a number of countries, and it is also clear that there are considerable price differences in buying and selling sugar. In relation to the prices of exports implemented between individual countries around the world there are very significant differences.

The differences in this respect exist not only at the regional levels, but also between developed and developing countries. It should also be noted that at the regional level the export price of sugar fluctuates between USD 0.58 to 1.10 per kg. By contrast, in the various countries being analyzed, the prices of exports round the world oscillate in the range of USD 0.10 - 4.39 per kg. Thus, if we consider the world sugar market from a global perspective, one has to state that we are looking at a quantity which is evolving very dynamically.

In relation to its future development, it can be expected that there will be further growth in the dynamics of the volume of both the production and consumption and, last but not least, in trade. In particular, the process of liberalization of world trade, which will lead to the removal of trade barriers across all regions, will also lead to a realignment of production capacity across the regions.

The growing demand for sugar and also for sugar crops will lead to further growth in sugar prices on the world market and for this reason it is rather difficult to predict the future shape of the sugar market. The rising sugar prices will be reflected in the profitability of the sector and thus a situation could arise in which the regions that today seem unpromising in terms of production and export may gradually become promising.

However, in this respect it has to be emphasized that the formation of the market is not only a question of economics, but also a question of strategic-political dimension. It is, therefore, very difficult to state what the further development of the global market will be like. In general, it is only possible to make an educated guess that the supply and demand for sugar will continue to rise. It is also possible to expect growth in prices, and that the market or its territorial structure will become even more concentrated.

However, in this regard it should be noted that in the coming years the actual nature of the sugar market will be very significantly affected by individual countries' policies towards the agrarian market and towards sugar as such. An important role will also be played by the current hotly debated issue of biofuels or, more precisely, a decision to increase or decrease their production and the degree of support for their production by public sources.

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## The Competitive Environment in the Dairy Industry and its Impact on the Food Industry

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### Anotace

Cílem článku je vyhodnotit konkurenční prostředí zpracovatelů mléka v ČR. K analýze ekonomické situace podniků v letech 2007–2011 je použita finanční analýza. Výběrový soubor 38 zpracovatelů mléka reprezentuje klíčové podniky v odvětví. Základní metodou pro vyhodnocení konkurenčního prostředí je Porterův model pěti sil. V článku je rovněž vyhodnocena technická efektivnost zpracovatelů mléka. Ekonomická krize postihla mlékárenský průmysl již v roce 2008. Zhoršení finanční situace bylo způsobeno nepříznivými cenovými relacemi vstupů a produkce. Současně začali zákazníci více spotřebovávat levnější výrobky privátních značek. Konkurenční prostředí zpracovatelů mléka v ČR se vyznačuje poměrně vyostřenými konkurenčními vztahy. Analýza odhalila, že slabou stránkou českého mlékárenského průmyslu jsou tržně nevyrovnané vztahy na straně vstupů, tak i odbytu produkce.

### Klíčová slova

Mlékárenský průmysl, konkurenční prostředí, finanční výkonnost, dodavatelský řetězec.

### Abstract

The aim of the paper is to present in-depth view on the competitive environment of the Czech dairy industry. The financial statement analysis evaluates the financial performance of the dairy industry in the period 2007–2011. The sample of 38 dairy processors represents leading market players. The basic method for industry analysis is Porter five forces analysis. The paper also comprises brief analysis of technical efficiency of the dairy industry. The economic recession affected the financial performance of the Czech dairy industry in 2008. It was showed by unfavourable input-output price relations. Simultaneously, the economic downturn made consumers to switch from branded dairy products to cheaper private labels, as the analysis proved. The competitive environment within the Czech dairy industry is slightly concentrated with greatly heightened competitive relations. The vertical business relationships within dairy supply chain can be considered as the weakness of the Czech dairy industry.

### Key words

Dairy industry, competitive environment, financial performance, supply chain.

### Introduction

The dairy industry together with the dairy farms produces essential products to meet nutritional needs of the whole population. This paper defines the dairy industry as the branch of the food industry that includes enterprises processing milk and producing various dairy products from milk (CZ-NACE 10.5). In the Czech Republic, the dairy industry accounts for 17 % of the sales and for 10 % of the number of employees of the total food industry (MoA, 2012).

The competitive strategy of the enterprises

within the dairy industry affects economic efficiency of both milk processors and dairy farms. Competitiveness of the dairy industry and the dairy products can be improved in different ways. Látečková, Kučera and Brédová (2009) suggest enhancing the competitiveness of the dairy products by implementation of ICT systems. Gray et al. (2011) identify three main ways to increase the productivity in the dairy industry – the technical change, changes in the technical efficiency and structural adjustment. Generally, one of the key tools for improving competitiveness is the innovation strategy (Krause, 2012).

Another important part of the competitive strategy is the corporate social responsibility. Lušňáková et al. (2012) focus on the implementation of the concept of corporate social responsibility (CSR) in the major dairy enterprises in Slovakia. They conclude that the concept of CSR significantly affects the business activities of some dairy farms in Slovakia. Even though, some of them have large reserves in implementation of the CSR concept.

Mejstříková, Mezera and Plášil (2011) briefly evaluate the financial performance of the Czech dairy market. They point out very low profitability and high debt-to-equity ratio relative to the whole sector Manufacture of Food Products (CZ-NACE 10). It is desirable to further support adding value to dairy products as well as promotion of the national quality brand KLASA and regional food brands. (Mezera, Mejstříková, 2011) They also suggest more intensive vertical integration in the dairy industry, especially between farmers and dairy processors.

The dairy market in the EU is distorted by quota system. However, the EU milk quotas expire in 2015 and the whole market will liberalize. Schönhart et al. (2012) expect that a drop in the number of the dairy farms and an increase of total milk volumes will be important consequences of the phasing out of the EU milk quota regime. Abolition of market regulation will change market conditions and the competitive environment within the dairy industry. Lelyon, Chatellier, and Daniel (2012) confirm the large potential of farmers to increase milk production, but they do not expect significant structural changes. It is important to emphasize that the potential to increase milk production will be limited by the demand for dairy products.

Because of lack of published information about the structure and recent economic development of the dairy industry in the Czech Republic, the aim of the paper is to present in-depth view on the competitive environment of the Czech dairy industry. The market overview of milk processors and their suppliers and retailers can facilitate subsequent predictions of possible impacts of abolition of milk quotas on the dairy industry. The paper targets to obtain answers to following important questions:

1. In what way the economic recession affects the financial performance of the dairy industry in the Czech Republic?
2. What type of competitive environment is

in the Czech dairy industry?

3. What brands dominate the main market segments and how important are the private labels?
4. What structure has the supply chain in the Czech dairy industry?

## **Materials and methods**

The database Albertina provides data on the financial statements of the Czech milk processing companies as well as on overview of the corporate headquarters and total turnover. As accounting data are available with a lag of t-2, it is possible to use data only for the period 2007 - 2011. A total of 38 out of more than 200 firms in the branch CZ-NACE 10.5 have full accounting data available during the whole period. The number of firms in the Czech dairy industry varies every year with an increasing trend. As shown in table 1, the sample represents leading players in the Czech dairy market. It includes more than 60 % of branch' sales of production, cost of sales, value added and staff costs. On the other hand, small enterprises are not covered due to the lack of accounting data.

The relevant indicators are selected for the financial statement analysis. The financial statement analysis allows for companywide point of view, not owners expectations. Moreover, enterprises have various shares of remunerated liabilities and different attitudes to paying taxes (deferred taxes, payable taxes). So, the indicators of profitability use EBIT (Earnings before Interest and Taxes), instead of Net Income. Similarly, the total company turnover instead of sales of goods and production is used. The financial statement analysis consists of following indicators:

- A) Indicators of profitability:
  - Return on Assets (ROA) =  $EBIT / \text{Total Assets}$
  - Return on Sales (ROS, Profit Margin) =  $EBIT / \text{Total Turnover}$
- B) Value Added per Staff Costs: Value added =  $(\text{Sales of goods} - \text{Cost on goods sold}) + (\text{Sales of production} - \text{Cost of sales})$
- C) Net Working Capital per Total Assets: Net Working Capital =  $\text{Current Assets} - \text{Current Liabilities}$
- D) Indicator of cost efficiency:  $\text{Cost of sales} / \text{Sales of production}$
- E) Indicators of liquidity:
  - Current Ratio =  $\text{Current Assets} / \text{Current Liabilities}$

- Acid Test Ratio = (Current Assets – Inventory)/ Current Liabilities = Short-term Accounts Receivable/ (Total Turnover/360)
- Cash Ratio = Short-term Financial Assets/ Current Liabilities
- Accounts Payable Turnover Ratio in Days = Short-term Accounts Payable/ (Total Turnover/360)

F) Turnover indicators

- Assets Turnover = Total Turnover/Total Assets
- Long-term Assets Turnover = Total Turnover/ Fixed Assets
- Inventory Turnover = Total Turnover/ Inventories
- Accounts Receivable Turnover in Days

G) Indicators of capital structure

- Debt Ratio = Liabilities/Total Assets
- Credit Debt Ratio = Bank Loans & Overdrafts/Total Assets
- Short-term Debt Ratio = Short-term Liabilities/Total Assets
- Long-term Debt Ratio = Long-term Liabilities/Total Assets

In order to make benchmarking of financial indicators within the branch, results of the financial analysis present weighted average, median, 25<sup>th</sup> and 75<sup>th</sup> percentile.

A) Sales of production ('000 CZK)

	2007	2008	2009	2010	2011*
Branch 10.5	44,046,209	41,212,726	36,276,046	37,040,407	38,080,173
Sample	28,228,023	27,733,798	24,041,346	24,359,869	25,916,082
%	64.1	67.3	66.3	65.8	68.1

B) Cost of sales ('000 CZK)

	2007	2008	2009	2010	2011*
Branch 10.5	39,488,156	37,508,394	30,809,674	33,032,507	34,262,394
Sample	25,590,561	25,791,220	20,856,098	22,236,008	23,607,677
%	64.8	68.8	67.7	67.3	68.9

C) Value added ('000 CZK)

	2007	2008	2009	2010	2011*
Branch 10.5	5,899,776	5,063,694	5,899,324	5,322,627	5,187,280
Sample	3,696,004	2,997,978	3,404,410	3,191,144	3,301,854
%	62.6	59.2	57.7	60.0	63.7

D) Staff costs ('000 CZK)

	2007	2008	2009	2010	2011*
Branch 10.5	3,118,834	3,161,603	3,340,424	3,352,249	3,228,236
Sample	1,784,098	1,834,184	1,920,475	1,990,112	1,955,710
%	57.2	58.0	57.5	59.4	60.6

E) Number of enterprises

	2007	2008	2009	2010	2011*
Branch 10.5	188	178	186	229	225
Sample	38	38	38	38	38
%	20.2	21.3	20.4	16.6	16.9

Notes: \* Branch 10.5 in 2011 - estimate of the Ministry of Industry and Trade

Source: Own calculation based on Albertina database and Panorama of the food industry 2011 (Ministry of Agriculture, 2012)

Table 1: The absolute and relative size of the sample in the branch CZ-NACE 10.5.

The main data sources for competitive environment analysis are Albertina Gold Edition, MarketLine and Euromonitor International. The University of Economics in Prague uses the databases and reports. The basic method for industry analysis is Porter five forces analysis (Porter, 1998) - intensity of competitive rivalry, bargaining power of suppliers, bargaining power of customers, threat of substitute products or services, and threat of new competition.

The paper also comprises brief analysis of the economic efficiency of the dairy industry. Analysis of economic efficiency of milk processors respects the view of efficiency in utilization of production factors (Coelli et al, 1998; Fried, Lovell, Schmidt, 2008). To determine the level of the technical efficiency of farms, the Data Envelopment Analysis method (DEA) is applied. Production unit is efficient when there isn't any other unit maintaining the same level of outputs with lower level of inputs, respectively, when there isn't any other unit achieving the higher level of outputs with the same level of inputs. Units with the highest efficiency are located on the efficient frontier. The purpose of the DEA method is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. The technical efficiency (TE) estimates vary between 0 (0%) and 1 (100 %). The model assumes variable returns to scale. The issue of returns to scale concerns

what happens to units' outputs when they change the amount of inputs that they are using to produce their outputs. Under the assumption of variable returns to scale a unit found to be inefficient has its efficiency measured relative to other units in the data-set of a similar scale size only. Whereas under the assumption of constant returns to scale a units efficiency is measured relative to units of all different scale sizes. Material and energy, costs on services and wages are inputs, sales of production represents output.

The DEA method is suitable when production units are relatively homogeneous regarding inputs and technologies. The dairy industry largely fulfils this condition. The data source for DEA consists of 44 milk processors excluding companies specializing in the production of ice cream (CZ-NACE 10.52) in the period 2007 - 2010. The analysis of TE determinants will be subject of subsequent research.

## Results and discussion

### Financial performance of the dairy industry

Table 2 illustrates the results of profitability indicators and labour productivity.

The Czech dairy industry experienced the deepest crisis in 2008 when the global economic recession became evident. The weighted average ROA dropped from 9.81 % in 2007 to 2.36 % in 2008 because of sharp slump in prices of dairy products

Indicator	Boundary	2007	2008	2009	2010	2011
ROA (%)	Weighted Average	9.81	2.36	6.90	4.08	5.85
	75 <sup>th</sup> percentile	12.61	8.63	10.31	6.79	7.41
	Median	7.31	2.93	4.74	3.67	3.67
	25 <sup>th</sup> percentile	3.85	-1.76	1.86	-2.50	-0.37
ROS (%)	Weighted Average	3.18	0.79	2.45	1.41	2.02
	75 <sup>th</sup> percentile	4.66	3.40	4.28	3.01	2.65
	Median	2.83	1.05	1.69	0.97	0.97
	25 <sup>th</sup> percentile	1.29	-1.04	0.72	-0.96	-0.32
Value Added / Staff Costs	Weighted Average	2.07	1.63	1.77	1.60	1.69
	75 <sup>th</sup> percentile	2.26	2.12	1.86	2.16	1.96
	Median	1.87	1.59	1.69	1.55	1.46
	25 <sup>th</sup> percentile	1.38	1.19	1.32	1.11	1.21
Cost of sales / sales of production	Weighted Average	0.90	0.92	0.88	0.90	0.90
	75 <sup>th</sup> percentile	0.93	0.95	0.93	0.93	0.96
	Median	0.88	0.89	0.88	0.88	0.89
	25 <sup>th</sup> percentile	0.83	0.82	0.81	0.83	0.82

Source: own calculation

Table 2: Indicators of profitability, labour productivity and cost efficiency.

in the fourth quarter of 2008 and during the whole year 2009, as shown in figure 1. In the crisis period, industrial producer price index and agricultural producer price index were moving in a similar direction. On the one hand, the dairy processors suffered from low price level of milk products. On the other hand, they used cheaper input from dairy farmers. Relatively favourable input-output price relations induced higher profitability in the dairy processing industry in 2009. It is also obvious when looking at the indicator “cost of sales / sales of production” The more dynamic increase in input prices than output prices caused the poor profitability in the previous year 2008, just as later in 2010.

The dairy industry as the whole did not reduce the total amount of staff costs during 2007 – 2010 (table 2). The first year with lower inter-annual amount of staff costs was 2011. The labour productivity, measured by value added per staff costs, reflects impacts of adverse input-output price relations in 2008 and 2010 and increasing staff costs.

Table 3 provides information about firms’ short-term liquidity. The liquidity indicators express the degree of coverage of current liabilities by current assets, which can be relatively easily converted into cash.

The liquidity ratios did not significantly change during the crisis. Generally, companies in the dairy industry have lower liquidity than recommended

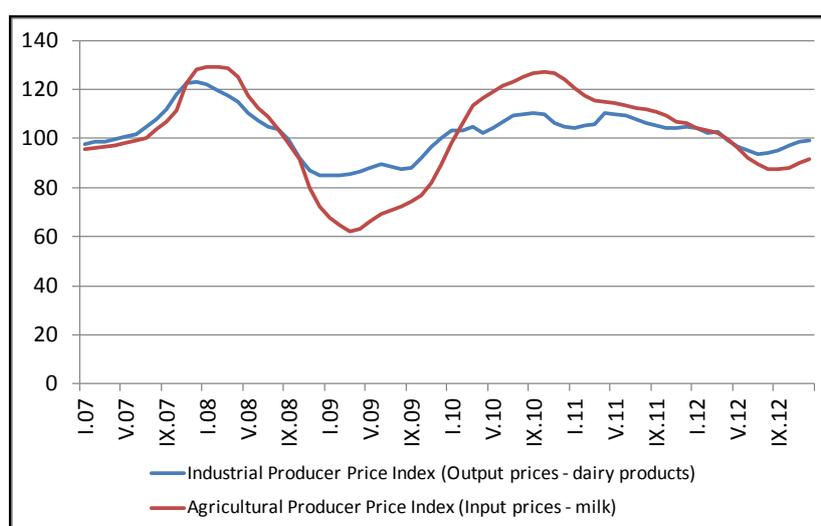
values, as indicate 25<sup>th</sup> and 75<sup>th</sup> percentile of all three liquidity ratios. Generally recommended values of the liquidity ratios for average strategy are 1.6 – 2.5 for current liquidity and 0.2 for cash ratio (Kislingerová et al., 2007).

Net working capital is mostly negative. It is possible for companies with low level of inventory, high inventory turnover and the accounts receivable. The difference between current ratio and acid test ratio indicates relatively low level of inventory, compared to short-term receivables as the most significant part of current assets. The dairy industry operates with perishable products that need to be quickly processed. The storage costs are high. So, firms operating in the dairy industry cannot have large stocks of materials. However, this financing approach can be very risky. Such firms are more sensitive to cash flow volatility and they can face serious financial problems because there is not much cushion between the value of liquid assets and the amount of short-term debt.

Accounts payable turnover exceeds 70 days on average. The most volatile accounts payable turnover have 75<sup>th</sup> percentile. Their accounts payable turnover is higher than 90 days. Such firms face the risk of struggling for existence.

Table 4 summarizes the turnover indicators which express the amount of sales generated by assets.

The turnover indicators show a sharp drop of sales in 2008 and 2009. The assets turnover and the long-term assets turnover move in the same direction,



Source: Czech Statistical Office, own processing

Figure 1: Development of price level in the dairy industry in the period 2007 – 2012 (corresponding period of the previous year = 100).

<b>Indicator</b>	<b>Boundary</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
Current Ratio	Weighted Average	0.88	0.84	0.92	0.92	0.97
	75 <sup>th</sup> percentile	1.24	1.39	1.42	1.38	1.35
	Median	0.95	0.94	1.05	1.06	1.06
	25 <sup>th</sup> percentile	0.77	0.72	0.75	0.76	0.79
Acid Test Ratio	Weighted Average	0.64	0.59	0.69	0.69	0.74
	75 <sup>th</sup> percentile	0.92	0.90	0.97	1.02	1.07
	Median	0.70	0.67	0.79	0.75	0.81
	25 <sup>th</sup> percentile	0.54	0.51	0.58	0.51	0.53
Cash Ratio	Weighted Average	0.05	0.07	0.10	0.08	0.08
	75 <sup>th</sup> percentile	0.13	0.11	0.17	0.16	0.15
	Median	0.06	0.04	0.07	0.07	0.07
	25 <sup>th</sup> percentile	0.01	0.02	0.01	0.02	0.01
Accounts Payable Turnover in Days	Weighted Average	73.45	77.45	71.97	73.04	75.41
	75 <sup>th</sup> percentile	89.96	95.61	88.33	108.58	97.78
	Median	76.36	66.96	71.30	65.38	69.55
	25 <sup>th</sup> percentile	59.53	57.73	57.48	54.61	51.79
Net Working Capital per Total Assets	Weighted Average	-0.076	-0.104	-0.043	-0.050	-0.019
	75 <sup>th</sup> percentile	0.119	0.148	0.146	0.124	0.184
	Median	-0.031	-0.036	0.020	0.025	0.031
	25 <sup>th</sup> percentile	-0.147	-0.166	-0.151	-0.164	-0.142

Source: own calculation

Table 3: Indicators of liquidity and net working capital.

<b>Indicator</b>	<b>Boundary</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
Assets Turnover	Weighted Average	3.08	2.98	2.82	2.90	2.89
	75 <sup>th</sup> percentile	3.40	3.17	2.77	3.35	3.07
	Median	2.90	2.70	2.50	2.53	2.47
	25 <sup>th</sup> percentile	2.10	2.19	2.11	2.09	1.89
Long-term Assets Turnover	Weighted Average	7.26	6.67	6.08	6.55	7.19
	75 <sup>th</sup> percentile	10.10	8.42	7.42	8.25	9.09
	Median	6.77	6.16	5.72	5.83	5.90
	25 <sup>th</sup> percentile	4.78	4.64	4.50	4.35	3.86
Inventory Turnover	Weighted Average	20.77	18.72	21.36	21.58	21.36
	75 <sup>th</sup> percentile	29.98	31.89	30.06	38.39	27.22
	Median	20.61	19.45	20.12	20.69	19.73
	25 <sup>th</sup> percentile	15.57	14.42	12.69	12.06	13.72
Accounts Receivable Turnover in Days	Weighted Average	43.42	40.17	42.54	44.17	50.44
	75 <sup>th</sup> percentile	56.90	54.63	53.44	55.91	54.61
	Median	51.48	42.47	45.65	43.47	46.01
	25 <sup>th</sup> percentile	36.61	35.18	33.38	34.30	33.39

Source: own calculation

Table 4: Turnover indicators.

unlike the inventory turnover. The inventory turnover increased in 2009 due to the low value of inventory as a consequence of low input prices of raw milk. The accounts receivable turnover

is lower than accounts payable. So, companies in the dairy industry use supplier credits and short-term credits to a large extent.

Table 5 completes the picture of the financial situation by indicators of the capital structure.

The debt ratio is relatively high compared to recommended level of 50 %. The average debt ratio in the dairy industry is about 70 % and ranges mostly from 50 % (25<sup>th</sup> percentile) to 80 % (75<sup>th</sup> percentile). Such high values emerge from a high use of short-term liabilities including credits as shown by negative net working capital (table 3). During economic downturn, companies in the dairy industry tried to cut down their dependency on bank loans and overdrafts. Thus,

the credit debt ratio has been significantly lower since 2009. Comparing long-term and short-term debt ratios, it can be revealed that the companies are able to quickly reduce short-term indebtedness, not long-term debts. The long-term debts substantially dropped in 2011.

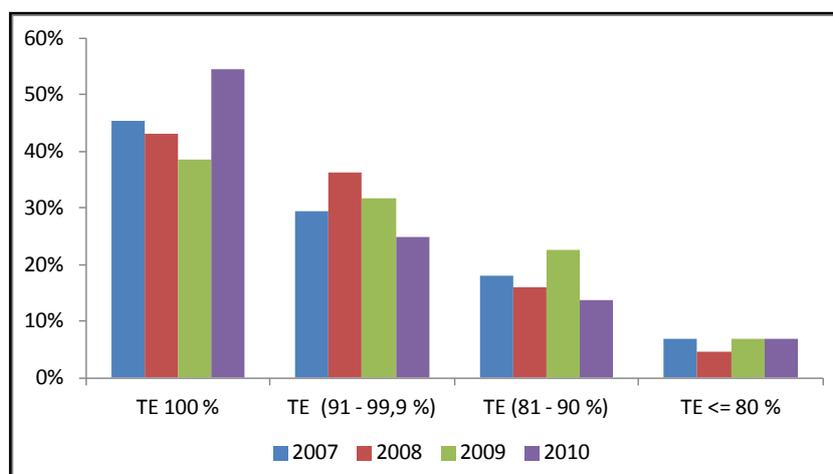
The technical efficiency in the Czech dairy industry is relatively high (figure 2).

About 75 % of dairy processors on average are fully effective or highly effective with TE above 90 %. There is one quarter of enterprises doing less well, and could improve the input-output efficiency.

Indicator	Boundary	2007	2008	2009	2010	2011
Debt Ratio (%)	Weighted Average	74.81	76.18	70.41	71.92	69.72
	75 <sup>th</sup> percentile	87.59	86.45	80.05	86.38	80.04
	Median	71.25	69.59	64.79	68.37	69.23
	25 <sup>th</sup> percentile	60.39	52.47	53.79	52.90	51.14
Short-term Debt Ratio (%)	Weighted Average	62.91	64.01	56.38	58.88	60.53
	75 <sup>th</sup> percentile	74.39	71.04	64.96	70.26	71.25
	Median	59.87	56.69	50.36	55.10	52.06
	25 <sup>th</sup> percentile	44.25	42.15	36.14	37.71	32.71
Long-term Debt Ratio (%)	Weighted Average	12.55	12.62	14.53	13.55	9.76
	75 <sup>th</sup> percentile	17.22	17.73	16.03	20.17	17.11
	Median	7.78	6.92	6.47	5.52	7.92
	25 <sup>th</sup> percentile	2.42	2.21	1.02	0.82	1.56
Credit Debt Ratio (%)	Weighted Average	26.24	26.33	21.76	21.44	21.96
	75 <sup>th</sup> percentile	29.44	31.86	29.08	24.11	26.57
	Median	15.99	19.81	13.81	12.72	13.63
	25 <sup>th</sup> percentile	3.79	6.46	0.00	0.00	0.00

Source: own calculation

Table 5: Indicators of capital structure.



Source: own calculation

Figure 2: Distribution of technical efficiency in the Czech dairy industry (2007 – 2010).

### The structure of the dairy industry – the degree of rivalry

The Czech dairy industry covers relatively important segment in the European dairy market. MarketLine data (2012) inform that the Czech Republic accounts for 1.7 % of the European dairy market value. Since the Czech EU accession there have been some important mergers and acquisitions. For example, AGROFERT HOLDING acquired Olma Olomouc and Mlékárna Hlinsko. French group Lactalis owns the majority share in the Czech dairy Mlékárna Kunín.

Table 6 shows the concentration ratio  $CR_4$  for the 4 largest market players in the Czech dairy industry. The values express the shares of production values in the total branch CZ-NACE 10.5 (in current prices).

The level of concentration in the Czech dairy industry in the period covered by the assessment shows a slightly decreasing trend. The concentration ratio in the Czech dairy industry varies around 35 %. MarketLine database presents higher market

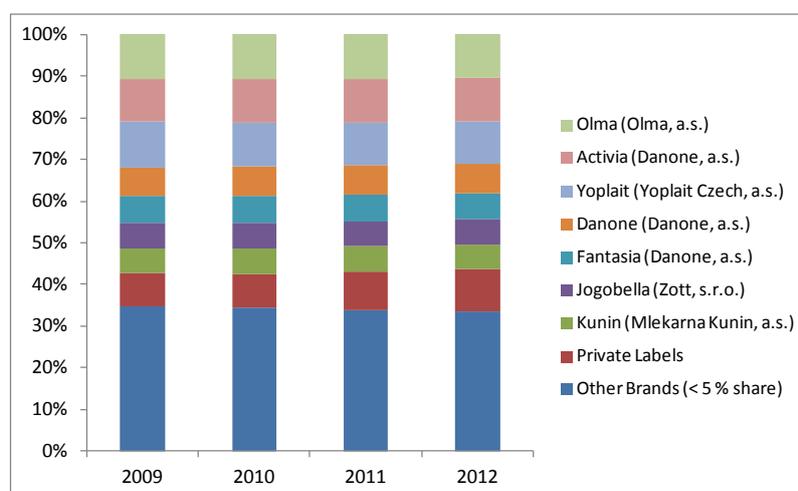
shares of the key market players – the three leading players (Madeta a.s., OLMA, a.s., Groupe Danone) generate more than 40 % of the market value. Such market structure comes near loose oligopoly. The oligopoly means a market form in which a market or industry is dominated by a small number of sellers. The leading players operate on the whole market, so the competition among them is fierce. Furthermore, there is a considerable downward pressure on prices by grocery retailers because the leading distribution channels in the Czech dairy market are supermarkets and hypermarkets with more than 50 % share of the total market's value. Independent retailers account more than 20 % of the market (MarketLine, 2012). Barring the leading market players, there is also a large number of small and medium enterprises so called “oligopoly hem” operating either on the whole market or are regionally based.

Figure 3 depicts the shares of yogurt and sour milk products brands. Figures 4 and 5 focus on the drinking milk products and cheese brand shares in the period 2009 – 2012.

	Major shareholder	2007	2008	2009	2010	2011
Madeta a. s.	Faltha Investment, S.A. (95 %)	13.8%	14.1%	12.9%	11.7%	12.1%
Mlékárna Pragolaktos, a.s.	Müller Sachsen GmbH (100 %)	3.7%	4.8%	5.4%	7.6%	7.9%
Olma, a.s.	AGROFERT Holding, a.s. (100 %)	10.4%	10.0%	8.6%	7.5%	7.4%
Danone, a.s.	PRODUITS LAITIERS FRAIS EST EUROPE - GROUPE DANONE, S.A. (100 %)	7.8%	8.2%	9.7%	7.9%	7.4%
Mlékárna Hlinsko, a.s.	AGROFERT Holding, a.s. (100 %)	5.8%	5.7%	5.7%	5.8%	6.0%
<b>CR<sub>4</sub></b>		<b>37.8%</b>	<b>38.1%</b>	<b>36.9%</b>	<b>34.7%</b>	<b>34.9%</b>

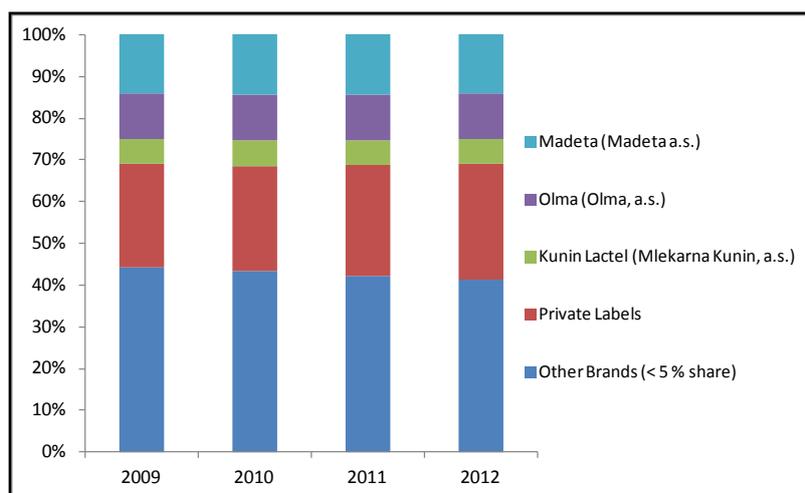
Source: own calculation

Table 6. Concentration ratio  $CR_4$  in the Czech dairy industry by sales of production.



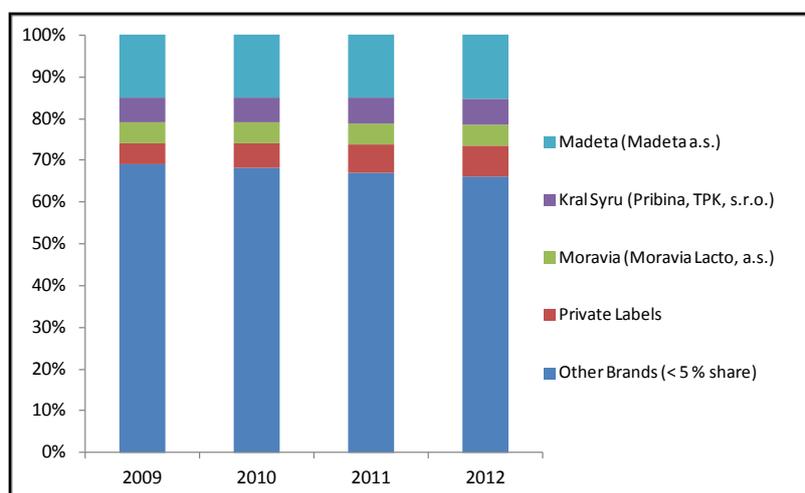
Source: Estimations by Euromonitor International database, own processing

Figure 3: Yoghurt and sour milk products company shares in 2009 – 2012 (% of retail value).



Source: Estimations by Euromonitor International database, own processing

Figure 4: Drinking milk products brand shares in 2009 – 2012 (% of retail value).



Source: Estimations by Euromonitor International database, own processing

Figure 5: Cheese brand shares in 2009 – 2012 (% of retail value).

The dairy market is not dynamic, as shown by the relative stable market shares of main brands in the Czech dairy industry. Nevertheless, increasing market share of private labels in the main product segments of the dairy industry indicates that price becomes important decision factors for Czech consumers. The private labels are strongly developed within drinking milk products, both in long-life/UHT milk and fresh/pasteurised milk, with more than 25% market share (Euromonitor International, 2012b). The market share of private labels in butter exceeds 10 % (Euromonitor International, 2011). Because of the ongoing economic recession, high price sensitivity of milk products and strong power of hypermarkets/

supermarkets, private labels seem to further increase its market share.

Even though Madeta is the leading company in the Czech dairy industry by value of sales, Danone leads yoghurt and sour milk drinks with approximately 25 % share (figure 3). It is top seller of both drinking and spoonable yoghurt and benefits from wide range of product portfolio with well-established brands. Danone takes advantage of consumer trust and loyalty because of long-standing presence on the Czech market since early 90<sup>th</sup> of the 20<sup>th</sup> century. Olma takes the second rank in yoghurt and sour milk products with approximately 12 % market share. In this segment, the most popular is plain spoonable yoghurt. Besides this, Olma's product

portfolio includes fresh milk, long life milk, milk desserts and flavoured milk drinks including organic products. It benefits from traditional Czech brand, like Madeta.

Madeta is a leading company in the segment of drinking milk products, followed by Olma and Mlékárna Kunín (figure 4). Madeta has the highest success in flavoured milk drinks and long-life/UHT milk, the second rank takes Olma. Madeta also produces fresh/pasteurised milk, where it ranks second place behind Olma. Mlékárna Kunín has success with long-life/UHT milk. No other brands reach more than 5% value share. Olma and Madeta also have strong position in butter, where they accounted for an aggregate retail value sales share of 37 % in 2010 (Euromonitor International, 2011).

The dominant company within cheese market is Madeta (figure 5) with relative stable cheese market share about 17 % (all cheese brands of Madeta). Madeta is the leading producer of unprocessed cheese in the Czech Republic. The second positions within the Czech cheese market ranks the company Bel Sýry Česko with approximately 14% value share. Because any of its brands does not exceed the 5% value share, company's name does not appear in the figure 5. Bel Sýry Česko is a leading producer of processed cheese and important producer of packaged hard cheese in the Czech Republic. TPK ranks third position. It is particularly famous for soft cheese and takes second position in processed cheese.

There are also specific market segments in the dairy market. Market research by Euromonitor international (2012b) presents, that "Nestlé Česko leads flavoured powder milk drinks and is expected to hold a 47% value share in 2012 with its brands Orion Granko and Nesquick, followed by Emco with an 11% market share. Lactel (by Lactalis) and Bettine brand are the leading brands in goat milk. Powder milk is dominated by PML Protein Mleko Laktoza and Bohemilk. Within soy milk, brand Alpro Soya (distributed by Emco), followed by Provamel (distributed by Country Life)."

Considering product innovations in the recent years, producers have launched new flavours, new milk products for children, light milk products, spreadable processed cheese with lower salt content, yoghurts with cereals and organic milk products. Producers also focus on new packaging like new package design, family packaging or improving packaging materials to extend the high quality of production.

### **Bargaining power of customers (buyers)**

Buyer power depends on the structure of market channels as well as on the character of the product. In the Czech Republic, as mentioned above, the main distribution channels for dairy products are hypermarkets and supermarkets with more than 50 % of the total market value. The competitive environment of the hypermarkets and supermarkets is highly concentrated. The CR<sub>4</sub> ratio of the grocery retailers company shares in the Czech Republic is 46.3 % in 2011. The CR<sub>4</sub> ratio was 40.1 % in 2007, so the concentration has been gradually increasing. It means that the market share of the four leading grocery retailers – Ahold Czech Republic, a. s., Tesco Stores CR, a. s., Kaufland Česká republika, v.o.s., Penny Market, s. r. o. - indicate oligopoly. The biggest grocery retailers are multinational companies with strong bargaining power. There is not vertical integration between leading grocery retailers and dairy processors. Thus, the consumer price setting is highly independent on suppliers (dairy processors) and considers the purchasing power and preferences of final consumers of food products. Moreover, all main hypermarkets and supermarkets started to increasingly promote their cheaper private labels brands. It also affects the brand competition environment within the dairy industry. The increasing market share of private labels brands indicates that the price sensitivity of milk products becomes higher.

### **Bargaining power of suppliers (dairy farms)**

The dairy processors are dependent on one major raw material – milk. There are no basic substitute inputs for the dairy processors. It means that the dairy industry must face bargaining position of dairy farms. Although there is no significant vertical integration between dairy farms and processors in the Czech Republic, the supply chain is based on the long-term contracts. AGROFERT Holding attempts to integrate dairy farms and processors, but it is not typical vertical integration like in Germany or Denmark. Some small dairy farms also process own milk and produce milk products with higher value added, or even organic products, for distribution at local farmers' market, via Internet or via automatic milk vending machines. Large dairy processors often use hedging against price fluctuation as well as against exchange rate changes, when they export milk.

The number of suppliers in the Czech Republic can be set by the number of registered milk quota holders (table 7). There can be both direct sales

quotas, for producers who sell dairy products direct to consumers, or wholesale quota, for producers who sell milk to approved milk purchasers.

The number of wholesale quota holders has been decreasing. It goes hand in hand with gradual decline of the number of dairy cows. Alternatively, the number of quota holders for direct selling has not dropped against 2004/2005.

Producers' organisations increase the weak bargaining power of more than 2 000 milk suppliers. Bošková (2013) finds that 66.7 % of milk production was sold via 39 registered producers' organisations in 2011. The market share of each of the three largest producers' organisations exceeds 5 % of total amount milk sold. The market share of other seven producers' organisations ranges from 2 % to 5 %. It means that supplier power in the dairy industry can be considered as relatively weak.

#### Threat of substitute products

Milk and milk products are important components of peoples' diet. Milk products are used directly or indirectly as ingredients for home-made food. Nevertheless, it is possible for consumers to replace conventional milk products with vegetable alternatives, such as soya milk, almond milk, rice milk, oat milk, coconut milk. The vegetable alternatives are often available as powdered milk drinks. Cow's milk can be also replaced by goat milk, sheep milk or buffalo milk. The special alternatives of cow's milk and milk products represent only a marginal market share. Moreover, milk alternatives are relatively expensive. The milk substitutes have marginal market share. The average annual consumption of goat milk is stable at 0.1 kg per capita (Czech Statistical Office).

Butter can be substituted either by other animal fats or by vegetable edible fats and oils. The butter substitutes have more appreciable market position. Nevertheless, the average annual consumption of hardened cooking fats dropped from 3.5 kg (2003) to 3.1 kg (2011) per capita (Czech Statistical Office). Margarine and cooking fats saw an ongoing decline in retail volume and value sales over the recent period due to the decreasing popularity of baking and cooking at home. Overall, the threat of substitute milk products can be assessed as weak (milk substitutes) or moderate (butter substitutes).

#### Threat of new competition

Generally, enterprises entering into the food industry benefits from higher assets turnover than other branches, especially in primary sectors (agriculture, mining) and real estate activities (figure 6).

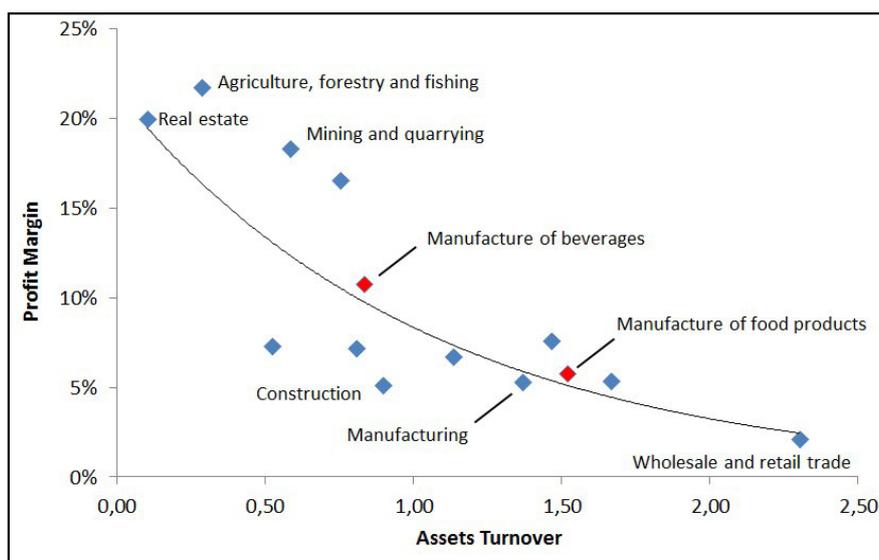
Overall, branches that have high assets turnover and relatively low profit margin have lower barriers to entry than branches with high profit margin and low assets turnover (Holečková, 2008). Nevertheless, there are some high barriers to entry in the dairy industry, among them the most important are laws on food safety, customer loyalty to established brands of leading market players and contracting with grocery retailers and milk suppliers. Moreover, dairy products are mostly perishable, which requires high turnover, reliable supply chain and distribution channels. Alternatively, there are relatively weak barriers to entry for small dairy processors looking to sell products at the local market. They must obey laws on food safety and have to build up consumer confidence in the region.

Concerning capital requirements, the dairy industry does require relatively large amounts of capital,

Quota year	Quota holders for		Approved purchasers
	wholesale	direct selling	
2004/2005	2,950	252	82
2005/2006	2,871	264	86
2006/2007	2,699	197	82
2007/2008	2,581	176	82
2008/2009	2,479	162	83
2009/2010	2,344	249	83
2010/2011	2,182	268	84
2011/2012	2,072	276	81

Source: Yearbook of the livestock production in the CR 2011

Table 7: The number of milk quota holders and approved milk purchasers.



Source: Own calculation based on data provided by the Ministry of Industry and Trade

Figure 6: Profit Margin and Assets Turnover in selected branches in the CR (2011).

Processing of	Number of completed projects	Investment expenditures per project ('000 CZK)
Oils and fats	5	20,079
Milling products	27	17,973
Milk products	39	15,899
Tea blends/herbs/spices	14	10,724
Fruit and vegetables	43	9,387
Meat products	115	8,768
Feeds	23	8,518
Wine grapes	46	7,524
Honey products	7	5,750
Other products	17	8,736
Total	336	10,412

Source: Own calculation based on data provided by the Ministry of Agriculture

Table 8: Number and average investment expenditures of completed projects in RDP measure I.1.3.1 by branch (2007 - 2011).

compared to other branches of the food industry, because of strict regulations for hygienic milk processing and packaging. Table 8 shows average investment expenditures of completed (settled) applications within measure I.1.3.1 “Adding value to agricultural and food products” of the Rural Development Programme in the period 2007 – 2011.

It can be concluded that investments in modernisation of small and medium milk processors belong to the most capital-demanding projects among other food-processing branches. It relates to the need for investments in advanced

technological equipment for processing dairy raw materials and production of dairy products. Average investment expenditure per project was 15.9 million CZK.

## Conclusion

The aim of the paper is to present in-depth view on the competitive environment of the Czech dairy industry. The sharp drop of profitability reveals that the economic recession affected the financial performance of the Czech dairy industry early in 2008. It was caused by unfavourable input-

output price relations. The gulf between agriculture producer price index and processors producer price index gave rise to farmers' clamour against low milk prices in 2009. The dairy processors had higher profitability in 2009 than in 2008. The crisis in the dairy sector accelerated the ongoing decline of the milk cow population. The brief analysis of the technical efficiency of the dairy industry shows that one quarter of enterprises could improve the input-output efficiency. In this respect, it is desirable to further promote investments in technology upgrades. The more comprehensive analysis of determinants of the technical efficiency will be subject of subsequent research.

The competitive environment within the Czech dairy industry is slightly concentrated and comes near loose oligopoly. The leading players operate on the whole market, so the competition among them is fierce. Alternatively, there are relatively weak barriers to entry for small dairy processors looking to sell products at the local market. This is particularly noticeable in the increase of number of the small dairies engaged in direct selling of milk and milk products to consumers.

The relationships within dairy supply chain can be considered as the weakness of the Czech dairy industry. At the bottom of the vertical, there are more than 2 000 dairy farmers and 39 registered producers' organisations with rather weak bargaining power, partly because of missing

forward integration between dairy farmers and dairy processors. At the upper level of the vertical, there is strong bargaining power of large multinational chain of the hypermarkets and supermarkets. Moreover, the consumer price setting is highly independent on suppliers (dairy processors) and considers the purchasing power and preferences of final consumers of food products. The economic downturn made consumers to switch from branded dairy products to cheaper private labels, as the analysis proved.

The incentives to the dairy industry should more focus on contracting. The bargaining power of dairy farmers should be bolstered up by concentration of dairy farmers to less number and more powerful producers' organisations. It is also necessary to strengthen the position of dairy processors towards retailers, to prevent abuses of dominant market power of big grocery retail chains. Last but not least, it is desirable to continue supporting of consumers education about quality of the Czech dairy products.

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## Optimization of Irrigation Spray Distribution in the Term of its Uniformity

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### Abstract

The production process of agricultural and livestock production is affected by climatic conditions, mostly including the amount and quality of rainfall. In High Tatras region is annual atmospheric rainfall between 500 and 2000 mm. During vegetation period the rainfall on the most agriculturally significant areas is even less and its value is between 300 and 250 mm. This amount is insufficient for the most of economic significant plants. From this point of view, the artificial irrigation represents one of the most important factors that improve the agricultural production.

Considering stochastic effects like wind or technical parameters of irrigation machines, slope of terrain, the distribution of spray is not equal over the whole irrigated area. For economic benefits in the process of irrigation and supplying water to the irrigation machines, this spray non-uniformity must attain smallest possible value. This can be achieved by proper mathematical modeling of economic and technological processes, the irrigation process includes.

### Key words

Irrigation uniformity, overlaps, simulation model, sprinkler.

### Introduction

The optimization of spray has been the subject of research of many authors. They used many different methods and practices. Palková, Okenka and Rodný (1998, 2012) used principles of the Queuing theory and heuristic algorithms in their thesis. Domínguez (2010) described the methodology for determining the most suitable irrigation schedule under regulated deficit irrigation conditions. Pereira dealt with the optimization of central pivot irrigation machines (2012). Based on analysis of meteorological parameters during the irrigation season, Yacoubi (2010) developed models simulating the effectiveness of the night irrigation of tomatoes.

This contribution deals with optimization modeling of the spray distribution in the term of its uniformity using reel hose irrigation machines with calculations of the optimal overlap width.

### Materials and methods

Spray uniformity is an important factor of irrigation quality and according to some authors, spray non-uniformity leads to a reduction of yield per hectare

by 2-10%.

The spray equality mainly depends on the curve  $i - \overline{L_d}$  (intensity-range), on the spacing of the sprinklers works in and on the effect of wind. Center pivot irrigation machines are placed to the vertexes of a square, rectangle or a triangle. The circles sprayed by the water stream are more or less overlaps, so some areas are irrigated more than one times. The amount of water in the overlapped areas is summed. This leads to deviations from the average amount of water on each elementary area. In 70<sup>th</sup> of the last century, many formulas determining the spray equality has been developed.

The coefficient of uniformity  $C_u$  according to Christiansen:

$$C_u = 100 \cdot \left( 1 - \frac{|\sum h_i - h_m|}{n \cdot h_m} \right) \quad (1)$$

where:

- $h_i$  is the amount of rainfall at  $i^{\text{th}}$  area (mm),
- $h_m$  is the average amount of rainfall over the whole area (mm)
- $n$  is the number of elementary areas (pcs).

The degree of non-uniformity  $E_f$  (Hofmeister,

Oroszlany-Szalai):

$$E_f = \frac{\frac{\sum e_i}{n}}{\frac{\sum h_i}{n}} \quad (2)$$

where:

- $e_i = |h_i - \bar{h}|$
- $\sum_{i=1}^n h_i = n \cdot \bar{h}$
- $\bar{h}$

After substituting:

$$E_f = \frac{\sum_{i=1}^n |h_i - \bar{h}|}{n \cdot \bar{h}} \quad (3)$$

The coefficient of variation  $C_v$  (Stefanelli, Strong):

$$C_v = \frac{\sigma}{\bar{h}} \quad (4)$$

Where standard deviation  $\sigma = \sqrt{\frac{\sum_{i=1}^n |h_i - \bar{h}|^2}{n}}$ .

The coefficient of uniformity  $C_{ws}$  (Wilcox-Swales):

$$C_{ws} = \left( 1 - \sqrt{\frac{\sum_{i=1}^n |h_i - \bar{h}|^2}{n \cdot \bar{h}^2}} \right) \quad (5)$$

The coefficient of uniformity  $\beta$  given as the ratio between the maximum and average amount of rainfall (Lipták):

$$\beta = \frac{h_{\max}}{\bar{h}} \quad (6)$$

Geometrical factor  $\gamma$  represents the ratio between effectively irrigated area  $S_h$  and the whole area  $S$ .

$$\gamma = \frac{S_h}{S} \quad (7)$$

Effectively irrigated area is the area, where the amount of water has a deviation from average amount. Lipták (1971) have used 3 values of geometrical factor with deviation from average value -  $\pm 10\%$ ,  $\pm 20\%$ ,  $\pm 33\%$ . Instead of the factors mentioned, lots of exact procedures are used. These factors can be divided into five groups like below:

1.  $C_u$  and  $E_j$
2.  $C_v$  and  $C_{ws}$
3.  $E_{p1}$  and  $E_{ph}$
4.  $\beta$
5.  $\gamma_{10}, \gamma_{20}, \gamma_{30}$

Factors from 1 to 4 represent the uniformity of spray by one value determined by a statistic processing of rainfalls catch in rain gauge vessels.

Using these formulas in a mathematic-analytic model, uniformity optimization of spray can be achieved.

### Simulation model for optimizing the spray uniformity with optimal overlaps using reel hose irrigation machines

During the irrigation with hose reel irrigation machine, the irrigation truck continuously moves down the proper line. Practical measurement of water volumes dropped in all elementary areas the whole irrigated area is divided into is not possible (Látečka, 2000). One of the most widespread methods is the method of evaluating the transverse uniformity of spray.

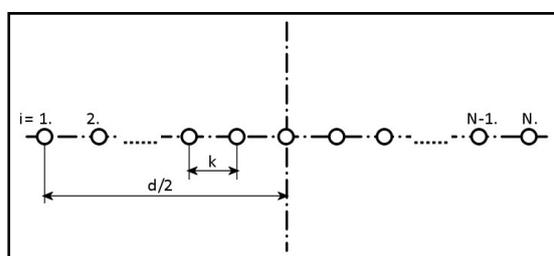


Figure 1: Method of evaluating the transverse uniformity of spray.

Rain gauge vessels are set along the irrigation width perpendicular to the direction of the irrigation truck. The input file for the simulation model contains water volumes measured in all rain gauge vessels for two tested nozzles. We have used Bauer Rainstar 90/300 reel hose irrigation machine.

Technical parameters of Bauer Rainstar 90/300 are as follows (Jobbágy, 2011):

Diameter and length of the hose	90 mm / 300 m
The maximum length of the belt	340 m
Flow rate	17 – 65 m <sup>3</sup> .h <sup>-1</sup>
Connecting pressure	0,35 – 1 MPa
Nozzle diameter	16 – 30 mm
Weight with a hose with water	3270 kg
Weight with a hose without water	1850 kg
Total length including the tripod	5350 mm

We have used SR 101 sprinkler with two different nozzles of the same diameter of 20 mm. During the measurements, the wind speed did not exceed 1 m.s<sup>-1</sup> and the terrain was flat, the slope was up to 1°. The speed of spooling of the hose was set to 15,1 m.h<sup>-1</sup>. Number of plastic rain gauge vessels was 61 and they were placed according to Christiansen perpendicular to the direction of move. The distance between two adjacent vessels was 1

meter (Jobbágy, 2011).

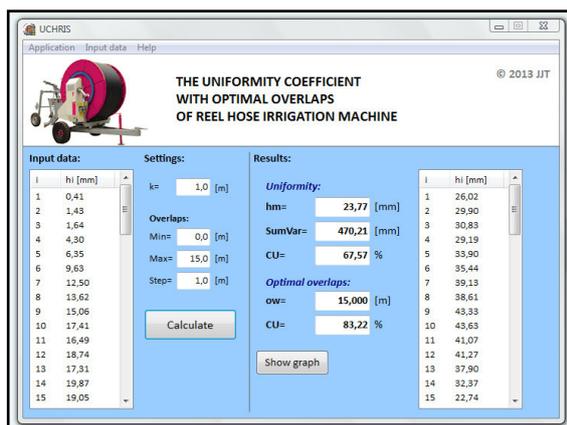
By measuring the transverse uniformity in one irrigated line, we measured the following water volumes in all vessels:

Index of rain gauge vessel	Nozzle #1 Volume [mm]	Nozzle #2 Volume [mm]
1	0.41	1.17
2	1.43	2.4
3	1.64	2.53
4	4.30	2.61
5	6.35	3.87
6	9.63	6.42
...	...	...
56	26.22	6.49
57	24.58	7.03
58	22.53	3.61
59	20.59	2.04
60	12.50	0.57
61	3.69	0.2

Source: own measurement

Table 1: Measured water volumes

We designed a Win32 application that calculates the coefficient of uniformity according to Christiansen out of the input data shown in the table above. The application was designed in Embarcadero Delphi 2010 Architect programming environment. Its executable is fully compatible with all Windows versions from Windows NT to Windows 7.



Source: own processing

Figure 2: The front page of application of modeling optimal overlap of hose reel irrigation machines.

To do any further calculation, a user must load the input values representing the water volumes in all rain gauge vessels. The application expects the raw ANSI text file with CRLF line separator

to be selected containing these values. There is no need of special extension for this file. The structure of this file is simple, where every line of the file represents the water volume. The proper structure of this file looks like this:

```
0.41
1.43
1.64
4.30
6.35
9.63
12.50
13.62
15.06
...

```

Because every line represents one vessel, the count of vessels must equal to the number of rows. If there are more rows in the file, extra lines are ignored. In the application, a user can enter the value representing the distance between two adjacent rain gauge vessels as they were placed during the test in real conditions. For the calculation of optimal overlap values representing the minimum and maximum width of overlaps on both sides of irrigation belt are also entered, even we can set the step in which the width of overlaps increases. The default value for the maximum overlap width is 15 meters – a quarter of the watering range of the sprinkler we used. Values higher than a quarter are not considered of having an economical benefit due to ineffective water consumption. We set the step 1 meter that equals the distance between two adjacent vessels.

For the calculation of optimal overlaps we used modified formula for the coefficient of uniformity according to Christiansen (form. 1). Modeling of overlapping is realized by the sum of water volumes in a pair of vessels according to the following formula:

$$h_i = h_{n-i+1} = h_i + h_{n-i+1} \quad (8)$$

where:

- $h_i$  – water volume in the  $i$ th rain gauge vessel,
- $n$  – total number of vessels.

The formula shown above is valid in case of indexing vessels from 1. In computer programming we tend to start indexing from 0 due to natural organization of data stored in the operation memory. In that case, the proper right vessel is determined with the index of  $h_{n-i}$ . The highest vessel index is determined according to the known total number of used vessel during the spray

measuring test. This is the last vessel in the row that receives the water drops. Using the following formula, we calculated the last vessel in the overlap area:

$$i = trunc(ow/k) \tag{9}$$

where:

- ow** – actual modeling width of overlap,
- k** – distance between two adjacent vessels.

Optimal overlap width is determined by the highest possible value of the coefficient of uniformity over the whole irrigated belt. Application simulates all possible widths of overlap by increasing its value by an entered step. Direct calculation of the coefficient of uniformity would be slow and less effective. Sufficient calculation might be realized by the following formula:

$$c_f = \frac{\sum_i^n |h_i - h_m|}{h_m} \tag{10}$$

In the denominator of the formula above, value *n* representing the total number of used vessels is omitted. This value is constant during the whole process of calculation. We are looking for the value of *c<sub>f</sub>* that represents the minimum calculated of all simulated overlap widths. In the formula, sharp inequality is used. In case of testing with even possible equality, if the application finds two or more equal minimum calculated values, the result would be the last value which means higher overlap width. We need to know the smallest overlap width possible.

After determining the minimum calculated value of *c<sub>f</sub>*, application transforms this value into the coefficient of uniformity using the following formula:

$$CU = 100 * (1 - \frac{c_f}{n}) \tag{11}$$

### Results

According to measured water volumes using two different nozzles, we simulated the optimal overlap width with calculation of the coefficient of uniformity.

In the table below, the results calculated for the first nozzle are shown. The CU without overlaps is very low and insufficient. The optimal overlap width was calculated to 15 meters that equals to the quarter of the whole irrigation width (60 meters). The CU after simulating overlaps was calculated to 83.22%.

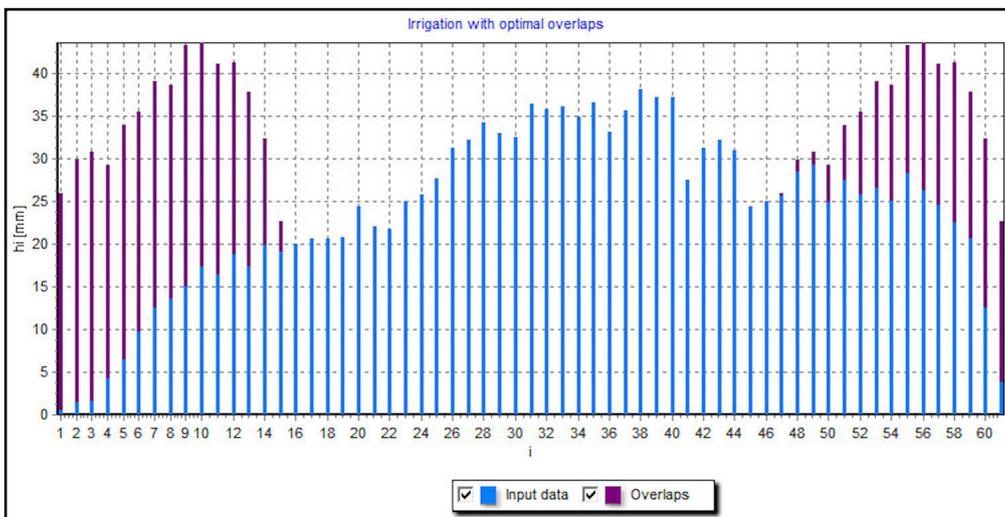
Nozzle #1	
<b>x</b>	1.0 m
<b>hm</b>	23.77
<b>CU without overlaps</b>	67.57 %
<b>ow (optimal overlap width)</b>	<b>15.0 m</b>
<b>CU with overlaps</b>	<b>83.22 %</b>

Source: own measurement

Table 2: CU using the first nozzle.

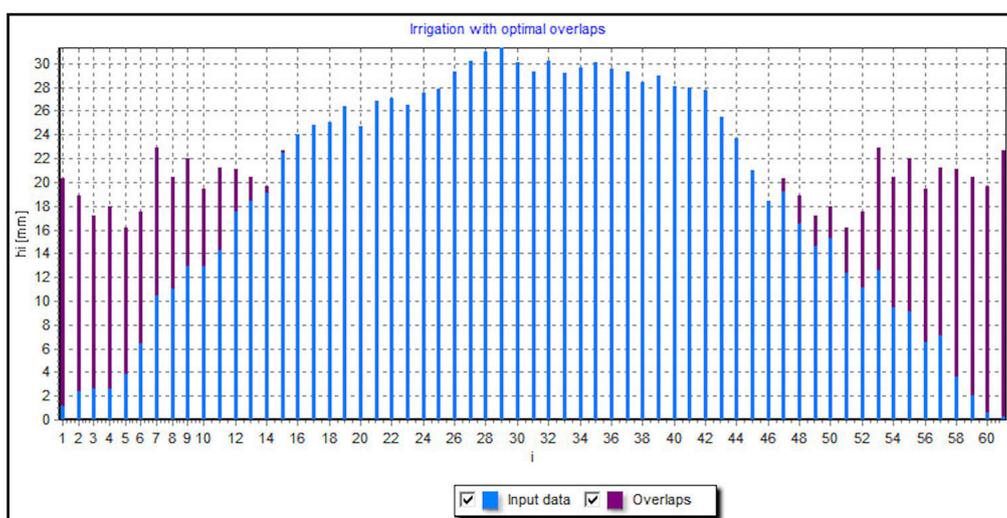
In the figures below, the water volumes with overlaps are presented.

The horizontal axis represents the index of rain



Source: own processing

Figure 3: Measured and calculated water volumes using nozzle #1.



Source: own processing

Figure 4: Measured and calculated water volumes using nozzle #2.

gauge vessel. The distance between two vessels was set to 1 meter. Even the whole irrigation width was 60 meters we used 61 vessels to also catch the drops falling on both edges. Light blue bars represent measured water volumes in each vessel. Magenta bars represent the calculated optimal overlap width. The waters volumes on left and right sides sum to the final volumes. The vertical axis represents the water volume in ml.

The next table shows the calculated results for the second nozzle.

Nozzle #2	
x	1.0 m
hm	18.82
CU without overlaps	52.74 %
ow (optimal overlap width)	15.0 m
CU with overlaps	82.98 %

Source: own measurement

Table 3: CU using the second nozzle.

As shown in the table, the CU without overlaps is a lot worse than that when using the first nozzle. Instead, the final CU with overlaps is similar.

## Conclusion

In the presented paper, we focused on optimization of the amount of spray during irrigation. Since the quality of work of reel hose irrigation machines is evaluated by the coefficient of uniformity on one side, we developed an application to ease its calculation. One of the results is the design of optimal overlap width to achieve

the maximum value of the Christiansen’s coefficient of uniformity. The optimal overlap width is calculated depending on minimum and maximum width of overlaps. The user of this application can set this interval. The value of the coefficient of uniformity is influenced by many external factors, including the terrain of irrigated area, effect of wind and the slope of the irrigated area. The results obtained after measurement in 2011 were successfully evaluated by the UCHRIS (JJT, 2013) application. The results shows, that according to some authors, the quality of work of tested reel hose irrigation machine was sufficient, but according to the ISO norm was not. Our program calculated the optimal overlap width to 15 m, getting the higher value of the coefficient of uniformity (83.22 % and 82.98 %). The increment of the quality of work generally leads to higher values of uniformity in irrigation of crops, providing higher agricultural and livestock production. On the other hand, the overlaps decrease the effective scope of irrigation machines and increase the irrigation costs.

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## Factors Affecting Loan Repayment Performance Among Yam Farmers in the Sene District, Ghana

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### Abstract

The study analyzed the factors that are critical in improving loan repayment by yam farmers in the Sene district of Ghana. Random sampling technique was used to select 100 respondents in the district and structured questionnaire was administered to collect data. Descriptive statistics and the probit model were employed. The results show that 42% of yam farmers in Sene district are illiterates. More males (93%) are involved in yam farming than females (7%) and most of the farmers are married (91%). Also most of the yam farmers in the district have a family size of 6-10 households (66%) and 54% of them have 1-10 years of yam farming experience. Also, the results show that education, experience, profit, age, supervision and off-farm income have positive effects on loan repayment performance. Conversely, gender and marriage have negative effects on loan repayment while the effect of household size was found to be ambiguous.

### Key words

Yam farmers, Loan repayment, Probit model.

### Introduction

Yams (*Dioscorea* species) are a major component of rural people's livelihoods in Ghana. They are an important source of food and income for producers' households and an important food source for both local consumption and export. A survey by German Technical Cooperation (GTZ) of the Northern region of Ghana identified yams as the most important cash and food crop in that region. According to Fowler (2000), yam also received the highest priority ranking of all crops in the National Agricultural Research Strategy Plan (NARSP) and in the Agricultural Services Sector Investment Programme (AgSSIP).

West Africa produces more than 90 per cent of the world's yam output, with Ghana the third most important producer, ranked behind Nigeria and Côte d'Ivoire. Ghana produced 2.2 million tonnes in 1995, compared with 2.8 million tonnes in Côte d'Ivoire and Nigeria's 23 million tonnes (Vernier et al, 1997). The crop is one of Ghana's major staples. Yams are ranked second in importance (in tonnage terms) after cassava in staple food production and, as a result of their relatively high unit price, are the most important food crop in terms

of value of production. Together with cassava, they provide 31 per cent of national food security and supply in excess of 50 per cent of the calorie needs of the average Ghanaian. The crop is grown mainly by smallholders, covering approximately 10 per cent of the country's cultivated land which is approximately one-third of the area planted to cassava (Nkum Associates, 1994).

While cocoa provides 14 per cent of the natural resources sector's GDP, other crops, which include yams, make up 61 per cent (1994 data). More detailed analysis shows that roots and tubers account for 46 per cent (of which cassava: 19 per cent; yams: 17 per cent; and, cocoyams: 10 per cent) and maize for 5 per cent (Anon, 1994). Fisheries (5 per cent), forestry (11 per cent) and livestock (7 per cent), comprise the balance. The importance of yams as a food staple is underlined by the observation that its consumption is sometimes used as a poverty indicator – thus, if *fufu* is prepared only rarely, the household is considered to be poor. Indeed, it is reported that rural households seek to extend the period of tuber storage so that they can eat yams regularly in order to demonstrate to neighbours that they are not poor (Anamoh and Bacho,

1994). In addition, the crop is important to rural households for food security purposes because its yields fluctuate less than those of cassava (Impact Evaluation Consulting Team, 1999). The crop is grown widely in 34 of the country's 43 agricultural districts, although data showing the breakdown of production by region are unfortunately not published regularly (Anon, 1994). The principal areas of production are the northern forest and southern savanna zones, with about two-thirds of the national harvest being produced in Brong Ahafo and Northern regions. The crop is consumed in all parts of the country (GTZ, 1999).

Yams are a prestigious crop having strong cultural, ritual and religious significance and their consumption is preferred to other starchy staples at social gatherings (Dorosh, 1988; GTZ, 1999; IITA, 1998; Orkwor et al, 1998; Tetteh and Saakwa, 1991). They are used, for example, to fulfill social obligations to chiefs and in-laws in the rural areas (Langyintuo, 1993), which is why the production of 'ware yams for daily consumption and sale continues alongside the production of even larger tubers which are used principally for ceremonial purposes. They are also an indispensable part of bride-price. Consequently, yams are likely to remain an important component of the crop mix in Ghana's savanna and northern forest agro-ecological zones for the foreseeable future.

Many financial institutions in developing countries provide financial services such as saving and credit to aid several smallholder enterprises including farmers. This is an effort in line with the Millennium development goals which seeks to reduce poverty by 50% by the year 2015. However, the sustainability and continuity of the financial institutions to increase the volume of credit to stimulate the poverty reduction goal depends on the repayment rates. High repayment rates allow the institutions to lower the interest rates and processing costs and consequently increase patronage of loans. Repayment performance thus serves as a positive signal for increasing the volume of credit availability to various sectors of the economy (Acquah and Addo, 2011). However, the financial institutions continue to decline credit to the agricultural and fisheries sectors. This decline is partly due to poor loan repayment performance from these sectors. Most of the loans default in these sectors could arise from poor management procedures, loans diversion and unwillingness to repay loans as well as other socioeconomic characteristics.

Generally, in spite of the importance of loan in agricultural production, its acquisition and repayment are fraught with a number of problems especially in the small holder farming (Awoke, 2004). Awunyo-Vitor (2012) has reported in empirical studies that large rate of default has been a major problem in agricultural credit delivery and sustainability, consequently large proportion of formal financial institution has suspended agricultural credit. Thus a key issue in the sustainability of agricultural credit delivery hinges on improved loan repayment. It is therefore, important for the financial institutions to devise means to reduce the levels of loan default. This can be achieved if they know the factors that influence loan repayment. The question this study seeks to answer is what factors are critical in improving loan repayment by farmers?

Inability of borrowers to repay amount of loans collected is crucial for the long-term sustenance of the credit institutions. As a result, many studies have tried to examine loan repayment performance of many socio-economic groups. Empirical work by Arene (1993) revealed income, farm size, age of farmers, farming experience and level of education of farmers contributed positively to the credit worthiness of farmers. Oladeebo and Oladeebo (2008) examined the determinants of loan repayment among smallholder farmers in Ogbomoso Agricultural Zone, Nigeria. Results from multiple regression analysis showed that amount of loan obtained by farmers, years of farming experience with credit and level of education were major factors that positively and significantly influenced loan repayment. Eze and Ibekwe (2007) examined the determinants of loan repayment under the indigenous financial system in Southeast Nigeria. Empirical results from multiple regression analysis revealed amount of loan received, age of beneficiary, household size, years of formal education and occupation as important predictors of loan repayment under the system. Mashatola and Darroch (2003) analyzed the factors affecting the loan status and repayment scheme of sugarcane farmers who received graduated mortgage loan in Kwazulu-Natal, South Africa. Results identified farm size (proxied by annual gross turnover), access to off-farm income, and average annual gross turnover relative to loan size as criteria in selecting potential farmers for such scheme as they provided additional liquidity to fund future operations and debt repayment. Okorie (1986) examined the major determinants of agricultural smallholder loan repayment in Ondo State, Nigeria.

Results identified the nature and timeliness of loan disbursement, the number of supervisory visits by credit officers, profitability of the enterprise on which the loan funds were invested as significant factors that stimulate loan repayment. Kohansal and Mansoori (2009) investigated the factors affecting loan repayment performance of farmers in Khorasan- Razavi Province of Iran. Results from a logistic model showed that loan interest rate was the most important factor affecting repayment of agricultural loans. Farming experience, and total application cost were the next factors respectively. Chirwa (1997) analyzed the determinants of credit repayment among smallholder farmers in Malawi using a probit model. Results revealed sales of crops, size of group, degree of diversification, income transfer and the quality of information as significant determinants of agricultural credit repayment. Bassem (2008) examined the factors vulnerable to affect the repayment performance of group lending in Tunisia. Empirical results from a logistic regression estimation showed that the repayment is influenced positively by the internal rules of conduct, the same business, and the knowledge of the other members of the group before its formation, the peer pressure, the self-selection, the sex, the education and the non financial services. However, the homogeneity, and the marital status had a negative influence on repayment.

## **Materials and methods**

### **Study area and data collection**

Sene District is one of the 22 districts in the Brong Ahafo Region of Ghana. It was created out of the Atebubu District in 1988. Kwame Danso is the capital town of the district. Sene District is bounded to the north by the Volta Lake and East by the Gonja District (in the Northern Region), to the east and south-east by the Volta Lake, Krachi West, Krachi East and Jasikan District in the Volta Region, to the south and south-west by Afram Plains and Sekyere East District in the Eastern and Ashanti Region respectively, to the west by Atebubu-Amanten and Pru district of Brong Ahafo Region.

The Sene District is located between longitudes 0°15E and 0°15W, and latitudes 7°N and 8°30N. Out of the 19 administrative districts in the Brong Ahafo Region, Sene has the largest land area which is about 8586.44 km<sup>2</sup>. The distance from the district capital (Kwame Danso) to the regional capital (Sunyani) is about 241km via Nkoranza

and Techiman. According to the 2010 population and housing census, the district has a population of about 118,820 people. It is characterized by two climatic seasons. These are the dry season between November and March and the rainy season between April and October. The favourable climate of the area encourages about 70 percent of the people to engage in farming activities. Farming is the main industry in the area and they specifically major in grain- and tuber-production but yam dominates all other product in the district. Farming in the district is mostly on a small scale.

The study used both primary and secondary data. Primary data, which was mainly cross-sectional, was collected from 100 yam farmers in the four main yam producing communities in the Sene District. These communities include: Kwame Danso, Lemu, Kyeamekrom and Bassa. In each community, 25 yam farmers were selected from lists of members of the existing yam cooperative society using random sampling technique. The main data collection instruments employed in the study were the use of structured questionnaires and interviews. Primary data for the 2011-2012 production seasons was collected. Variables included in the questionnaire were: farmers' age, sex, educational level, marital status, yam farming experience, household, occupation, whether or not farmers have ever applied for a loan, amount of loan given to farmers, whether or not farmers were able to pay for their loans on time, interest on loans given to yam farmers, timeliness of release of loans, farm size and other factors influencing loan repayment by yam farmers in the Sene district. The study also made use of secondary data obtained from the internet, academic journals, Libraries etc. Data was analysed using version 3.1 of the computer based Econometric Views software (E-Views).

### **Analytical framework**

Frequency and percentages were used to describe the socioeconomic characteristics of respondents while the probit regression model was used to analyze the factors influencing loan repayment performance by yam farmers. The yam farmer's ability to pay for his/her loan at the right time is dichotomized, involving two mutually exclusive alternatives. The yam farmer is either able to pay for his/her loan at the right time or not. Models for estimating such phenomena in which the dependent variable is binary have been propounded (Madala, 2005; Asante et al., 2011). The framework for such analysis has its root in the threshold theory of decision making in which a reaction occurs

only after the strength of a stimulus increases beyond the individual's reaction threshold (Hill and Kau, 1981). This implies that every individual when faced with a choice has a reaction threshold influenced by several factors (Asante et al., 2011). This yields a binary dependent variable,  $y_i$  which takes on the values of zero (yam farmer's inability to pay for his/her loan) and one (a yam farmer's ability to pay for his/her loan). The probability of observing a value of one is:

$$P_r(y_i = \frac{1}{x_i\beta_i}) = 1 - F(-x_i\beta_i) \quad (1)$$

where  $F$  is a cumulative distribution function. It is a continuous, strictly increasing function that takes a real value and returns a value which ranges from 0 to 1. Then, it follows that the probability of observing a value of zero is:

$$P_r(y_i = \frac{0}{x_i\beta_i}) = F(-x_i\beta_i) \quad (2)$$

Given such a specification, we determine the parameters for estimating this model using the maximum likelihood estimation approach. The dependent variable is an unobserved latent variable that is linearly related to  $y_i$  by the equation:

$$y_i = \beta_i x_i + u_i \quad (3)$$

Where  $u_i$  is a random disturbance term. The observed dependent variable is determined by whether  $y_i$  exceeds a threshold value or otherwise:

$$y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \quad (4)$$

where  $y_i^*$  is the threshold value for  $y_i$  and is assumed to be normally distributed. Common models for estimating such parameters include probit (standard normal), logit (logistic) and tobit (extreme value) (Madala, 2005; Asante et al, 2011).

**The Model**

The study adopted the probit model partly because of its ability to constrain the utility value of the ability to pay for loans variable to lie within 0 and 1, and its ability to resolve the problem of heteroscedasticity. The other advantages of the probit model include believable error term distribution as well as realistic probabilities. Following from Madala (2005) and Asante et al (2011), the probit model adopted for the study is specified as:

$$P_i = P(y_i^* < y_i) \\ P_i = P(y_i^* < \beta_0 + \beta_i x_{ji}) = F(y_i) \quad (5)$$

$$P_i = F(y_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z_i} e^{-\frac{s^2}{2}} ds$$

where  $P_i$  is the probability that an individual will make a certain choice (ability to pay for loans collected or otherwise);  $s$  is a random variable normally distributed with mean zero and unit variance;  $y_i$  is the dependent variable (ability to pay for loans collected or otherwise);  $y_i^*$  is the threshold value of the dependent variable. To obtain an estimate of the index  $Z_p$ , the inverse of the cumulative normal function is used:

$$y_i = F^{-1}(P_i) = \beta_0 + \beta_i x_i + u_i \quad (6)$$

The parameters  $\beta_0, \beta_1, \beta_2, \beta_3, \dots, \beta_n$  of the probit model do not provide direct information about the effect of the changes in the explanatory variables on the probability of a yam farmer being able to pay his loan alone. The relative effect of each explanatory variable on the likelihood that a farmer will be able to repay his or her loan (marginal effect) is given by:

$$\frac{\partial P_i}{\partial x_{ij}} = \beta_{ij} f(Z_i) \quad (7)$$

Where  $P_i$  is the mean dependent variable whose value is given in the probit results as:

$$f(Z_i) = F^{-1}(P_i) \quad (8)$$

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_k X_k \quad (9)$$

$f(Z_i)$  = Density function of the standard normal variable and is given by:

$$f(Z_i) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}Z_i^2} \quad (10)$$

The empirical model is specified as:

$$ATP_i = \beta_0 + \beta_1 AML + \beta_2 FAE + \beta_3 EDU + \beta_4 FSZ + \beta_5 TIME + \beta_6 ACOFI + \beta_7 NSPV + \beta_8 PGF + \beta_9 MAR + \beta_{10} AGE + \beta_{11} SEX + \beta_{12} HOS + u \quad (11)$$

Where

ATP = Whether or not farmer was able to pay his loan (measured as a dummy, 1 for able to pay and 0 for not able to pay for his loan). This is the dependent variable.

AML = Amount of loan obtained by farmers (Gh¢)

FAE = Years of yam farming experience (years).

Borrowers who have been in business for a long time are expected to be more successful with their farming activities because they have more stable sales than those who just started. Thus experience farmers may have higher repayment rates.

EDU = Level of education (measured in years of schooling). Higher educational levels enable borrowers to comprehend more complex information, keep business records, conduct basic cash flow analysis and generally speaking, make the right business decisions. Hence borrowers with higher levels of education may have higher repayment rates.

HOS = Household size (measured in number of members of farm family). There is a possibility of loans diverted to unintended purposes because of many responsibilities resulting from meeting the needs of many members of the family. Hence borrowers with large family sizes may have lower repayment rates.

FSZ = Farm size (measured in acres). Some borrowers may use a higher percentage of the loan in clearing an unreasonably large land area and at the end they suffer getting money to meet the other cultural practices. This results in low yield and hence farmers with large farm sizes may have lower repayment rates.

ACOFI = Access to off farm income (measured as a dummy, 1 for access to off-farm income and 0 for no access to off-farm income). Borrowers with other sources of income may make loan repayment from the proceeds of those jobs. Thus farmers with other sources of income may have higher repayment rates.

TIME = Timeliness of release of loan (measured as a dummy, 1 for loans released at the right time and 0 for loans not released at the right time). Farming activities in the study area is mostly seasonal and rain fed, hence if the loan is not released at the right time yield will be affected and repayment rate may be low.

NSPV = Number of supervisory visits by credit officers (measured in number of days within the production period). Visits by loan officials to borrowers will motivate the farmers to work harder and make sure the loans given to them are not diverted to unintended purposes. Therefore borrowers who are visited frequently may have higher repayment rates.

PGF = Profit gained from loan (Gh¢). Since profits are additions to principals, borrowers who are able to make substantial profits are expected to have

higher repayment rates.

MAR = Marital status (measured as a dummy, 1 for married and 0 for single). Borrowers who are married may use their loans in meeting the needs of their families; hence borrowers who are single may have higher repayment rates.

AGE = Age of yam farmer (measured in years). It is argued that older borrowers are wiser and more responsible than younger borrowers. On the other hand younger borrowers are argued to be more knowledgeable and more independent. Hence age might have a positive or negative effect on loan repayment rates.

SEX = Gender (measured as a dummy, 1 for male and 0 for female). Females are normally hypothesized to be very discipline when it comes to loans management. Therefore females may have higher repayment rates.

$u_i$  = Error term (which is assumed to have zero mean and constant variance).

## Results and discussions

### Descriptive Analysis

#### Gender distribution of yam farmers

Table 1 below shows the percentage distribution of male and female yam farmers in the Sene District of Ghana. The results show that 93% of the sampled yam farmers in the Sene District are males and 7% are females. The results show that more men are involved in yam farming in the District than women. It also shows that only few females in the district take yam farming as their business and a source of employment.

Sex	Frequency	Percentage (%)
Male	93	93
Female	7	7
Total	100	100

Source: Field Survey data 2012

Table 1: Gender distribution of yam farmers.

The result is in line with those of Ojiako and Ogbukwa (2012) who studied the economic analysis of loan repayment capacity of smallholder cooperative farmers in Yewa North Local Government Area of Ogun State, Nigeria who found out that the ratio of respondents who were men was 91.8% and that of women was 8.2%.

#### Age distribution of yam farmers

According to table 2 below, the results of the study

shows that only few of the yam farmers in the study area (2%) are at most 20 years. This means that only few teenagers are into yam production in the district. Table 2 also indicates that 48% of the farmers are between the ages of 21 and 40. Farmers in this age group constitute the very energetic youth and are likely to work effectively to increase their yields. Table 2 also shows that 43% of the yam farmers in the district are between the ages of 41 and 60. In addition 7% of the farmers are at least 60 years old. The results suggest a promising future for yam production in the Sene district. This compares well with the results of Ojiako and Ogbukwa (2012), who reveals the average age of farmers to be 44.8 years. Also Acquah and Addo (2011) reveals that fishermen in Cape Coast of Ghana have a mean age of 43.04 years with majority of them (40.3%) in the age range of 41-50 years, 22.4% in the age range of 19-30 years and 7.5% in the range of 61-70 years. This result contradicts the growing evidence of ageing farming population in most parts of rural Nigeria as reported by Akpan (2010).

Age Group	Frequency	Percentage (%)
≤ 20	2	2
21-40	48	48
41-60	43	43
≥60	7	7
Total	100	100

Source: Field Survey data 2012

Table 2: Age distribution of yam farmers.

### Educational level of yam farmers

Table 3 summarizes the educational status of yam farmers in the Sene District. The results show that 42% of yam farmers in the Sene District are illiterates. Such farmers did not receive formal education and are likely to have inadequate knowledge of loan acquisition and management, thereby making them unable to repay the loans given to them.

Educational level	Frequency	Percentage (%)
Primary	23	23
JSS/JHS	21	21
SSS/SHS	10	10
Tertiary/Post Secondary	4	4
Illiterate	42	42
Total	100	100

Source: Field Survey data 2012

Table 3: Educational distribution of yam farmers.

23% of yam farmers in the Sene District ended

in the primary school while 21% of them were educated up to the Junior Secondary School (JSS) level. Some yam farmers in the District (10%) had Senior Secondary School (SSS) education while very few of them (4%) got to the Tertiary level. This is in line with the results of Acquah and Addo (2011). They found that fishermen in the Cape Coast Metropolis have on the average 5.79 years of formal education; with majority (43.3%) having obtained basic education. 20.9% of the fishermen have junior high school education, while only 4.5% of them have senior secondary school education. However, 31.3% have no formal education.

### Marital status of yam farmers

Table 4 shows that only a few of the yam farmers in the Sene District (9%) are not married and the remaining (91%) are married. This results show that most of the farmers in the district are married and these married farmers are likely to spend much of their income on their families. Since married farmers are likely to have a larger family size, they will have higher expenses than single farmers. Therefore single farmers are likely to have better repayment ability than married farmers.

Marital Status	Frequency	Percentage (%)
Single	9	9
Married	91	91
Total	100	100

Source: Field Survey data 2012

Table 4: Marital status of yam farmers.

### Family size of yam farmers

The results show that 25% of the yam farmers in the Sene District have a family size of one to five while 66% of them have a family size of six to ten. This shows that a greater percentage of the farmers have large family sizes and this could likely raise their total expenses and negatively affect their loan repayment ability. Only 9% of the yam farmers in the Sene District have a family size of more than ten members (see table 5).

Family Group	Frequency	Percentage
1-5	25	25
1-10	66	66
> 10	9	9
Total	100	100

Source: Field Survey data 2012

Table 5: Family size of yam farmers.

On the other hand, the large sizes of the families could serve as a source of labour which will increase

the output of the yam farmers and hence positively affect the farmer’s ability to repay the loan. This is consistent with the results of Ojiako and Ogbukwa (2012) which showed the average household size of farmers to be 7 persons.

**Farming experience of yam farmers**

Table 6 below shows that 54% of the respondents have 1 to 10 years of experience in yam farming and 46% of them have more than ten (10) years of experience in yam farming. Therefore famers with less experience in yam farming are more than those with high level of experience in the Sene District of Ghana. The low level of farming experience could negatively influence loan repayment abilities of the yam farmers in the district. This corroborates the results of Ojiako and Ogbukwa (2012) who found the average agricultural years of experience of farmers to be 9.1 years. Also Acquah and Addo (2011) revealed the distribution of average years of fishing experience to be 24.21 years, with 35.8% having from 11 to 20 years of experience, 34.3% having from 21 to 30 years of experience, 19.4% having from 31 to 40 years of experience and only 1.5% of the fishermen had from 51 to 60 years of fishing experience.

Years of Experience	Frequency	Percentage (%)
1-10	54	54
> 10	46	46
Total	100	100

Source: Field Survey data 2012

Table 6: Farming Experience of Yam Farmers.

**Yam farmers ability to repay loans**

Table 7 below presents the results of the ability of the farmers to repay for the loans they went for. The results show that 59% of the yam farmers in the Sene District were able to pay for their loans within the stipulated time. This could be attributed to positive factors like access to off farm income, high yield obtained from the farm, high profitability of loan invested, etc. 41% of the farmers were not able to pay for their loans at the right time. This may be due to the effect of some negative factors like large family size, time schedule for repayment and poor yield among others. The above result implies that the number of farmers who were able to pay for their loans is more than those who were unable to pay. This is consistent with the results of Olagunju and Adeyemo (2007) who found a high loan repayment rate of 78.02% in their investigation of the determinants of loan repayment decisions among smallholder farmers

attached to the National Agricultural Cooperative and Rural Development Bank (NACRDB) in Oyo and Ondo States of southwest Nigeria. Ojiako and Ogbukwa (2012) also found that the average amount of loan repaid by respondents was 69.0% of the amount due for payment, which was by far below the 90% repayment rate found elsewhere (Oke et al., 2007).

Response	Frequency	Percentage (%)
Yes	59	59
No	41	41
Total	100	100

Source: Field Survey data 2012

Table 7: Ability of yam farmers to repay their loans.

**Determinants of loan repayment among yam farmers**

From the results in Table 8 below, a likelihood ratio (LR) statistic of 21.78107 with a Chi-squared ( $X^2$ ) distribution at 13 degree of freedom is significant at 10% level. This means that at least one of the explanatory variables in the model has a significant effect on yam farmers ability to pay for their loans and that the explanatory variables jointly influence yam farmers’ ability to pay for their loans.

The coefficient of household size is negatively related to yam farmers’ ability to repay their loans and is highly significant at 1% level. Increasing farmers’ household size by one person decreases the likelihood of been able to repay one’s loan by 0.39%. This means that the smaller the size of the farm family, the higher the probability that yam farmers will be able to repay their loans and vice versa. This could have probably resulted from the fact that large household sizes increased the household head’s domestic responsibilities and thereby constituted leakage to the household’s income stream. As household income depleted, liability of the household increased and there would be greater tendency to divert loans meant for yam production resulting in default in loan repayment. The results corroborate those of Ugbomeh et al. (2008) who in their study of loan repayment performance among women self-help groups in Bayelsa State, Nigeria, found that household size impacted negatively on loan repayment performance of women farmers. They attributed the outcome to the likelihood of women with large household members to divert some of the borrowed fund to unintended purposes for the upkeep of their households. Moreover, Oladeebo and Oladeebo (2008) stated that family size has a negative influence on the loan repayment ability. Also Ojiako

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-1.760431	1.918304	-0.917702	0.3588
EDU	0.032534	0.120171***	0.270734	0.0066
FAE	0.004342	0.060146***	0.072195	0.0004
FSZ	0.026662	0.083961	0.317553	0.7508
SEX	-0.463365	1.056406*	-0.438624	0.0609
PGF	1.767525	0.495848***	3.564653	0.0004
AGE	0.069565	0.431602*	0.161179	0.072
HOS	-0.0099	0.105497***	0.093838	0.0002
NSPV	0.625628	0.542161**	-1.153953	0.0485
TIME	0.259276	0.520608	0.498025	0.6185
MAR	-1.373726	0.905465***	1.51715	0.0092
AML	-6.82E-05	0.000315	-0.216269	0.8288
ACOFI	1.249051	1.047271***	1.192672	0.003
LR statistic (13 df)	21.78107	McFadden R-squared	0.160898	
Probability(LR stat)	0.058848			
Obs with Dep=0	41			
Obs with Dep=1	59			

Note: (\*\*\*) Indicates significance at the 1% level. (\*\*) Indicates significance at the 5% level. (\*) indicates significance at the 10% level  
 Source: Field Survey data 2012

Table 8: Probit estimates of factors influencing loan repayment by yam farmers.

and Ogbukwa (2012) shows comparable results that the negative sign of household size implied that repayment capacity decreased with an increase in household size. On the other hand, Afolabi (2008) found a positive relationship between family size and loan repayment and attributed it to theyamfarmers'extensiveutilizationoffamilylabour in the farming activities. The effect of household size on loan repayment is therefore ambiguous. The effect depends on the management of the household.

Profit gain from loan and the years of farming experience are both highly significant at 1% level and are positively related to yam farmers' ability to repay their loans. An increase in the profit gained from the use of the loan by one Ghana cedi will increase the likelihood of been able to repay one's loan by 70.35%. Similarly, increasing yam farming experience by one more year increases the likelihood of a farmer been able to repay his/her loan by 0.17%. This means that the likelihood of the farmer been able to pay for his/her loan will increase when these variables (profit gain from loan and the years of farming experience) increase and vice versa. This confirms the findings of Oladeebo and Oladeebo (2008) in their study of determinants of loan repayment among small-holder farmers in Ogbomosho agricultural zone of Oyo state,

Nigeria. They found a significant positive relationship between loan repayment abilities and profit as well as farming experience. The implication is that farming experience could probably lead to proper utilization of agricultural loans and inputs and this could have a positive effect on the magnitude of farm profit and consequently loan repayment ability would be enhanced.

In addition, access to off farm income is very significant at 1%. Table 9 shows that yam farmers who have access to off farm income are 49.7% more likely to be able to repay their loans than yam farmers who depend solely on their farm income. This variable has a positive coefficient which means that if a farmer has access to off farm income, he or she has a greater probability of been able to repay his or her loan. This is in line with the results of Ojiako and Ogbukwa (2012) who found that the correlation between respondents' engagement in other jobs and their ability to repay their loans were positive and highly significant. The implication is that as the farmer engages in other income generating activities, he/she will not divert loans meant for farming activities to unintended purposes since those activities would be taken care of by off farm income. Also, Mashatola and Darroch (2003) analyzed the factors affecting the loan status and repayment scheme of sugarcane

farmers who received graduated mortgage loan in Kwazulu-Natal, South Africa. Results identified farm size, access to off-farm income, and average annual gross turnover relative to loan size as criteria in selecting potential farmers for such scheme as they provided additional liquidity to fund future operations and debt repayment.

Table 8 also shows that educational level and marital status are highly significant at 1%. While educational level is positively related to yam farmers' ability to repay their loans, marriage is negatively related. Increasing yam farmers' educational level by one year has the effect of increasing the likelihood of a yam farmer being able to repay his/her loan by 1.29%. In the same way, married yam farmers are 54.67% less likely to be able to repay their loans than single yam farmers. This implies that a farmer will likely have greater loan repayment ability when he or she has a higher educational level and vice versa while single farmers will probably have greater loan repayment ability than married farmers. This also confirms the results of Ojiako and Ogbukwa (2012) in which level of education and marital status had equally significant positive and negative correlations respectively. Also, empirical work by Arene (1993) reveals a positive relationship between loan repayment abilities of farmers and age of farmers, farming experience and level of education of farmers. Eze and Ibekwe (2007) examined the determinants of loan repayment under the indigenous financial system in Southeast Nigeria. Empirical results from multiple regression analysis revealed amount of loan received, age of beneficiary, household size, and years of formal education and occupation as important predictors of loan repayment under the system. Finally, Chirwa (1997) also reports a negative relationship between farmers' loan repayment abilities and marital status. The results aforementioned might be due to the fact that single farmers have fewer responsibilities than married farmers.

Furthermore, the number of supervisory visits is positively related to yam farmers' ability to repay their loans and is significant at 5% level. Increasing the number of supervisory visits by one day increases the probability of a yam farmer being able to repay his/her loan by 24.9%. This means that the more credit officers visit farmers to supervise how loan is used, the better farmers' repayment abilities and vice versa. This will motivate the farmers to work harder and there will be less likelihood of farmers diverting the loans to unintended purposes. Okorie (1986) also examined the major determinants

of agricultural smallholder loan repayment in Ondo State, Nigeria. Results identified the nature and timeliness of loan disbursement, the number of supervisory visits by credit officers, profitability of the enterprise on which the loan funds were invested as significant factors that stimulate loan repayment.

Gender has a negative coefficient and it is significant at 10% level. Table 9 shows that male yam farmers are 18.4% less likely to be able to repay their loans than female yam farmers. This means that females are more likely to be able to repay their loans better than males. This might be due to the saying that females are more discipline than males and will make sure production resources given to them are used for their intended purposes. The results confirm those of Ojiako and Ogbukwa (2012). Finally, age is also highly significant at 10% and has a positive coefficient. Addition of one more year to a yam farmers' age has the effect of increasing the likelihood of him/her being able to repay his/her loan by 2.77%. It means that older farmers have better loan repayment abilities than young farmers. This could be due to the many years of yam farming experience that these older yam farmers have. Ojiako and Ogbukwa (2012) had similar results.

Variable	Coefficient	Marginal Effects
C	-1.760431	
EDU	0.032534	0.0129485
FAE	0.004342	0.001728
FSZ	0.026662	0.010611
SEX	-0.463365	-0.18442
PGF	1.767525	0.70347
AGE	0.069565	0.027687
HOS	-0.0099	-0.0039402
NSPV	0.625628	0.248999
TIME	0.259276	0.1031918
MAR	-1.373726	-0.546744
AML	-6.82E-05	-0.000027
ACOFI	1.249051	0.4971222
$Z=-0.04591436, f(Z)= 0.398$		

Source: Field Survey data 2012

Table 9: Probit estimates of factors influencing loan repayment by yam farmers.

## Conclusion

The results of the study show that 42% of yam farmers in the Sene district are illiterates and fall within the ages of 21 to 60 (91%). More males (93%) are involved in yam farming than females

(7%) and most of the farmers are married (91%). Also most of the yam farmers in the district have a family size of 6-10 households (66%) and 54% of them have 1-10 years of yam farming experience. The study reveals that 41% of yam farmers in the Sene district were not able to repay their loans. Also, the results show that educational level, number of years of farming experience, profit gained from loan, Age of farmer, supervisory visits to farmers and access to off-farm income have positive effects on yam farmers' ability to repay the loans given to them by financial institutions. A rise in each of these factors will therefore enhance yam farmers' loan repayment abilities. On the other hand, gender and marriage have negative effects on yam farmers' loan repayment abilities. The effect of household size was however found to be ambiguous. The aforementioned factors are therefore critical in improving loan repayment by farmers in the Sene district of the Brong-Ahafo Region.

Based on the results obtained in this study, it is recommended that credit institutions or lending agencies should look out for the factors that significantly influence loan repayment before granting loans to yam farmers to reduce

the incidence of loan defaults. Routine visits by credit officers to farmers will help put farmers on track and monitor the proper use of the loan they acquire. The study also recommends that all farmers should be educated on the importance of having other sources of income apart from their farm so that they can use the loans they acquire for farming activities only. This will help them to have a better output and hence a better repayment capacity. Again, farmers in the Sene district should be encouraged to further their education, practice factors that encourage a higher repayment rate and reduce the factors that prevent them from being able to pay for their loans.

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