Czech University of Life Sciences Prague
Faculty of Economics and Management

agris on-line

Papers in Economics and Informatics

http://online.agris.cz

ISSN 1804-1930
VIII, 2016, 3

International scientific journal
Prague

Agris on-line Papers of Economics and Informatics

The international reviewed scientific journal issued by the Faculty of Economics and Management of the Czech University of Life Sciences Prague.

The journal publishes original scientific contributions from the area of economics and informatics with focus on agriculture and rural development.

Editorial office

AGRIS on-line Papers in Economics and Informatics
Department of Economics of FEM CULS Prague
Kamýcká 129, 165 21 Praha 6 – Suchdol
Czech Republic
Phone: +420 224 382 050, 056
E-mail: agrisonline(at)pef.czu.cz

Publisher

Faculty of Economics and Management
Czech University of Life Sciences Prague
Kamýcká 129, 165 21 Praha 6 – Suchdol
Czech Republic
Reg. number: 60460709

ISSN 1804-1930

VIII, 2016, 3
30th of September 2016
Prague

Agris on-line
Papers in Economics and Informatics

ISSN 1804-1930

VIII, 2016, 3

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Content:

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

"Feed Assist"- An Expert System on Balanced Feeding for Dairy Animals

U. B. Angadi[1], S. Anandan[2], N. K. S. Gowda[2], D. Rajendran[2], L. Devi[2], A.V. Elangovan[2], S. Jash[2]

[1] Centre for Agriculture Bioinformatics, Indian Agricultural Statistics Institute, Pusa, New Delhi, India

[2] National Institute of Animal Nutrition and Physiology, Adugodi, Bangalore, Karnataka, India

Abstract

Inadequate feeding is the major factor for low livestock productivity in India. In dairying, feed cost is a major input and feeding practices has to be improved to ensure profits. Still the small scale farmers are following traditional feeding practices and fail to address the complexities involved in ration formulation. To address the complexities in ration balancing based on the nutrient requirements for different categories of livestock, nutrient composition of wide range of feed resources and the cost - a number of expert systems have been developed. However existing expert systems have not been widely used by majority of small farmers due to lack of awareness, access and basic skills required to operate. To address these limitations, "Feed Assist" a farmer friendly expert system for balanced feeding of dairy animals at least cost has been developed using linear programming. "Feed Assist" does not require much expertise to operate and enables the farmers to formulate least cost rations for different categories of livestock using locally available feed resources.

Keywords

Feed formulation, Least cost, Optimization, Balance feeding, Expert system, Mobile apps.

Angadi, U. B., Anandan, S., Gowda, N. K. S., Rajendran, D., Devi, L., Elangovan, A. V. and Jash, S. (2016) ""Feed Assist"- An Expert System on Balanced Feeding for Dairy Animals", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 3-12. ISSN 1804-1930, DOI 10.7160/aol.2016.080301.

Introduction

Livestock sector is an important sub-sector of the agriculture of Indian economy and contributes to 4% of the National Gross Domestic Product (GDP) and 25% of agricultural GDP. Distribution of livestock is more even than land in India where small, marginal and landless farmers account for 88% of the livestock ownership and produce most of the milk. Feeding practices for dairy animals in India are mostly traditional relying heavily on crop residues and byproducts mainly bran, pulse husk and oilcakes produced locally (Badve, 1991) and are more often opportunistic considering the availability and cost. Field surveys to assess the adequacy of traditional feeding practices in dairy cattle and buffaloes followed by farmers have revealed that most of the feeding practices across the different locations in India are imbalanced characterized by under or overfeeding of energy and protein (Mudgal et al., 2003, Singh et al., 2002). Shortage of feeds and fodder apart from imbalanced feeding is one of the major constraints for improving the dairy production (Garg, 2012). Cost of feeding is the single most important factor affecting the profitability of a dairy enterprise as feeding cost accounts for more than 70% of total cost of milk production (Garg, 2012).

Considering the economic importance of feeding and the complexities involved in the precise formulation of diets for the critical nutrients for various categories of livestock least cost formulation packages using linear programming (O'Coner et al., 1989; Munford, 1996; Duangdaw et al., 2009; Chakeredza et al., 2008) and fuzzy logic (SalooKolayi et al., 2011) has been in vogue abroad since very long. However, the same has not been adopted by the dairy sector in India as dairy sector is unorganized and still evolving from subsistence to commercial scale. Dairy sector in India is characterized by large number of low producing animals, variations in the genetic potential, feed resources, body sizes, livestock holdings and farmers resources/capacity to adopt improved practices. Added to the variation in the feed resources, variation in the body weights and production potential of animals across the different regions makes the ration balancing

much more complex to the small and marginal livestock farmers who produce the bulk of milk in the country. A number of ration balancing tools like WinFeed (http://www.winfeed.com) and FeedSoft (www.feedsoft.com) etc. have been developed overseas that are either paid or free (trial versions) capable of formulating feeds for a wide range of species and range of nutrients targeted at professionals who have good knowledge of nutrition and soft skills. These software's have not been adopted widely by the small scale farmers in rural areas or the commercial farms in peri-urban India due to lack of awareness, knowledge and soft skills. Majority of the dairy farmers continue to manage the feeding following traditional way and very few of them use the services of professional. Even the software programs developed in India like - Make feed Dairy (www.clfmaofInida.org) and ration balancing program by NDDB exclusively for dairy sector has not been widely adopted by small scale farmers although they have been customized to suit Indian production systems and are reported to reduce the feed costs by 19-23% (Goswami, 2013) and increase in net income by 15-25% per animal in 11500 animals tested across seven locations (Garg, 2012). Some of the major limitations of these tools are that these were designed mainly for feed formulation by skilled and semiskilled people mainly from feed industry and practicing professionals with basic knowhow and skill sets to operate the tools and were never designed for small scale farmers with limited capacity and skill sets. Given the fact that the number of skilled people with the necessary expertise in least cost formulations are very limited relative to the number of end users and the fact that many of the farmers are not aware, lack access to professionals/tools and cannot afford to pay for the services resulting in poor adoption of least cost formulation tool. Further the animal husbandry departments and extension staff who have greater access to the large number of farmers give greater emphasis on health issues allocating larger resources and manpower to health coverage neglecting feeding aspects. Ration balancing program by NDDB addresses this limitation to a limited extent by identifying a livestock resource person dedicated for this program where in the services on ration balancing are provided on a continuous basis by the dairy co-operative societies (www.nddb.coop). However limited coverage in selected areas of dairy cooperatives and continued dependency on the skilled staff are some of the major limitations.

Expert system helps to overcome the problems related to the difficulties in working out the least cost formulations using a wide range of feed resources available with the farmers for the various categories of livestock leading to balanced feeding, cost reduction and profit maximization to a heterogeneous group of farmers and thus overcome the limitations inherent with the subject matter experts operating at the field. Expert system is a powerful tool that provides improved and sophisticated media for educating and transfer of technology to farmers and extension workers. It provides advisory services to the farmers according to their needs with available resources in a timely, easy, cost effective way without any dissemination loss. This leads to increased livestock and farm productivity, improved livelihood of farming community, reaching a larger section of farmers and encourages the farmers to improve his knowledge and awareness in farm management besides making him to become e-literate.

Considering the above facts, "Feed Assist" an expert systems has been developed to address these limitations. Feed assist - a farmer friendly ration formulation tool was specially developed in a multilingual mode ensuring that small scale farmers with limited knowledge and skill sets across different regions will be able to use this tool and interpret the results without any specialized training or assistance.

Materials and methods

The expert system computes balanced least cost rations for various categories of dairy animals as per the nutrient requirements of cattle and buffalo (ICAR, 2013b) using a choice of the feed resources available with the farmer. This system has been developed using MS-Access as back-end tool and Visual BASIC as front-end tool. The software is integrated with mobile apps for its wider use as mobile usage is much more common than the personal computers. The end user-farmer chooses the feed ingredients from the master list and provides the details of the animal with respect to the parameters like, body weight, average daily growth rate and milk yield. The expert system processes the data and provides a balanced diet at least cost utilizing the available feed resources in terms of the actual quantities of different feed resources that needs to be fed. The output is provided in a tabular and graphical display, showing the proportion

in terms of quantity and cost of the formulated diet for easy comprehension.

The expert system has three major components- databases, programming and the output solution.

1. Databases and data processing

The expert system has two sets of databases – nutrient composition of feeds and fodders, and the nutrient requirements of different categories of livestock.

Nutrient composition of feed stuffs in database cover a wide range of feed resources available in different regions of India and the composition of feed stuffs have been sourced from a wide range of published literature (ICAR, 2013a). Parameters for the composition include the dry matter, proximate principles and cost of the ingredient. Costs of ingredients have been included based on the prevailing rates for the traded commodities and for other resources that are not traded, costs have been provided based on the estimated values. Provision has also been made to include the concentrate mixtures as commercial dairy farmers and livestock owners under the cooperative sector invariably use concentrate mixtures in dairy rations. As the costs are dynamic changing with seasons, quality and locations the user can always use the actual value in the database to arrive at the realistic costs of the formulated diets,

Nutrient requirement of different categories of cattle and buffaloes have been sourced from nutrient requirements recommended by ICAR (2013b) while the range of body weights, average daily gains and milk production has been sourced from published literature from Indian studies and the basic animal husbandry statistics, (BAHS, 2013).

The data sets were subjected to data processing that included standardizing of the collected data, compiling to non-redundant data set and fitting of standard formula to calculate feed requirements and ration formulations as per end-user specified parameters in terms of the feed resource and animal category. A database has been developed with various tables in MS-Access and integrated those based on RDBMS concept (Figure 1). The data has been uploaded into the database.

2. Programming

A VISUAL BASIC program has been written to compute balanced least cost ration for dairy animals based on the nutrient requirements of selected category of the animal considering the list of feed resources defined by the end user. A multi-lingual user and farmer friendly graphical user interface (GUI) module (Figure 2) has been developed for providing the details of the animal with respect to the categories and parameters like body weight, average daily growth rate and milk yield by user, and the option to select feed ingredients available with the user from the master list. Based on selection of feed resources, animal category and other parameters like growth rate, maintenance and milk production, the system provides information on nutrient requirement in terms of DM, CP and TDN for maintenance, growth, reproduction and production. The program has facility to add, delete and modify feed master database with new resources or change the price and composition of the existing ones to account for the changes in the season, demand supply, composition due to processing or introduction of newer feed stuffs. Provision has been made for end-user to change ratio of feed components in terms of concentrate:roughage and the proportion of dry to green fodder based on availability and price due to seasonal variations. User can also set the constraints for fitting maximum and minimum level of inclusion of a particular feed resource or/and category of animal.

The least cost optimization program is developed based on Linear Programming Problem (LPP) for optimizing feed diet/ration at least cost. This is a mathematical algorithm to find the least-cost feeds that satisfy the nutritional requirements. Linear programming (LP) is a mathematical method for determining a way to achieve maximum profit or lowest cost based on list of requirements represented as linear relationships. The mathematical model developed by Leonid Kantorovich and George Dantzig during World War II to plan expenditures and returns in order to reduce costs to the army and increase losses to the enemy.

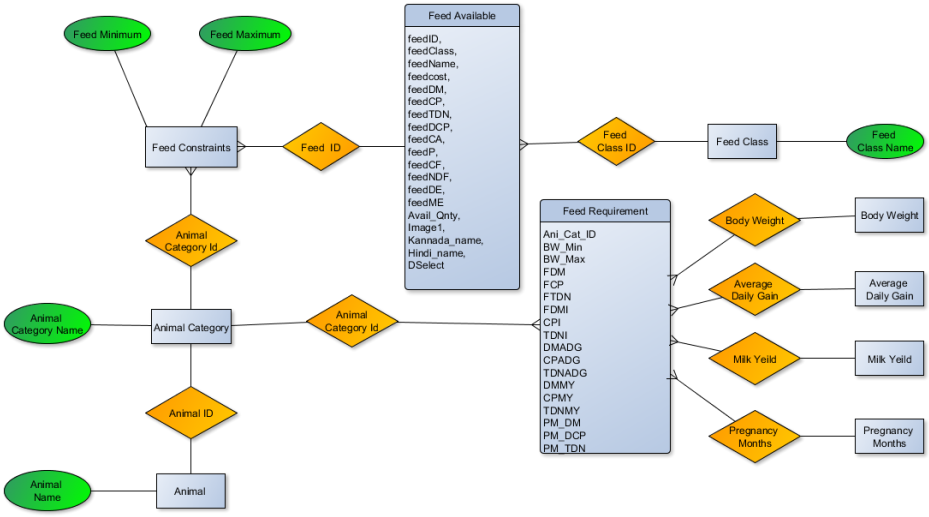
The standard form of linear programming is as follows.

Object function

$$\text{Minimise} \sum_{j=1}^{n} c_j x_j \rightarrow (j = 1, 2, 3, \ldots n)$$

Subject to constrains

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad \sum_{j=1}^{n} a_{ij} x_j \geq b_i$$



Source: own processing

Figure 1: Entity Relationship Diagram of Feed Assist.

Let c_j is cost per unit of j^{th} feed, x_j is quantity of j^{th} feed , a_{ij} is quantity of i^{th} nutrient per quantity of j^{th} feed, b_i is requirement (maximum/minimum) of i^{th} nutrient from the diet.

Based on this concept, many researcher have demonstrated application of the LP in least cost ration formulation for dairy animal and poultry. Tozer (2000) has illustrated LP as Least-cost ration formulation for Holstein dairy heifers, Bassam (2009) for Broiler and Olorunfemi (2007) for Poults. Chakeredza (2008) and team has explained ration formulation using MS Excel. Here, we have described implementation of the least cost ration formulation tool for personal computer and mobile apps.

3. Solution output

After providing inputs of the animal details and defining the feed ingredients, user proceeds to formulate balanced ration by clicking on formulation icon that gives the desired output with details of selected ingredients with their quantities, cost and dry matter proportion of each ingredient and finally the total cost and its breakup of the diet (Figure 2).

4. Steps for formulation

a) Selection of animal category - species (cattle, buffalo) and category (heifer, dry, pregnant, milch etc.,) and production parameters like body weight (or body measurements – length and girth), growth rate, milk yield etc.,

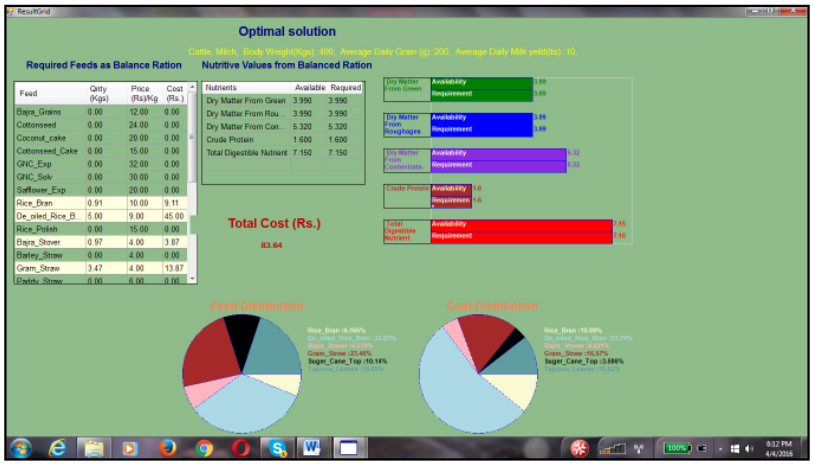
b) Selection of feed recourses available from the master list from the categories of concentrates, green roughages and dry roughages. Feed resources are categorized under three major categories – crop residues, greens and concentrates and the farmers have to select the feed resources available with him under each category.

c) Click on Formulation to obtain the least cost formulated ration. If the solution is not feasible with the specified parameters the system would prompt the same and the user is advised to modify the selection in feed resources selection by trial and error till he gets a feasible solution.

Farmer can obtain solution by clicking FORMULATION icon and the solution will display as Final Result form. The Final Result form (Figure 3) depicts the information on the category of the animals selected with the production parameters, list of user selected feeds, program selected feed resources their quantities and cost, total cost of diet, nutrient requirements as per the details of selected animal and nutrient available from the formulated balanced diet in terms of dry matter from green, dry roughage and concentrate, crude protein and total digestible nutrients. The output is presented in tabular and graphical form for quick comprehension and easy analysis of nutrients available against requirements. Graphical depiction about the proportion of cost and feed quantity in diet is provided by pie diagram to allow the end user to understand the cost breakup of the total diet. The program has provision to store the output solution and retrieving for feature use.

Source: own processing

Figure 2: Main Form of Feed Assist.



Source: own processing

Figure 3: Main Form of Feed Assist.

Source: own processing

Figure 4: Screen shots of mobile apps.

Results and discussion

In this section, a brief discussion has been made on the features of the software and how it differs from other least cost formulation packages/expert system already available in the market. Most of the least cost formulations require expertise to operate and farmers have to always depend on the professional help in accessing this services. Majority of these are developed for commercial use by feed industries to formulate compound feeds. Looking into the reasons for low adoption of the least cost formulations in dairy sector in spite of the fact that a number of studies using balanced diets have shown to improve the productivity and profitability of small scale dairy farmers (Garg, 2012), feed assist has been specifically designed to bridge this gap and allow the small scale farmers to take advantage of the powerful tool. Unlike other tools this expert system has been designed primarily for farmers use by simplifying the features- minimizing the steps involved and simplification of the features considering the major nutrients aided by the touch screen graphical user interface features using icons, pictures and graphs to ensure that any farmer with little practical knowledge on feeding with minimum literacy level will be able to operate this system independently. A balance has been struck between the ease of use and the features of the system restricting the important elements of feeding considering only cost, dry matter, protein and energy without considering fiber, minerals, protein quality, fats etc.

The expert system provides a powerful tool to the farmers in resolving the complexities involved in ration formulations as per the parameters defined by the farmers to suit his requirements without any help from the professionals. Thus this expert system empowers the farmers to operate themselves and understand the practical advantages of the benefits of least cost formulations without any assistance from external agents. This also provides an opportunity for the farmers to understand and appreciate the nitty gritty of ration formulation and try and test different combinations to suit his conditions without relying on the service providers who are difficult to access. The system can be installed on a personal computer, touch screen kiosk or as mobile application and ensure wider coverage of farmers across the different regions. As per the recent estimates, the number of mobile users in India is around 930 million covering 75% of the total population and fastest growth is being seen in rural subscribers (http://www.trai.gov.in/WriteReadData/WhatsNew/Documents/PR-TSD-Sep-14.pdf).

The operations are simple and initially a small demonstration to a group of farmers is required and the trained farmers in turn can assist the other farmers in access and using the system. Periodical follow up by the extension staff in the initial stages is required till the farmers get familiarized with the tool and once they understand, they can continue to use the system on their own and modify their diets with changes in the feed resources and individually optimize the diet to different categories of the animals with the available resources. The main features of the expert system which has been made user friendly are;

- **Data maintenance** – Has provision for addition of new feed resources, deletion and modification of feed master table with nutrient compositions and price of feeds. The changes are very easy to incorporate- by simply double clicking feeds list box, Feed Master Form would open and user can incorporate the desired changes in the feeds master table. Thus the features of software ensures that the data used in the least cost formulations are based on actuals and is dynamic to capture the changes relevant to the farmers situations.

- **User friendly** – The program is very easy to use with no need of special training and assistance to operate the system. Any individual with minimum skills and literacy capable of operating the mobile or bank Automated Teller Machines (ATM) can handle this expert system. Touch screen user interface feature similar to the ATM operation makes it easier to operate in providing the inputs and -- formulating least cost rations for various categories of animals in three simple steps- specifying the animal parameters, identifying the available feed resources and interpreting the solution provided.
- **Multi-lingual** - Has provision to be used with many languages, presently it is in three languages (Kannada, Hindi and English) and can be extended to other languages, input and output part is common and can be translated in other languages to cater different states/regions.
- **Storing and retrieval** – user can save the solution and retrieve the saved solutions
- **Display and printing** - Provides results in tabular, graphical form - bar chart and pie charts, which gives an instant overview of the solution and the formulated diet with its components. Has facility for printing and downloading.

- **Dual versions** - Basic and advanced. Basic version is designed for farmers where the body weight calculation can be carried out based on the heart girth and length of the animal and few of the components are set to default values and some edit features are locked given the fact that farmers do not have the required skills to alter/edit and make the solution practical and feasible. Advanced version is for professionals where the scope of changing/editing most of the data like nutrient requirements, changes in upper and lower limit for specific resources, changes in proportion of roughage to concentrate etc., is possible
- **System requirements**

  Computer configurations requirement: Hardware; Pentium Dual Core and above with 1GB RAM, OS; windows XP and above with .net 2.3 and above.
- **Mobile apps on Android 5.1.1 version** (Figure 4).

The expert system "Feed Assist" can play an effective role in scientific feeding and in improving livestock production of small/ marginal and landless livestock farmers as this is user friendly and can be used by the farmers themselves with minimum demonstration without any help from the expert. Feed assist expert system utilizes the available information on nutritive value of feeds and fodders and the nutrient requirement for various categories of livestock based on the Indian studies and match these two data sets to provide optimum solution to formulate the diets considering the nutrients, cost and the parameters specified by the farmer customized to his situations. Under field conditions formulating a balanced diet with the available resources is one of the major challenges as the farmer, field extension staff or vet is most of the times unaware or has limited knowledge of requirement for different categories and nutrient content of common feeds. The feed assist can be useful tool in taking care of this limitation wherein a variety of diets can be balanced at minimum costs using a combination of feed resources that are locally and readily available with the farmer for all categories of livestock. This can also help in decision making in terms of the feed ingredients to be purchased from a range of ingredients available locally and priced differently.

Presently feeding system in India for dairy is mostly traditional or conventional relying mainly on the crop residues and by products as dairy is very closely integrated into crop livestock system. With commercialization and emerging of dairying as an economic enterprise with greater reliance on purchased feed inputs, feeding for optimum returns is catching up and gaining significance. The expert system feed assist can play an important role in regulating feed costs and/or improving feed utilization through empowering the small holder farmers and improve their livelihoods and incomes through profitable dairying. This tool can help in achieving improving efficiency through balanced diets avoiding underfeeding or overfeeding either of which leads to loss of productivity and profits. The tool will also help the farmer in making the right decision regarding the type and quantity of feed ingredients to be purchased based on the least cost solution and maximize the use of his farm produced by products leading to economic balanced diets. Additionally this tool could also be useful for feed industries, researchers and extension staff in feed formulations for economic feasibility studies, extension and advisory services.

As an illustration least cost formulations using the feed assist expert system for various categories of animals is presented in Table 1. Different feed resources representative of different regions in India has been used in the illustration. The table contains information regarding nutrients requirement of different categories, description of animal parameters,, range of feed resources available with the farmers and the optimal solution of suggested feeds with nutritive values and total cost of the balanced feed.

The software has been already demonstrated at various fora involving the farmers, state extension agencies and dairy cooperative staff and the feedback received from this forums indicate that most of the times the prevailing feeding practices in dairy animals are imbalanced. The solution offered by the expert system when adopted can lead to balanced feeding with cost reduction. Currently the software is being pilot tested at village level dairy cooperative society of Karnataka Milk Federation center in association with the NGOs and the findings of the testing would guide us to further refine the existing features of the expert system to make it more robust and upscale it to cover larger number of dairy farmers.

Animal details	Nutrient required DM, CP, TDN (kg)	Feeds selected and price per Kgs	Suggested Feed, Quantity with price and total cost				Nutrients from feeds-DM, CP, TDN
Animal - Cattle, **Category** - Heifer, **Body weight** - 200, **ADG** - 250, **Milk yield** - 0, **Pregnant months** - 0	DM -5.25, CP -0.51, TDN -2.62	Cottonseed_Cake:15.00, De_oiled_ Rice_Bran:9.00,Maize_Grains:14.00, Rice_Bran:10,Hybrid_Napier:2.00, Bajra_Fodder:2.00,Maize-Fodder:2.00, Paddy_Straw:6.00, Gram_Straw:4.00		**Quantity**	**Price**	**Cost**	DM-5.25 CP-0.51, TDN-2.90
			De_oiled_Rice_Bran	2.38	9.00	21.43	
			Gram Straw	2.33	4.00	9.33	
			Napier	4.20	2.00	8.40	
			Total cost			39.16	
Animal - Cattle, **Category** - Dry, **Body weight** - 400, **ADG** - 200, **Milk yield** - 0, **Pregnant months** - 0	DM -8.20, CP -0.64, TDN -3.85	Cottonseed_Cake:15.00, De_oiled_Rice_ Bran:9.00, Hybrid_Napier:2.00, Sugarcane tops:2.00, Paddy_Straw:6.00, Gram_Straw:4.00		**Quantity**	**Price**	**Cost**	DM-8.20, CP-0.72, TDN-4.28
			De_oiled_Rice_Bran	3.64	9.00	32.80	
			Gram Straw	3.64	4.00	14.58	
			Sugarcane tops	1.82	2.00	3.64	
			Total cost			51.02	
Animal - Cattle, **Category** - Milch, **Body weight** - 450, **ADG** - 200, **Milk yield** - 5, **Pregnant months** - 0	DM -11.75, CP -1.17, TDN -5.81	Jowar_Grains:15.00, Cottonseed_ Cake:15.00, Mustard_Cake_Solv:14.00, Gram_Husk:10.00, Wheat_Bran:15.00, Wheat_Straw:4.00, Lucern:3.00, Hybrid_ Napier:2.00		**Quantity**	**Price**	**Cost**	DM-11.75, CP-1.18, TDN-6.49
			Mustard_Cake_Solv	1.79	14.00	25.11	
			Gram_Husk	3.39	10.00	33.89	
			Wheat_Straw	5.22	4.00	20.89	
			Hybrid_Napier	9.40	2.00	18.80	
			Total cost			98.70	
Animal - Cattle, **Category** - Milch, **Body weight** -500, **ADG** - 0, **Milk yield - 10, Pregnant months** - 0	DM -15.10, CP -1.55 TDN -7.23	Wheat_Straw:4.00, Cottonseed_Cake:15.00 Mustard_Cake_Solv:14.00, Wheat_ Bran:15.00, De_oiled_Rice_Bran:9.00, Jowar_Grains:15.00, Lucern:3.00, Hybrid_ Napier:2.00		**Quantity**	**Price**	**Cost**	DM-15.10 CP-1.72, TDN-8.39
			Mustard_Cake_Solv	1.67	14.00	23.43	
			De_oiled_Rice_Bran	5.00	9.00	45.00	
			Wheat_Straw	6.71	4.00	26.84	
			Hybrid_Napier	12.08	2.00	24.24	
			Total cost			119.44	
Animal - Cattle, **Category** - Pregnant, Milch, **Body weight** - 500, **ADG** - 0, **Milk yield** - 10, **Pregnant months** - 7-8	DM -16.09, CP -2.29 TDN -7.45	Jowar_Grains:15.00, , GNC_Solv:30.00, Sunfflower_Exp:20.00, , Gram_Husk:10.00, De_oiled_Rice_Bran:9.00, , Wheat_ Bran:15.00, Jowar_Stover:4.00, Gram_ Straw:4.00, Ragi_Straw:5.00,, Lucern:3.00,, Para_Grass:2.00, Soybean_Meal_Solv:30.00		**Quantity**	**Price**	**Cost**	DM-16.10, CP-2.29, TDN-9.42
			Soybean_Meal_Solv	2.08	30.00	62.42	
			Rice_Bran	0.07	10.00	0.71	
			De_oiled_Rice_Bran	5.00	9.00	45.00	
			Ragi_Straw	5.36	5.00	26.82	
			Para_Grass	19.31	2.00	38.62	
			Total cost			173.33	

Note: All feed quantities in kg on as such basis, price in INR
Source: own processing

Table 1: Illustration of the feed assist formulated balanced diets for various categories of animals with different resources.

Conclusion

This expert system is specifically designed for use by small scale farmers with limited skill sets and involves simple operations that are greatly facilitated by touch screen interface features. The input variables with regard to the animal parameters and feed resources are chosen by farmer to suit his production situations. A fine balance has been achieved between the simplicity of the system and the essential features of the balanced diet to ensure its wider adoption. It facilitates the farmers in enhancing their knowledge on feeding of different categories of dairy animals in a profitable manner using the available local resources without relying on the skilled professionals. The format of the output from the system is easy to understand and ensures that farmers make use of their feed resources to the maximum extent and the animals are fed optimally to support milk production in a profitable way increasing the overall livestock productivity, income and livelihood of the farmers. Current feeding practices followed in dairy are mostly traditional and there is ample scope to improve productivity and profitability through proper ration balancing and the Feed Assist - expert system would be a powerful decision making tool on feeding practices for every dairy farmer specially the small holders who have limited access to information on improved feeding practices or the services of extension staff. Optimization module of the expert system can be used for formulating concentrate mixtures or total mixed rations with minimum cost and maximum utilization of nutrients based on an objective function and a set of constraints/restrictions. The tool can be used on mobile as an Android application and given the wider usage of mobiles in rural India the chances of adoption and the benefits

from the adoption of this tool are likely to be high among the rural small holder producers who constitute the major share of the dairy sector in India.

Corresponding author:
Ulavappa B. Angadi
Centre for Agriculture Bioinformatics, Indian Agricultural Statistics Institute, Pusa, New Delhi, India
Cell-phone: 91-9868807174, E-mail: angadiub@gmail.com, angadiub@iasri.res.in

References

[1] Badve, V. C. (1991) "Feeding Systems and Problems in The Indo-Ganges Plain: Case Study", Proceedings Feeding dairy cows in the tropics of the FAO Expert Consultation held in Bangkok, Thailand. [Online]. Available: http://www.fao.org/docrep/003/t0413e/T0413E16.htm#ch16 [Accessed: 23 May 2016]. ISBN 92-5-103029-4.

[2] BAHS (2013) "Basic Animal Husbandry statistics 2013-14", Directorate of dairy, animal husbandry and fisheries, Ministry of Agriculture, Government of India. AHS SERIES-15. [Online] Available: http://dahd.nic.in/sites/default/files/Final%20BAHS%202014%2011.03.2015%20%202.pdf [Accessed:24 January 2016].

[3] Bassam A (2009) "Least-Cost Broiler Ration Formulation Using Linear Programming Technique", *Journal of Animal and Veterinary Advances*,Vol. 8, No. 7, pp. 1274-1278. ISSN 1680-5593.

[4] Garg, M. R. and Makkar, H. P. S (2012) "Balanced feeding for improving livestock productivity – Increase in milk production and nutrient use efficiency and decrease in methane emission", FAO Animal Production and Health Paper No. 173. Rome, Italy. [Online] Available: http://www.fao.org/docrep/016/i3014e/i3014e00.pdf. [Accessed 04 January 2016]. ISBN 978-92-5-107303-2.

[5] Goswami, S. N., Chaturvedi, A., Chatterji, S., Patil, N. G., Sen, T. K., Hajare T. N., and Gawande R. S. (2013) "Least cost diet plan of cows for small dairy farmers of Central India", *African Journal of Agricultural Research*, Vol. 8, No. 47, pp. 5989-5995. [Online]. Available: http://www.academicjournals.org/journal/AJAR/article-full-text-pdf/ADCEC6B42102. ISSN 1991-637X.

[6] Chakeredza S., Akinnifesi, F. K. ,Ajayi, O. C. and Gondwe, F. M. T. (2008) "A simple method of formulating least-cost diets for smallholder dairy production in sub-Saharan Africa", *African Journal of Biotechnology,* Vol. 7, No. 16, pp. 2925-2933. ISSN 1684-5315.

[7] Chakeredza, S., Akinnifegi, F. K., Ajayi, O. C., Sileshi, G., Mngoba, S. and Gondwe, M. T. (2008) "A simple method for formulating least cost diet for small holder dairy production in Sub-Saharan Africa", *African Journal of Biotechnology*, Vol. 7, No. 16, pp. 2925-2933. [Online] Available: http://www.academicjournals.org/journal/AJB/article-full-text-pdf/58E27208526 [Accessed: January 2, 2016]. ISSN 1684-5315.

[8] ICAR (2013a) "Nutrient composition of Indian Feeds and Fodders", Indian council of Agricultural Research, Krishi Bhavan, New Delhi.India. ISBN 978-81-7164-145-1.

[9] ICAR (2013b) "Nutrient Requirements of Cattle and Buffaloes", Indian council of Agricultural Research, Krishi Bhavan, New Delhi.India. ISBN 978-81-7164-145-2

[10] Mudgal,V., Mehta, M. K., Rane, A.S. and Nanavati,S. (2003) "A survey on feeding practices and nutritional status of dairy animals in Madhya Pradesh", *Indian Journal of Animal Nutrition*, Vol. 20, No. 2, pp. 217-220. [Online] Available: http://www.indianjournals.com/ijor.aspx?target=ijor:ijan&volume=20&issue=2&article=016 [Accessed: January 02, 2016]. ISSN 0970-3209.

[11] Munford, A. G. (1996) "The use of iterative linear programming in practical applications of animal diet formulation", *Mathematics and Computers in Simulation*, Vol. 42, No 2, pp. 255-261. ISSN 0378-4754. DOI 10.1016/0378-4754(95)00115-8.

[12] O'Coner, J., Sniffen, C. J., Fox, D.G. and Miligan, R. A. (1989) "Least cost dairy cattle ration formulation model based on the degradable protein system", *Journal Dairy Science*, Vol. 72, No.10, pp. 2733-2745. [On-line] Available: http://www.journalofdairyscience.org/article/S0022-0302%2889%2979417-0/pdf. [Accessed: January 25, 2016]. ISSN 0022-0302.

[13] Olorunfemi Temitope, O. S., (2007) "Linear Programming Approach to Least-cost Ration Formulation for Poults", *Information Technology Journal*, Vol. 6, pp. 294-299. E-ISSN 1812-5646, ISSN 1812-5638. DOI 10.3923/itj.2007.294.299.

[14] SalooKolayi, D. D., Yansari, A.T. and Nasseri, S. H. (2011) "Application of Fuzzy Optimization in Diet Formulation", *The Journal of Mathematics and Computer Science*, Vol. 2, No. 3, pp. 459-468. [Online] Available http://www.isr-publications.com/jmcs/127/download-application-of-fuzzy-optimization-in-diet-formulation. [Accessed: January 04, 2016]. ISSN 2008-949x.

[15] Singh, D., Yadav, A.S. and Yadav, R. K. (2002) "Feeding practices of lactating buffaloes in Mohindergarh district of Haryana", *Indian Journal of Animal Nutrition*, Vol. 19, pp. 153-155. ISSN 0970-3209.

[16] Sirisatien, D., Wood, G. R., Dong, M. and Morel, P. C. H. (2009) "Two aspects of optimal diet determination for pig production: efficiency of solution and incorporation of cost variation", J*ournal of Global Optimization*, Vol. 43, No. 2, pp. 249-261. ISSN 0925-5001. DOI 10.1007/s10898-007-9262-x

[17] Tozer, P. R. (2000) "Least-cost ration formulations for Holstein dairy heifers by using linear and stochastic programming", *Journal of Dairy Science*, Vol. 83, No. 3, pp. 443-51. E-ISSN 1525-3198 , ISSN 0022-0302. DOI 10.3168/jds.S0022-0302(00)74901-0.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Smallholder Maize Farmers' Food Consumption Expenditures in Ghana: The Mediating Role of Commercialization

S. B. Asante[1], Y. B. Osei-Asare[2], J. K. M. Kuwornu[3]

[1] International Food Policy Research Institute, Airport Residential Area, Accra, Ghana

[2] Department of Agricultural Economics and Agribusiness, University of Ghana, Legon, Ghana

[3] Agribusiness Management, School of Environment, Resources and Development, Asian Institute of Technology, Pathum Thani, Thailand.

Abstract

This paper examines the effect of smallholder maize farmers' commercialization on their household food consumption expenditures in Ghana using data from the Ghana Living Standard Survey Round Five (GLSS5). The results indicate that the intensity of smallholder maize commercialization is generally low and that better output price, quantity of maize produced, farm size, type of market or point of sale, access to mobile phone network coverage, proportion of crops given to landlord, instant payment for maize sold, are inter alia key incentive variables that influence the intensity of maize commercialization. The study also revealed that intensity of maize commercialization positively influenced food consumption expenditures. Increases in the sale of maize results in increases in purchases of food items needed to address household food security needs. These findings demonstrate the urgent need to strengthen smallholder market integration initiatives, encourage market information delivery systems, and establish more retail outlets with improved market facilities in order to promote production and trade in high value cereals such as maize in Ghana.

Keywords

Commercialization, smallholder maize farmers, consumption, food expenditures, households.

Asante, S. B., Osei-Asare, Y. B. and Kuwornu, J. K. M. (2016) "Smallholder maize farmers' food consumption expenditures in Ghana: The mediating role of commercialization", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 13 - 27. ISSN 1804-1930, DOI 10.7160/aol.2016.080302.

Introduction

Agricultural commercialization refers to the process of increasing the proportion of agricultural production that is sold by farmers in markets (Pradhan et al., 2010). However, commercialization of agriculture can take different forms by either occurring on the input side with increased use of purchased inputs from the markets or the output side of production with increased market surplus (Leavy and Poulton, 2007). Smallholder commercialization also typically leads to an increased diversity of marketed commodities at national level and increased specialization at regional and farm levels (Pingali and Rosegrant, 1995; Timmer, 1997). The demand for modern technologies promotes the input side of production and facilitates the development and advancement of technological innovations. In turn, the use of modern technologies can result in higher productivity with lots of produce offered for sale in the markets.

The basis of smallholder commercialisation as a development strategy involves the participation in markets by farmers which provides increased incomes that are able to maximize the returns to land and labour through market opportunities, using earned income for household food consumption in ways that are efficient than subsistence production (Timmer, 1997). It is commonly argued that productivity growth in African agriculture will require a transformation out of the subsistence level, low-input use, and low-productivity.

Commercializing smallholder agriculture is an essential pathway towards economic growth and development for most developing countries relying on the agricultural sector (Von Braun 1994; Pingali and Rosegrant, 1995; Timmer, 1997). However, it is observed that smallholder farmers are often risk averse and are reluctant to venture into commercialization that presents financial risks with potential adverse effects on household food

security. Rogers (1995) notes that subsistence and semi-commercial farmers find it difficult to entirely shift to commercial agriculture. In view of the above, several examples abound to show that smallholder farmers are very slow in shifting to commercialization within farming systems and land tenure systems constraints that negatively impacts on commercial agriculture and food security (Wiggins et al., 2011). This explains why commercialization by farmers is not high enough to enable them benefit from increased income, savings and investment in productive assets (IFAD-IFPRI, 2011; Mahelet, 2007). Therefore, in the long-run, subsistence agriculture has been identified not to be a viable activity to ensure sustainable household welfare and food security (Pingali, 1997).

High variability in market prices of farm products and farm inputs cause significant risks to household income. Lack of efficient marketing institutions and rural infrastructure and access to credit prohibits smallholder farmers from assuming such risks. These factors influence commercialization by affecting conditions of commodity demand and supply, input and output prices, and the transaction costs faced by farmers, traders, and other members in the food marketing channels.

Due to lack of adequate storage facilities and pressing needs for cash to spend on other household items, households end up in many cases selling excess produce during the harvesting period, and mostly rely on market purchases during the months before harvest. According to Okoboi (2008), low income households must also be able to purchase available foods in the market. Farm households with inadequate access to productive resources such as land, inputs and capital, required for attaining physical efficiency in food production could be food insecure, i.e., resource poverty could lead to low productivity, food insufficiency, and lack of income to purchase the needed food items for the household. The pattern of consumption is also affected, as consumers are likely to consume more protein in addition to grains.

In developing countries such as Ghana, greater share of income of people is spent on food (Banerjee and Duflo, 2007). The welfare gains from market -oriented production arise from specialization in certain crops such as maize that builds on and creates comparative advantage, potential for large-scale production, and from dynamic technological, organizational and institutional change effects that arise through the flow of ideas due to interactions, training and experiments (Romer, 1994). According to Mhango (2010), household spending constitutes the largest source of spending in the Ghanaian economy. Changes in food intake patterns have been associated with a change towards crop production, which often results in diminished nutritional quality in diets. The development of the maize sector in Ghana is integrated with other high value agro enterprises in a manner to have positive effects on incomes, food security and poverty reduction. Maize is cultivated in most parts of Ghana with leading producers found in the transitional and forest zones. Maize production is highly characterized by smallholder farms with fewer large farms. The intensity of maize commercialization by the farmers would influence their ability to purchase other commodities required by the households. The specific research questions are; what is the intensity of maize commercialization in Ghana? What are the factors influencing the intensity of maize commercialization in Ghana? How has the intensity of maize commercialization affected food consumption expenditures of farm households in Ghana?

This current paper examined the mediating role of commercialization on smallholder maize farmers' food consumption expenditures. The objectives of the study were threefold:

i. Estimate the intensity of maize commercialization in Ghana.

ii. Determine the factors influencing the intensity of maize commercialization in Ghana.

iii. Estimate the effect of the intensity of maize commercialization on food consumption expenditures of maize farming households in Ghana.

Materials and methods

Study area and data

Ghana is one of the countries located in the West African sub-region and covers an area of 238,540 square kilometers with a tropical humid climate. The southern part of the country has a double rainfall pattern (May-June and September -October) whereas the north has a single rainy season (June-August). The dry season occurs from January to March. Agriculture in Ghana largely follows the country's ecological and climatic patterns across the ten regions (Western, Central, Greater Accra,

Volta, Eastern, Ashanti, Brong-Ahafo, Northern, Upper East, and Upper West).

The Ghana Living Standard Survey Round Five (GLSS5) developed by the Ghana Statistical Service (GSS) was the main data set used for this study. The GLSS5 involved national and regional representative household survey that was undertaken by Ghana Statistical Service (GSS) over a one year period from 2005 to 2006. The data was employed due to its extensive coverage. The GLSS5 is the fifth comprehensive household survey implemented by GSS since 1987; such surveys generally aim at providing data concerning household welfare. The average price of food items within the study period was obtained from the GSS since the survey did not capture the prices of food items. The survey covered household demographics, education, health, employment, migration and tourism, housing, agriculture, non-farm enterprises, consumption and expenditure, income, credit, assets and savings with a sample size of 8,687 households in 580 enumeration areas containing 37,128 household members. Out of the 8,687 households, 5,559 households owned and/or operated a farm or kept livestock or were engaged in fishing. From the 5,559 households engaged in agriculture, 1,670 households were involved in maize production and harvested within the period. The 1,670 maize producing households were further grouped into smallholder and large scale farmers based on the land size, from which 1,205 households who fall under smallholder farmers were used for the analysis of this study.

Intensity commercialization of maize

This study assesses the commercialization of smallholder production from the output side. This was achieved by employing the household commercialization index (HCI) to determine household specific intensity of commercialization (Von Braun, 1994; Strasberg et al., 1999, Martey et al., 2012). The index as specified in equation (1) measures the ratio of the value of crop sales by household to the value of all crops produced by the same household expressed as a percentage:

$$HCI = \frac{Value\ of\ crops\ sold}{Value\ of\ crops\ produced} \times 100\% \qquad (1)$$

The index measures the extent to which household crop production is oriented toward the market. A value of zero would signify a subsistence oriented household and the closer the index is to 100, the higher the degree of commercialization. Since HCI depends on the output Y, and assuming that farmers consume a fixed amount (C) of crops produced, then:

$$HCI = \frac{Y - C}{Y} \times 100\% \qquad (2)$$

This assumption is realistic since farmers' consumption of a particular food crop cannot increase indefinitely with increasing production, for instance, if a farmer or a household consumes an amount equal to C, then any excess above C will be sold. The household commercialization index was calculated for maize. The calculated commercialization index was then used to categorize the farm households. Following Abera (2009) and for the purpose of the study, the degree of commercialization is grouped into four: zero (none of the output sold), low (1 to 25% of output sold), medium (26% to 50% of output sold) and high (> 50% of output sold). Consequently, a one way Analysis of Variance (ANOVA) test was performed to compare the index outcomes among households at varying degrees of commercialization.

Factors influencing the intensity of commercialization

The Tobit regression model was employed for this analysis since data generated about household commercialization index was in proportions. The dependent variable in this case has an upper limit of one in all cases and a lower limit of zero. The rationale for this is to match farmers' decision to fit the Tobit model which cannot take dependent variables greater than one or a negative and target policy interventions at farmer levels appropriately. According to Sindi (2008), it is assumed that both the decision to commercialize and the degree of commercialization are influenced by the same variables that increase the probability of commercialization and also increase the intensity of commercialization. The Tobit or censored normal regression model assumes that the observed dependent variables Y*i* for observations *i* =1,…, n must satisfy:

$$Y_i = \max(Y_i^*, 0) \qquad (3)$$

Where Y_i^* represents the latent variable generated by the classical linear regression model. The Tobit model used to estimate the factors that influence the intensity of commercialization is specified as follows:

$$Y^* = \beta_i X_i + e_i, \quad Y_i = \begin{cases} Y_i^* \text{ if } Y_i^* > 0 \\ 0 \text{ if } Y_i^* \le 0 \end{cases} \quad e_i = N(0, \sigma^2) \qquad (4)$$

Where X_i is a vector of exogenous explanatory variables, β_i represents the estimated maximum likelihood parameters; e_i represents the captured random influence on the relationship which is assumed to be normally distributed with mean zero and variance . Observation of zeros on the dependent variable could mean either a ''true'' 0 or censored data or y would always equal y and the model will be linear regression and not Tobit. The Tobit model does not correspond directly to changes brought about by changes in the independent parameters but rather the direction of the effect. The marginal effect of the changes in an explanatory variable on the intensity of maize commercialization is given as follows (Greene, 2003):

$$\frac{\partial E\left[Y_i / X_i\right]}{\partial X_i} = \beta\phi\left[\frac{\beta' X_i}{\sigma}\right] \quad (5)$$

From the above, the empirical Tobit model estimated for the factors likely to affect the intensity of commercialization for maize is given as:

$$\begin{aligned} Y_{maize} &= \beta_0 + \beta_1 GEN + \beta_2 AGEH + \beta_3 AGESQ + \beta_4 MARST \\ &+ \beta_5 HHSIZ + \beta_6 AVFOD + \beta_7 EDUH + \beta_8 OCCU + \beta_9 FMEXP \\ &+ \beta_{10} AFON + \beta_{11} LOC + \beta_{12} FMS + \beta_{13} LANT + \beta_{14} QTYP \\ &+ \beta_{15} QTYS + \beta_{16} SMKT + \beta_{17} SFGB + \beta_{18} SHSE + \beta_{19} TPAY \\ &+ \beta_{20} NFMI + \beta_{21} PCRL + \beta_{22} SAV + \beta_{23} TCIN + \beta_{24} UPM \\ &+ \beta_{25} RMIT + \beta_{26} FORZO + \beta_{27} SAZO + e \end{aligned} \quad (6)$$

Description of variables

The descriptions of variables in equation (6) are presented in Table 1.

Effect of the intensity of commercialization on food consumption expenditures

The food expenditure is the product of the food demand and the price of food as shown in equation (7). The food consumption expenditure (F_{cexp}) is a function of the price of food, all other prices, income, tastes and preferences. For cross-section data, it is reasonable to assume that all prices are stable within the time period under consideration (Meng, et al., 2012). In this respect, the expenditure on food is only determined by the consumer's income level (I), and tastes and preferences (T).

$$F_{c\exp} = P_f * F = P_f * f(P_f, P_m, I, T) = H(I, T \mid P_f P_m) \quad (7)$$

In empirical analysis, the interest is on real consumption across all farm households and the market prices which are used to aggregate the value of consumption of different goods in the consumption basket (Eskola, 2005). The total food consumption expenditure is a direct function of real quantities of goods consumed at their market prices with a chosen intensity of commercialization, i.e. the choice of optimal resource allocation into agricultural production, wage employment, and allocation of income into different markets and home produced goods (Eskola, 2005). The function is defined in equation (8) as:

$$F_{c\exp} = f(P_i^m, C_i, HCI_m) \quad (8)$$

Where F_{cexp} is the total food consumption expenditure by farm household, P_i^m denotes the market price of the good i (food items), C_i denotes the quantity of goods consumed by farm household, HCI_m denotes a measure of maize commercialization intensity by each household.

Following Baber and Shahnawaz (2010), Safdar, Ahmad and Sher (2012) and Meng, et al., (2012), the data was logarithmically transformed to examine the effect of the intensity of commercialization and other socio-economic factors on food consumption expenditures in Ghana. Baber and Shahnawaz (2010) indicated that the logarithmic function provides estimates that generate more realistic elasticities. The slope parameter is a direct measure of elasticity. Therefore, in estimating this functional form using the OLS, data for F_{cexp} and X were transformed into the logarithmic form. This is specified in equation (9) as:

$$InF_{c\exp} = \beta_0 + \beta_i InX_i + ... + \beta_n InX_n + e \quad (9)$$

Where F_{cexp} denotes the dependent variable (the total food consumption expenditure); X_i to X_n denote a vector of explanatory variables comprising the maize commercialization index (HCI_{maize}), farm size, demographic variables including the age, gender, family size, average price of food items (cereals and bread, meat, fish, oils and fats, fruits, vegetables, pulse and nuts, roots and tubers, others including dairy products) as shown in Tables 1 and 2; β_i denotes a vector of coefficients and e denotes the error term. The robust Huber/White estimator was used to obtain robust standard errors.

Variables	Description	Measurement	Expected sign
Maize comercialization index (Y_{maize})	Proportion of the value of maize sold to total maize produced	Ratio	
GEN	Gender of the household head	Dummy; 1 if male; 0 = otherwise	+/-
AGEH	Age of household head	Number of years	+/-
AGESQ	Age squared	Number of years	-
MARST	Marital status	Dummy; 1 if married; 0 = otherwise	+/-
HHSIZ	Household size	Number	-
AVFOD	Availability of food items	Dummy; 1 if No , 0 = otherwise	-
EDUH	Number of years of formal education	Number of years	+
OCCU	Main Occupation of respondent	Dummy; 1 if agriculture, 0 = otherwise	+
FMEXP	Number of years of Experience in Farming	Number of years	+
AFON	Access to mobile phone network	Dummy; 1 if yes, 0 = otherwise	+
LOC	Location of household	Dummy; 1 urban; 0 = otherwise	+
FMS	Size of the farm	Hectares	+
LANT	Status of land ownership	Dummy; 1 if owned; 0 = otherwise	+/-
QTYP	Total output of maize produced for the year	Kilogram	+
QTYS	Total output of maize produced used as seed	Kilogram	-
SMKT	Sale of maize by farmer in the market	Dummy; 1 if yes, 0 = otherwise	+
SFGB	Sale of maize to farm gate buyer	Dummy; 1 if yes, 0 = otherwise	+
SHSE	Sale of maize in the house of farmer	Dummy; 1 if yes, 0 = otherwise	+
TPAY	Time of payment if maize is sold	Dummy; 1 if instant payment, 0 = otherwise	+
NFMI	Proportion of non-farm annual income in total annual household income	Ratio	+/-
PCRL	Proportion of crop given to landlord	Percentage	-
SAV	Savings account or susu	Dummy; 1 if yes, 0 = otherwise	+
TCIN	Total Cost of input use	Ghana cedi (GHS)	-
UPM	Average price at which each unit of output is sold	Ghana cedi (GHS)	+
RMIT	Income from remittances	Ghana cedi (GHS)	+
FORZO	Forest zone	Dummy; 1 if Forest zone, 0 = otherwise	+/-
SAZO	Savannah zone	Dummy; 1 if Savannah zone, 0 = otherwise	+/-

Source: own processing

Table 1: Description of dependent and explanatory variables.

Variable	Description (GHS)	Food Item
Fexp	Average annual food expenditure	
Pcb	Average price of cereals and bread	Guinea corn/sorghum, Maize, Millet, Rice –Local, Rice –Imported, Bread –sugar bread, Biscuits, Flour (wheat), Maize ground/corn dough
Pmeat	Average price of meat	Corned beef, Pork, Beef, Goat meat, Mutton Bush meat/wild game, Chicken
Pfish	Average price of fish	Fish (fresh), Fish (dried), Fish (smoked), Fish (canned)
Poils	Average price oils and fats	Coconut oil, Groundnut oil, Palm kernel oil, Palm oil, Shea butter, Margarine /Butter
Pfruits	Average price of fruits	Coconut, Banana, Orange/tangerine ,Pineapple
Pveg	Average price of vegetables	Cocoyam leaves (kontomire), Garden eggs, Okro, Pepper (fresh or dried), Onions (large/small), Tomatoes(fresh), Tomato puree (canned)
Pnuts	Average price of pulse and nuts	Beans, Groundnuts, Palm nuts, Cola nuts
Prtube	Average price roots and tubers	Cassava and processed forms of cassava, Cocoyam, Plantain, Yam
Pothers	Average price of others	Sugar (cube, granulated), Ice cream, Salt, Ginger, Milk (powder), Tinned milk, eggs, cooked food

Source: GSS, 2012

Table 2: Description of prices of food items.

Following Blundell and Robin (1999), the "augmented regression approach" was used to control for endogeneity of maize commercialization intensity in the model. The following steps were followed:

a. the reduced form regression was performed in which HCImaize was regressed on the endogenous variables as specified in equation (10):

$$HCI_{maize} = \alpha_0 + \beta_2 lnP_{cb} + \beta_3 lnPmeat + \beta_4 lnPfish + \beta_5 lnPoils + \beta_6 lnPfruit + \beta_7 lnPveg + \beta_8 lnPnuts + \beta_9 lnPrtube + \beta_{10} lnPother + \beta_{11} Gen + \beta_{12} lnHsize + \beta_{13} lnFrmS + \beta_{14} Loc + \beta_{15} lnEdu + e \quad (10)$$

b. the residuals were predicted from Equation (10);

c. the main Equation (11) was regressed including the predicted residuals from equation (10) as explanatory variable;

d. F-test was used to test if the residuals were significantly different from zero.

The decision rule was that if the test shows significance then this implies endogeneity issues, hence the two stage least squares involving the use of an instrumental variable can be applied. The empirical equation with the dependent variable expressed in logarithmic form is specified as follows:

$$ln(Fexp) = \alpha_0 + \beta_1 HCI + \beta_2 lnPcb + \beta_3 lnPmeat + \beta_4 lnPfish + \beta_5 lnPoils + \beta_6 lnPfruit + \beta_7 lnPveg + \beta_8 lnPnuts + \beta_9 lnPrtube + \beta_{10} lnPother + \beta_{11} Gen + \beta_{12} lnHsize + \beta_{13} lnFrmS + \beta_{14} Loc + \beta_{15} lnEdu + e \quad (11)$$

According to the economic theory of demand, the income or wealth are important variables to explain the food demand. Hopper (2011) showed the close relationship between the income of the household and the quantities of milk, cream, cheese, eggs, meat, fish, and fresh fruits and vegetables purchased. Income was found to be one of the most prominent measures of food consumption behavior (Muhammad, et al., 2011). Hence the household maize commercialization intensity was instrumented using the value of crops sold (i.e. the income obtained from maize). The proportion of maize sold is therefore expected to be positively related to the average annual food consumption expenditures.

The socio-demographic characteristics of the consumers (i.e. age, gender, marital status, education, family size) are also expected to affect the food consumption expenditures. The age and education influences the frequency of food item consumed; and the total revenue and gender affect the product form consumed by the household (Jolly, et al., 2008).

The price of food items is expected to have a negative relationship with food consumption expenditure. Socio-cultural factors affect consumers' preference, eating habits, indigenous knowledge about the method of preparation, cooking time or convenience, nutritional and medicinal values and taste (Quaye, et al., 2009). The presence of children in the households is expected to have a positive relationship with expenditure (e.g. Han and Wahl, 1998).

Results and discussion

Socio-economic characteristics of smallholder farm households

The socio-demographic characteristics of sampled respondents are presented in Table 3.

The minimum age of a household head in the sample was 18 years whiles the maximum age of a household head was 99 years. The economically active population (19 to 60 years) represents 85.90 percent while 14.1 percent are supported by the economically active (less than or equal to 18 years and greater than 60 years). The survey reveals a dependency ratio of 0.14 as compared to 82 of the GLSS5 report (GSS, 2008). The mean age is 45 years which implies that the age distributions of the sample are in the active labour force.

The result of the survey also shows that males constitute 71.2 percent while females constitute 28.8 percent of the sampled population. This indicates a sex ratio of 40 females to every 100 males which is different from 94 males to every 100 females of the GLSS5. This implies the majority of males are found in the agricultural sector as compared to females.

The level of education of sampled heads of farm households in Ghana illustrates a majority (60.25%) having basic level of education. However, 30.29 percent of household heads had no formal education as compared to 31 percent of the GLSS5 survey results (GSS, 2008). This is a worrying situation due to the fact that, education serves as a means to gain extra employment activities especially in the non-farm sector (Minot et al., 2006). The mean years

of education is 6 years indicating that, on the average the educational level attained by a household head is primary or basic.

Variable	Frequency	Percentage
Gender		
• Female	347	28.80
• Male	858	71.20
Age		
• 18 – 30	221	18.34
• 31 – 40	337	27.97
• 41 – 50	287	23.82
• 51 – 60	191	15.85
• > 60	169	14.02
Level of Education		
• None	365	30.29
• Basic	726	60.25
• Secondary	71	5.89
• Tertiary	43	3.56
Marital Status		
• Married	706	58.59
• Single	61	5.06
• Otherwise	438	36.34
Household Size		
• 1 – 3	490	40.66
• 4 – 6	534	44.32
• 7 – 9	158	13.11
• > 9	23	1.91
Location		
• Rural	943	78.26
• Urban	262	21.74
Ecological Zone		
• Coastal	279	23.15
• Forest and transition	724	60.08
• Savannah	202	16.76
Main Occupation		
• Agriculture	822	68.22
• Otherwise	383	31.78
Land Tenure Status		
• Ownership with deed	143	11.87
• Otherwise	1062	88.13
Farm Size (ha)		
• < 0.5	471	39.09
• 0.5 – 1.0	454	37.68
• > 1.0	280	23.24

Note: *Total Number of respondents (N) = 1205
Source: Authors' calculations from GLSS5, 2013

Table 3: Summary of socio-demographic variables.

The mean household size is four implying that on the average 4 persons live in a household which is consistent with the findings of the GLSS5 survey. The minimum household size ranged from a minimum of 1 person to the maximum of 14 persons per household. Majority (40.66%) of household size ranged between 1 to 3 persons per household. In addition, 56.85 percent of sampled farm households were married whiles 5.06 percent constitutes sample households who were single and 36.34 percent were neither married nor single.

Majority (78.26%) of sampled households lived in rural areas whiles 21.4 percent lived in urban areas. The majority (60.08%) of respondents can be located in the forest and transition zone whiles 23.15 percent and 16.76 percent of sampled farm households can be located in the coastal and savanna ecological zones respectively. The majority (68.22%) of the households sampled engaged in farming as their major occupation and 31.78 percent had other sources as their major occupation although they had farms they work on. The results give an indication of the importance of farming and its related activities to households, producing varying crops such cocoa, rubber, coconut, Cassava, Plantain etc. and the rearing of animals for cash and food. The results further confirm the centrality of agriculture to households in the Ghanaian economy.

The majority of sampled farm households heads have landholdings between 0.6 to 1.2 hectares representing 46.89 percent. The mean land size is 1.2 hectares with 0.1 and 1.8 hectares being the minimum and maximum land holdings respectively. Knowledge of the various land sizes operated by smallholder farmers is important since, higher farm sizes serves as incentive to produce more for the market. About 12 percent of sampled farm households owned their farm lands with deed whiles 88 percent owned their farms without deed. This implies that most households are not outright owners but have access to land for their farming activities either through rent or sharecropping.

Intensity of maize commercialization in Ghana

Analysis of the intensity of maize commercialization in Ghana was measured as a ratio of the gross value of maize sold per household to the gross value of all maize produced. From Table 4, about 41 percent of respondents do not sell any portion of their maize produced, implying that these group of smallholder maize farmers do not commercialize their produce. Out of 711 respondents who commercialize their produce, about 89 percent of them sell more than 25 percent of maize produced. Smallholder farmers with low intensity of maize commercialization

Intensity of maize commercialization	Frequency	%	Mean household size	Mean farm size (ha)
Zero (0%)	494	41.00	4.41	0.68
Low (1-25%)	76	6.30	3.87	0.74
Medium (26-50%)	196	16.30	4.03	0.70
High (51-100%)	439	36.40	4.02	0.82

Source: Authors' calculations from GLSS5, 2013

Table 4: Intensity of maize commercialization by mean household size and farm size.

Source	SS	df	MS	F	P-value
Between groups	150.637659	3	50.212552	6399.91	0.0000
Within groups	9.42282476	1201	.007845816		
Total	160.060483	1204	.132940601		

Source: Bartlett's test for equal variances: chi2(3) = 4.9e+03 Prob>chi2 = 0.000

Table 5: Analysis of Variance.

(1 to 25%) and the medium intensity (26 to 50%) have about similar mean farm size of 0.74 and 0.70 hectares respectively. This finding is attributed to the fact that although farmers are cultivating larger land sizes their yield still remains low to commercialize at a higher intensity. Low yields are compounded in the long run by production shocks from the irregular rainfall pattern due to climate change, pest and disease attack, and constraints to adoption of technology are among the factors contributing to low yields among low commercialization intensity smallholder farmers. In addition, larger household size hinders smallholder farmers' ability to commercialize their harvested maize produce.

The ANOVA test presented in Table 5 revealed that there is a statistically extreme significant differences among the commercialization groupings (zero, low, medium and high) in terms of the mean commercialization index ($p<0.0001$). This implies that the intensity group of commercialization a farmer belongs to determines the amount of income earned.

Factors influencing the intensity of maize commercialization

Tobit regression was used to estimate the factors influencing the intensity of maize commercialization in Ghana. In cross-sectional data, heteroskedasticity is a common problem; hence the robust option in Stata 12 was selected to correct the problem.

Income of smallholder farmers was dropped out of the model due to correlation problems. Due to this problem, the farm income has been segregated into the following variables: Total output of maize produced for the year, and Average price at which each unit of output is sold as indicated Tables 1 and 6. The F-value was significant at 1 percent indicating that the explanatory variables included in the Tobit model jointly influence the intensity of maize commercialization (Table 6). Intensity of maize commercialization in Ghana is significantly determined by gender, age, age squared, availability of food at the time of purchase, access to mobile phone network coverage, farm size, quantity of maize produced, farmer being a market trader, sale to farm gate buyer, sale to consumers, time of payment, proportion of crops to landlord, unit price of maize and remittances.

Gender of household head is significantly associated with a decrease in the intensity of maize commercialization. Being a male headed household is likely to decrease the intensity of maize commercialization by 4.17 percent. This result is somewhat consistent with the fact women play a major role in most Ghanaian markets as compared to men. However, this is contrary to the findings of Cunningham et al., (2008) who found that men are likely to sell more grain early when prices are still high, while women prefer to store more output for household self-sufficiency.

Intensity of maize sales is likely to decrease by 0.75 percent for every additional year added to the age of the household head. However, a positive relationship exists between the age squared and the intensity of commercialization in Ghana. This implies that there is the likelihood of older household heads to have much experience in the aspect of commercialization, since they are likely to have more contacts with trading partners than younger and upcoming smallholder farmers who are yet to establish such contacts coming at a cost to them during their search.

Non availability of food at the time of purchase significantly influences the intensity of maize commercialization negatively. A unit change in the number of food items not available at the time of purchase by the farmer is likely to decrease the intensity of maize commercialization by 4.46 percent. This connotes that smallholder farmers tend to store their harvested produce for home consumption in times when there is no available food item required for the household at the time of purchase.

The telecommunication sector plays a major role in most businesses in Ghana of which the agricultural sector is not an exception (Aker, 2010). Access to mobile phone network is likely to influence the intensity of smallholder maize commercialization positively by 3.37 percent.

Variable	Estimated Results		
	Coefficients	Robust Std Error	Marginal Effect
Gender	-0.0566**	0.0273	-0.0417
Age	-0.0104**	0.004	-0.0075
Age squared	0.0001***	0.00004	0.0001
Marital Status	0.0077	0.0243	0.0056
Household size	-0.0012	0.0049	-0.0009
Availability of food	-0.0622*	0.0345	-0.0446
Years of education of household head	0.0040	0.0026	0.0029
Main Occupation	0.0316	0.0258	0.0027
Years of Experience in Farming	-0.0006	0.001	-0.0005
Access to mobile phone network	0.0471**	0.0223	0.0337
Location	0.0160	0.0262	0.0116
Farm Size	0.0950***	0.0249	0.0687
Land tenure	-0.0133	0.032	-0.0096
Quantity of Maize Produced	0.0001**	0.00003	0.0001
Quantity of Maize used as seed	-0.0016	0.0016	0.0001
Market Trader	0.9287***	0.0507	0.6364
Sale to farm gate buyer	0.9046***	0.0580	0.7098
Sale in the house	0.8466***	0.0599	0.6798
Time of Payment	0.1240***	0.0369	0.0897
Non-farm Income	-0.0151	0.0421	-0.0109
Proportion of Crops to landlord	-0.0023***	0.0007	-0.0016
Savings	0.0085	0.0261	0.0062
Expenditure on crop inputs	0.00002	0.00002	0.0001
Unit price of maize	0.0012***	0.0002	0.0008
Remittances	0.0001*	0.00003	0.00004
Forest zone	0.0344	0.0410	0.0248
Savannah zone	0.0367	0.0352	0.0270
Constant	-0.2988	0.1069	
Number of observations		1205	
F (27, 1178)		71.70	
Prob > F		0.0000	
Pseudo R2		0.7393	
Log Pseudo likelihood		-286.401	

Note: ***p < 0.01, **p < 0.05 and *p < 0.10

Source: Authors' calculation from GLSSS, 2013

Table 6: Tobit estimates of the factors influencing the intensity of maize commercialization in Ghana.

This is attributed to the fact that farmers will be able to contact input dealers, extension agents during periods of production and their buyers through the phone during periods when their maize is ready for the market. This finding is consistent with studies by Asingwire and Okello (2011) who investigated the telecommunication role and its effects on smallholder and market performance in Africa, their results revealed that ICT usage has positive benefits to farmers and market actors with users of such services receiving higher margins than their counterparts due to reduced marketing costs. The study also revealed that, using the Coastal zone as the base zone, the Savanna and the Forest zones had no effect on the intensity of maize commercialization in Ghana.

Farm size was significant at 1 percent significance level with a positive sign as expected. Farm size indicates the possibility to produce more for the household and the market. The intensity of maize commercialization increases by 6.87 percent for every additional hectare of land used for maize production. Quantity of maize produced (kg) was also identified to possibly influence the intensity of maize commercialization positively. This result confirms similar findings by Martey et al., (2012) in Ghana and findings by Olwande and Mathegene (2010) in Kenya suggesting that households with larger farm sizes are able to produce more marketable surplus and hence sell more in the market.

Numerous studies have examined the effect of marketing cost and access to markets on the intensity of smallholder commercialization (Sadoulet and de Janvry, 1995; Key et al., 2000; Pender and Alemu, 2007; Alene et al., 2008; Barrett, 2008). However, this study identified that the intensity of maize commercialization is likely to be influenced positively by the sale of maize by farmers in the market, to farm gate buyers and in the house. According to Kirsten et al., (2012), policy measures would provide opportunities for these farmers not only to improve market orientation but also increase market access of smallholder producers. This is a key issue as success and failure of smallholder commercialization has in many instances hinged on not only the ease and/or difficulties associated with producing for the market but also with accessing markets.

The proportion of maize harvested given to landlords significantly affects the intensity of maize commercialization negatively. A unit increase in the proportion of maize harvested given to landlords is likely to decrease the intensity of maize commercialization by 0.16 percent. Households without their own land normally are likely to engage in markets in order to fully meet their financial obligations at home and to their landlords (land owners).

An instant payment for the quantity of maize purchased is likely to increase the intensity of maize commercialization by 8.97 percent. Farmers will be assured of a reliable market if maize purchased is paid for instantly. In addition, income from remittances positively increases the intensity of maize commercialization. This implies that farmers' income received from remittances are used to increase the quantity of maize produced thereby intensifying the level of commercialization.

As expected the intensity of maize commercialization is positively related to increases in the price of maize. An additional increase in the price of maize will lead to a 0.08 percent in the quantity (kg) of maize sold. Households with good maize storage facilities store their produce in order to await higher prices. This finding is consistent with findings by Martey et al., 2012; Olwande and Mathegene 2010, Omiti et al., 2009, and Alene et al., 2008 that the output price is an incentive for producers and sellers to supply more to both domestic and international markets.

Effect of intensity of maize commercialization on food consumption expenditure

Using the two stage least squares (2SLS) instrumental variable approach, the result of the effects of the intensity of maize commercialization on food consumption expenditures is presented in Table 8. The result indicates that intensity of maize commercialization positively affects the food consumption expenditures in smallholder maize producing households in Ghana. This is important since an increase in household income leads to the households' ability to address its food security needs.

The intensity of maize commercialization significantly influenced food consumption expenditures in Ghana at 1 percent significance level. This implies that a unit increase in the proportion of maize commercialized is likely to increase food consumption expenditures by 43.8 percent, ceteris paribus. This means that as smallholder maize farmers commercialize more of their produce to earn more income, there is

the likelihood of an increase in the amount spent on other food items to meet household food needs. Other factors that were likely to affect the food consumption expenditures were also considered in the analysis. These variables include the average prices of food items as described in Table 2 and socio demographic variables (gender, household size, location and the years of education of respondent).

The share of food item category expenditure in total food expenditures in Ghana is shown in Table 7, with other food items having the highest proportion of 28.10 percent. The price of cereals and bread, price of fish and the price of pulses and nuts were identified to significantly influence food consumption expenditures. For instance, price elasticity for cereals and bread (3.78) indicates that an increase in the price of cereals and bread should cause a more than proportionate decrease in the quantity demanded. Hence, total expenditure decreases.

Similarly, the price elasticity for fish (1.99) indicates that it is fairly elastic implying that an increase in the price of fish ceteris paribus, will cause a more than proportionate decrease in fish demand. Hence total expenditure is likely to decrease. However, the price elasticity for pulses and nuts (0.91) is inelastic indicating that a rise in price causes a rise in total expenditure because demand decreases less than proportionately, ceteris paribus.

Food item category	Percentage
Cereals and bread	12.4
Meat	5.6
Fish	9.3
Oils and fat	6.4
Fruits	7.4
Vegetables	17.0
Pulse and nuts	3.6
Root and tubers	10.4
Other food items	28.1

Source: Authors' calculation from GLSSS, 2013

Table 7: Share of food item category expenditure in total food expenditures.

Furthermore, other explanatory variables such as farm size, household size, urban dwelling of the household (location) and the years of education respectively had positive relationship with the food consumption expenditure. Thus, larger farm sizes, is likely to enable farm households to raise more

Variable	Coefficient	Std. Err.	t	P > t
HCI	0.438***	0.137	3.21	0.001
Ln(Pcb)	3.780**	1.506	2.51	0.012
Ln(Pmeat)	1.961	1.327	1.48	0.140
Ln(Pfish)	1.985***	0.524	3.79	0.000
Ln(Poils)	1.058	1.347	0.79	0.432
Ln(Pfruit)	-0.175	0.466	-0.38	0.707
Ln(Pveg)	-2.663	1.870	-1.42	0.155
In(Pnuts)	0.909***	0.226	4.01	0.000
Ln(Prtube)	0.598	0.751	0.80	0.426
Ln(Pother)	-0.759	1.181	-0.64	0.520
Gender	0.036	0.036	1.01	0.314
Ln(Household size)	0.375***	0.024	15.43	0.000
Ln(Farm Size)	0.041*	0.024	1.73	0.083
Location	0.267***	0.037	7.13	0.000
Ln(Educ)	0.031*	0.016	1.91	0.056
Constant	5.470	0.126	43.36	0.000
Observations		1205		
Prob.>F		0.0000		
R^2		0.2134		
Adjusted R^2		0.2035		

Note: ***p < 0.01, **p < 0.05 and *p < 0.10

Source: Authors' calculations from GLSS5, 2013

Table 8: Effect of Intensity of Maize Commercialization on Food Consumption Expenditure in Ghana.

income to expand farm production, spend on food items to address household food security issues and also invest in the non-farm income sector. Larger household sizes are likely to increase the expenditure spent on food since there will be more people to feed. In addition, large household sizes promotes the division of labour into labour and time demanding investment in both farm and non-farm sector.

Conclusion

The intensity of smallholder maize commercialization in Ghana is generally low with about 59 percent venturing into commercialization and the remaining 41 percent of these farming households being purely subsistence farmers. For those practicing commercialization, about 6 percent attained low intensity commercialization; 16 percent (medium intensity); and only about 36 percent attained high intensity of commercialization. It was found that significant differences in farm income earnings existed among the three different commercialization intensity groups. The study also revealed that intensity of maize commercialization positively influenced food consumption expenditures. Increases in the sale of maize results in increases in purchases of food items needed to address households' food security needs.

The study provides the following policy recommendations to improve farm household food consumption expenditures in Ghana.

There is the urgent need to strengthen smallholder market integration initiatives, encourage market information delivery systems, and establish more retail outlets with improved market facilities in order to promote production and trade in high value cereals such as maize in Ghana.

It is recommended that the Ministry of Food and Agriculture, NGOs such as Techno-serve Ghana and other stakeholders should strengthen the business orientation of smallholder farmers through training towards commercialization.

Farm size significantly influences the intensity of maize commercialization. It is therefore recommended that the Ministry of Food and Agriculture (MoFA) through their extension agents should identify committed farmers and facilitate their acquisition of additional farm lands and other relevant purchased inputs for increased production and commercialization.

The unit price of maize produced significantly affects commercialization and food consumption expenditures. With the existence of the National Food Buffer Stock Company (NAFCO), realistic guaranteed minimum prices of maize should be set so that farmers can at least recover their cost of production. This would serve as an incentive for farmers to commercialize. Evidence has shown that investment in infrastructure has large net returns and also reduces transaction costs for farmers. In order to promote commercial agriculture, the Ministry of Roads and Transport and the Local Government Authorities in partnership with MoFA should invest in rural infrastructure such as markets and feeder roads. This could support the establishment and/or refurbishment of quality retail outlets in farming areas and to help farmers to target off-peak seasons to take advantage of high prices.

The use of mobile phones has been a major innovation for businesses, as adapted by Esoko to disseminate markets and price information of food commodities at different locations to farmers. It is recommended that telecommunication companies (MTN, Vodafone, Tigo, Expresso, Airtel and GLO) should enhance their network service coverage to enhance or promote the flow of market information to smallholder farmers in rural areas.

Corresponding author:
John K. M. Kuwornu
Agribusiness Management, School of Environment, Resources and Development, Asian Institute of Technology, Pathum Thani 12120, Thailand
Phone: +66 624 309 104, E-mail: jkuwornu@ait.asia, jkuwornu@gmail.com

References

[1] Abera, G. (2009) "Commercialization of Smallholder Farming: Determinants and Welfare Outcomes." A cross-sectional study in Enderata District, Tigari, Ethiopia, (Unpublished master thesis), University of Agder, Kristiansand, Norway.

[2] Aker, J. C. (2010) "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger", *Applied Economics*, Vol. 2, No. 3, pp. 46–59. ISSN 1945-7782. DOI 10.1257/app.2.3.46.

[3] Alene, A. D., Manyong, V. M., Omanya, G., Mignouna, H.D., Bokanga, M. and Odhiambo, G. (2008) Smallholder market participation under transaction costs: Maize supply and fertilizer demand in Kenya, *Food Policy*, Vol. 33, pp. 318-328. ISSN 0306-9192. DOI 10.1016/j.foodpol.2007.12.001

[4] Asingwire, N. and Okello, J. J. (2011) "Challenges facing smallholder farmers' ICT-based market information service projects: The case of BROSDI and WOUGNET in Uganda", *International Journal of Economic Research*, Vol. 2, pp. 142-152. ISSN 2229-6158.

[5] Baber, A. and Shahnawaz, M. (2010) "Household Consumption Patterns in Pakistan: A Rural Urban Analysis", *Forman Journal of Economic Studies*, Vol 6, pp. 1-25. ISSN 1990-391X.

[6] Banerjee, A. V. and Duflo, E. (2007) "The Economic Lives of the Poor", *Journal of Economic Perspectives*, Vol. 21, No. 1, pp. 141–167. ISSN 0895-3309.

[7] Barrett, C. (2008) "Smallholder Market Participation: Concepts and Evidence from Eastern and Southern Africa", *Food Policy*, Vol. 33, pp. 299-317. ISSN 0306-9192. DOI 10.1016/j.foodpol.2007.10.005 · Source: RePEc.

[8] Blundell, R. and Robin, J. M. (1999) "Estimation in Large and Disaggregated Demand systems: An estimator for conditionally linear systems", *Journal of Applied Econometrics*, Vol. 14, pp. 209-232. ISSN 0883-7252. DOI: 10.1002/(SICI)1099-1255(199905/06)14:3<209::AID-JAE532>3.0.CO;2-X.

[9] Cunningham, L. T., Brorsen, B. W., Anderson, K. B. and Tostao, E. (2008) „Gender Differences in Marketing Styles", *Journal of Agricultural Economics*, Vol. 38, No. 1, pp. 1-7. ISSN 1574-0862, DOI 10.2139/ssrn.937928.

[10] Eskola E. (2005) "*Commercialization and Poverty in Tanzania: Household-Level Analysis"*, (Unpublished discussion papers), Department of Economics, University of Copenhagen [Online] Available: http://www.econ.ku.dk/english/research/publications /wp/ 2005/0527.pdf/ [Accessed: September 29, 2012].

[11] Ghana Statistical Service (GSS) (2008) "Ghana Living Standards Survey", Reports of the Fifth Round, Accra, 1-5.

[12] Greene, W. H. (2003) "*Econometric Analysis*" (fifth edition), Prentice Hall, Upper Saddle River, New Jersey. ISBN 0-13-066189-9.

[13] Han, T. and Wahl, T. I. (1998) "China's Rural Household Demand for Fruit and Vegetables". *Journal of Agricultural and Applied Economics*, Vol. 30, No. 1, pp. 141-150. ISSN 2056-7405. DOI http://dx.doi.org/10.1017/S1074070800008129.

[14] Hopper, W. C. (2011) "Income and Food Consumption", *The Canadian Journal of Economics and Political Science/ Revue canadienne de economiques et science politique*, Vol. 9, pp. 487-506. No longer published. E-ISSN 1920-7220, ISSN 0315-4890.

[15] IFAD–IFPRI Partnership Newsletter (2011) "*Agricultural Commercialization in Northern Ghana"*. [Online] Available: http//ifadifpri.word pressed.com. [Accessed: September 24, 2012].

[16] Jolly, C. M., Awuah, R. T., Fialor, S. C., Agyemang, K. O., Kagochi, J. M. and Binns, A. D. (2008) "Groundnut consumption frequency in Ghana", *International Journal of Consumer Studies*, Vol. 32, pp. 675–86. ISSN 1470-6423. DOI 10.1111/j.1470-6431.2008.00697.x.

[17] Key, N., Sadoulet, E. and de Janvry, A. (2000) "Transaction Costs and Agricultural Household Supply Response", *American Journal of Agricultural Economics*, Vol. 82, No. 2, pp. 245–259. E-ISSN 1467-8276, ISSN 0002-9092. DOI 10.1111/0002-9092.00022.

[18] Kirsten, J., Mapila, M., Okello, J. and Sourovi, D. (2012) "Managing Agricultural Commercialization for Inclusive growth in Sub-Saharan Africa". *GDN Agriculture Policy Series*, Vol. 1, pp. 1-58.

[19] Leavy, J. and Poulton, C. (2007) "Commercialization in Agriculture", *Ethiopian Journal of Economics*, Vol. 16, No. 1, pp. 3 – 42. ISSN 1993-3681.DOI 10.4314/eje.v16i1.39822.

[20] Mahelet, G. F. (2007) "*Factors Affecting Commercialization of Smallholder Farmers in Ethiopia: The case of North Omo Zone, SNNP region"*, Paper presented at the Fifth International Conference on the Ethiopian Economy, Addis Ababa, June 7-9, 2007. [Online] Available: from www.eeaecon.org/6th%20Int'l%20 Papers%20.htm [Accessed. October 20, 2012].

[21] Martey, E., Al-Hassan, R. M, and Kuwornu, J. K. M. (2012) "Commercialization of Smallholder Agriculture in Ghana: A Tobit regression Analysis", *African Journal of Agricultural Research*, Vol. 7, No. 14, pp. 2131-2141. ISSN 1991-637X.

[22] Meng, T., Florkowski, W. J., Kolavalli, S. and Ibrahim, M. (2012) "Food expenditures in rural households in Northern Region of Ghana". Selected paper prepared for presentation at the Southern Agricultural Economic Association. Annual meeting, Birmingham, AL, Feb. 4-7, 2012.

[23] Mhango, Y. (2010) "*Ghana: Annual economic outlook; The Eve of Oil Production*". Standard Bank Report. [Online] Available: http://ws9.standardbank.co.za/sbrp/Latest Research.do [Accessed: October 26, 2012] .

[24] Minot, N., Epprecht, M., Anh, T. T. T. and Trung, Q. L. (2006) "Income diversification and Poverty in the Northern uplands of Vietnam". IFPRI Research report, 145, pp. 1-111.

[25] Muhammad, A., Seale, J. L. Jr., Meade, B. and Regmi, A. (2011) "International Evidence on Food Consumption Patterns", *Technical Bulletin*, TB-1929, 59.

[26] Okoboi, G. (2008) "A Case Study of a Best-Bet Market Chain Approach: How Smallholder Potato Producers in Kabale Market Potatoes to Nandos in Kampala". Final Report, ASARECA.

[27] Olwande, J. and Mathenge, M. (2010) "Market Participation among the Poor Rural Households in Kenya", Tegemeo Institute of Agricultural Policy and Development.

[28] Omiti, J. M., Otieno, D. J., Nyanamba, T. O. and Mccullough, E. (2009) "Factors Influencing the Intensity of Market Participation by Smallholder Farmers: A Case Study of Rural and Peri-urban areas of Kenya", *African Journal of Agricultural Resource Economics*, Vol. 3, No. 1, pp. 57-82. ISSN 1993-3738.

[29] Pender, J. and Alemu, D. (2007) "Determinants of smallholder commercialization of food crops: Theory and evidence from Ethiopia". Discussion Paper No. 745, International Food Policy Research Institute (IFPRI), Washington, DC.

[30] Pingali, P. (1997) "From Subsistence to Commercial Production System: The Transformation of Asian Agriculture", *American Journal of Agricultural Economics*, Vol. 79, No. 2, pp. 628-634. ISSN 1467-8276.

[31] Pingali, P., and Rosegrant, M. (1995) "Agricultural commercialization and diversification: Processes and policies", *Food Policy*, Vol. 20, No. 3, pp. 171–185. ISSN 0306-9192. DOI: 10.1016/0306-9192(95)00012-4.

[32] Pradhan, K., Dewina, R. and Minsten, B. (2010) "Agricultural Commercialization and Diversification in Bhutan", International Food Policy Research Institute, Washington, DC, USA.

[33] Quaye, W., Gyasi, O., Larweh, P., Johnson, P-N. T. and Obeng-Aseidu, P. (2009). "The extent of marketability and consumer preferences for traditional leafy vegetables – A case study at selected markets in Ghana", *International Journal of Consumer Studies*, Vol. 33, pp. 244–249. ISSN 1470-6431. DOI 10.1111/j.1470-6431.2009.00768.x

[34] Rogers, E. M. (1995) "Diffusion of Innovations". The Free University Press, New York. ISBN-13: 978-0029266717; ISBN-10: 0029266718.

[35] Romer, P. (1994) "New Goods, Old Theory and The Welfare Cost of Trade Restrictions", *Journal of Development Economics*, Vol. 43, No. 1, pp. 5-38. ISSN 0304-3878. DOI 10.3386/w4452.

[36] Sadoulet, E. and de Janvry, A. (1995). Quantitative Development Policy Analysis. The Johns Hopkins University Press, Baltmore, Maryland, USA. ISBN 0801847826 9780801847820.

[37] Safdar, S., Ahmad, N. and Sher, F. (2012) "Estimation of urban –rural expenditure and size ealasticities of food items in Pakistan: Evidence from PSLM data", *Academic Research International*, Vol. 3, No. 2, pp. 474- 481. ISSN 2223-9944.

[38] Sindi, J. K. (2008) "Kenya's Domestic Horticulture Subsector: What Drives Commercialization Decisions by Rural Households?" Department of Agricultural, Food and Resource Economics: Michigan State University.

[39] Strasberg, P. J., Jayne, T. S., Yamano T., Nyoro, J., Karanja, D. and Strauss, J. (1999) "Effects of agricultural commercialization on food crop input use and productivity in Kenya". Michigan State University International Development Working Papers No. 71. Michigan, USA. ISSN 0731-3438.

[40] Technoserve (1997) BOAFO: the Newsletter of Technoserve/Ghana, Vol. 8, November, Accra, Ghana.

[41] Timmer, C. P. (1997) "Farmers and Markets: The Political Economy of New Paradigms", *American Journal of Agricultural Economics*, Vol. 79, No. 2, pp. 621-627. ISSN 0002-9092. DOI 10.2307/1244161.

[42] Von Braun, J., Bouis, H., Kennedy, E. (1994) "*Agricultural Commercialization, Economic Development, and Nutrition*" In: von Braun, J., and E. Kennedy (eds.). Johns Hopkins University Press, Baltimore, MD, 3-8. ISBN 0-8018-4759-1.

[43] Wiggins, S., Argwings-Kodhek, G., Leavy, J. and Poulton, C. (2011) "Small Farm Commercialization in Africa: Reviewing the Issues", Future Agricultures Consortium, Research Paper.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Technical Efficiency and Technology Gap in Indonesian Rice Farming

T. Haryanto[1], B. A. Talib[2], N. H. M. Salleh[2]

[1] Department of Economics, Airlangga University, Indonesia
[2] School of Economics, The National University of Malaysia

Abstract

This study aims to estimate the technical efficiency and technology gap in Indonesian rice farming, and analyze its determinants. An analysis of DEA Metafrontier and Tobit regression was applied respectively for the first and second objective. The data is based on farm level data of fifteen rice–producing provinces in Indonesia. The result showed that the technical efficiency based on metafrontier estimation is slightly lower than the technical efficiency based on regional frontier estimation, indicating the existence of technology gap which is quite small. Net income, education, and irrigated rice field found related to the technical efficiency and technology gap. Meanwhile, the effect of other factors on the technical efficiency and technology gap is ambiguous. Hence, this study suggests that these three factors should be considered in the policy to increase technical efficiency and to reduce the technology gap in Indonesian rice farming.

Keywords

Rice farming, technical efficiency, technology gap, DEA metafrontier, Tobit regression.

Haryanto, T., Talib, B. A. and Salleh, N. H. M. (2016) "Technical Efficiency and Technology Gap in Indonesian Rice Farming", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 29 - 38. ISSN 1804-1930, DOI 10.7160/aol.2016.080303.

Introduction

Technical efficiency of rice farming in Indonesia has been investigated by many researchers based on frontier production function estimation. As examples, Widodo (1986) showed that the average technical efficiency of rice farming in West Java is 0.73-0.76, while in Yogyakarta is 0.85-0.86. Squires and Tabor (1991) find that the average technical efficiency of rice farming in Java and off Java is 0.697 and 0.704 respectively. According to Llewelyn & Williams (1996), the average technical of rice farming in East Java is 0.87. Fabiosa et al. (2004) showed that the average technical efficiency in West Java is 0.66, while in East Java and Central Java are 0.72 and 0.76 respectively. Study conducted by Brazdik (2006) in West Java showed that the average technical efficiency of rice farming in this region is around 0.60-0.77. A Study by Kusnadi (2011) used a sample of 802 farmers based on PATANAS survey data showed that the average technical efficiency of rice farming in Indonesia is around 0.92. Makki et al. (2012) showed that the average technical efficiency of rice farming in the province of South Kalimantan is 0.78. Furthermore, Suharyanto et al. (2013) showed that the average technical efficiency of rice farming in the province of Bali is 0.88.

However, these studies did not take into account the technological gap between the farmers. Thereby, the technical efficiencies are not comparable between the farmers who operate under a given production technology and the farmers which are operating under different production technology. Conceptually, a comparable technical efficiency can be estimated by using metafrontier production function [see Battese and Rao (2002); Battese et al. (2004); O'Donnell et al. (2008); Chen and Song (2008) for a detailed discussion].

A meta production function introduced by Hayami (1969, 1970), Hayami and Ruttan (1969, 1970, 1972) to explain agricultural productivity differences on a global level. Meta production function or potential production function is described as an envelope for less elastic isoquant of agricultural producer groups in different countries with different technologies (Hayami and Ruttan, 1969), or the envelope for individual production curve (Hayami and Ruttan, 1972). The function can be obtained by estimating general production functions or cross country (Hayami and Ruttan, 1970).

The concept of meta production is interesting because it incorporate data from different countries to estimate general production function, thus increasing both the range of independent variables or even the total number of observations, and thereby reduce the possibility of multicollinearity, improve the reliability of the production estimation. In addition, the meta production function can be estimated using intercountry data, although the individual production functions of the countries can not be estimated using individual country data because the number of observations may not be enough.

Hayami and Ruttan estimate meta production functions using ordinary least squires (OLS) method. Many studies followed the concept and methodology of meta production function estimation [see for example Kawagoe and Hayami (1983); Kawagoe et al. (1985); Lau and Yotopoulus (1971, 1989); Marra and Schurle (1994); Fulginiti and Perrin (1998); Alston et al. (2000)]. Based on the concept of meta production, many studies estimate metafrontier production function to explain the technology gap between producer groups using parametric approach whether deterministic (DFA-MF) or stochastic (SFA-MF), and nonparametric approach Data envelopment analysis (DEA-MF). Kudaligama and Yanagida (2000) estimate DFA-MF and SFA-MF based on the data used by Hayami and Ruttan (1985) by modifying certain variables. The estimation of DFA-MF is conducted by using Minimum Absolute Deviation (MAD) techniques through linear programming (LP) as in Aigner and Chu (1968). Meanwhile, SFA-MF is estimated based on the data of all producers groups, all countries in the same time using a maximum likelihood method. This procedure estimation of SFA-MF is also used by Gunaratne and Leung (2000) to estimate the SFA-MF for black tiger shrimp production systems in Asia.

Rao et al. (2003) estimate DEA-MF and SFA-MF based on FAOSTAT data which consists of 97 major agricultural producing countries in the world. According to Rao et al. (2003), metafrontier function is an envelop to deterministic component of stochastic estimation for different regions. A similar definition can be seen as examples in Battese et al. (2004), Chen & Song (2008), O'Donnell et al. (2008), and Moreira and Bravo-Ureta (2010). The estimation of SFA-MF use linear programming and quadratic programming techniques. Battese et al. (2004) also apply this estimation procedure for textile industries in Indonesia. Chen and Song (2008) use the same procedur to explain efficiency and technology gap of agriculture in China.

O'Donnell et al. (2008) estimate DEA-MF and SFA-MF based on the same data used by Rao et al. (2003). The estimation of SFA-MF use linear programming technique. The same technique also used by Moreira and Bravo-Ureta (2010) in the study on technical efficiency and meta technology of dairy farms in Argentina, Chile and Uruguay. Some other studies applying DEA-MF to investigate the efficiency and technology differences in agriculture for example Nkamleu et al. (2006), Mulwa et al. (2009), Latruffe et al. (2012), Tung (2014), Nguyen and Fisher (2014). In addition, recent studies using SFA-MF in agriculture as example Uddin et al. (2014), Kramol et al. (2015), Cechura et al. (2015).

Empirically, SFA-MF and DEA-MF are the most widely use to investigate technical efficiency and technology gap in related studies. However, a study conducted by O'Donnell et al. (2008) which is applying both the approaches by using the same sets of data showed that technical efficiency and technology gap based on the estimation of DFA-MF and DEA-MF is greater than technical efficiency and technology gap based on SFA-MF estimation. In addition, the regional technical efficiency is greater than meta technical efficiency. This study employs DEA-MF. Because of DEA use linear programming technique, so that frontier estimated based on all observation data (pooled data) using DEA is already the metafrontier. The next section of this papers sequentially will discuss materials and methods, results and discussion, and conclusion.

Materials and methods

This study covered of fifteen rice-producing provinces in Indonesia. All the fifteenth of provinces will be grouped into five rice-producing regions, namely Sumatera, Java, Bali and Nusa Tenggara, Kalimantan, and Sulawesi. Total number of observation is 5537 rice farmers. Data used in this study is taken from a survey on the cost structure of rice farming conducted by the Central Bureau of Statistics of the Republic of Indonesia (BPS) in 2008.

An output-oriented DEA model assuming variable returns to scale (VRS) is used to estimate production frontier. The model was adopted from O'Donnell (2008):

$$\max_{\phi_i,\lambda_i} \phi_i$$

$$\text{st} \quad \phi_i y_i - Y\lambda_i \le 0$$
$$X\lambda_i - x_i \le 0$$
$$j'\lambda = 1$$
$$\lambda_i \ge 0 \qquad (1)$$

where y_i = the quantity of output in the form of dry grain harvest (in kilograms) of the i-th farmers; x_i = N x 1 vector of input quantities for the i-th farmers. These inputs consist of harvested area (in sequare meters), seeds (in kilograms), fertilizer (in kilograms), and labor (in person days); Y = L_k x 1 vector of output quantity for all L_k farmers; X = N x L_k vector of input quantities for all L_k farmers; j = an L_k x 1 vector of ones; λ_i = an L_k x 1 vector of weights; ϕ_i = a scalar. Solving the linear programming of equation (1) for each region separately will obtain the technical efficiency score for each farmers relative to regional frontier. The value of ϕ - 1 shows the proportional increase in output that can be achieved by the i-th farmers with inputs held constant. The technical efficiency defined as $1/\phi$ with value between 0 and 1.

A convex metafrontier can be estimated by apply DEA model such as in equation (1) based on pooled data observation of inputs and output for all L = $\sum_k L_k$ farmers in all regions (O'Donnell et al., 2008). The optimum solution of DEA metafrontier generates technical efficiency score for farmers in each region relative to metafrontier. The ϕ_i based on DEA metafrontier could not greater than the ϕ_i based on DEA regional frontier because of the regional frontier constraints will be part of the metafrontier constraints. Thus, the technical efficiency score based on DEA metafrontier surely could not greater than the technical efficiency based on DEA regional frontier. The estimation of regional frontier and metafrontier is conducted by using DEAP 2.1 version.

Technology gap is measured by metatechnology ratio (MTR). The ratio is defined as technical efficiency based on DEA metafrontier devided by technical efficiency based on regional frontier (O'Donnell et al., 2008; Battese et al., 2004). The value of MTR is between 0 and 1. MTR closer to 1 indicates that the maximum output achieved by farmers is closer to metafrontier output, meaning that technology gap between regional technology adopted and metatechnology is very small.

Tobit regression models was used to determine effects of the number specific factors on the technical efficiency and technology gap separately. The model is adopted from Chavas and Aliber (1993), Chavas et al. (2005), and Chen and Song (2008) by a modification in variables used. General specification Tobit model is written as:

$$Y_i = X_i\beta + e_i \quad \text{if } X_i\beta + e_i < 1,$$
$$= 1 \quad \text{otherwise} \qquad (2)$$

Model specifications in detail as follows:

$$Yi = \beta_0 + \beta_1 INCOME_{1i} + \beta_2 AGE_{2i} + \beta_3 EDU_{3i} + \beta_4 SIZE_{4i} + \beta_5 SEED_i + \beta_6 FIELD_{6i} + \beta_7 PEST_{7i} + \beta_8 GOV_{8i} + \beta 9CREDIT9i + \beta_{10} SUM + \beta_{11} JAVA + \beta_{12} KAL + \beta_{13} SUL + e_i \qquad (3)$$

where Y_i is the technical efficiency and MTR respectively obtained from the DEA estimation; β is unknown parameter to be estimated; e_i is an error term, assumed $e_i \sim$ iid. N (0, σ^2); *INCOME* = net income from rice farming (in log); *AGE* = age of farmers (in year); *EDU* = formal education (D = 1 for senior high school & the higher education, otherwise D = 0); *SIZE* = land size (in log); *SEED* = type of seed (D=1 for high-yielding certified seed, otherwise D = 0); *FIELD* = irrigated rice field (D = 1 for cultivation in irrigated rice field, otherwise D = 0); *PEST* = pests and diseases (D = 1 if there were pests and diseases, otherwise D = 0); *GOV* = government assistance (D = 1 for farmers who gets production input assistance free from government, otherwise D = 0); *CREDIT* = farmers' access to credit (D = 1 if farmers don't experience difficulty to obtain credit from formal financial institutions, otherwise D = 0), X_{11} = pests management (D = 1 if using pesticides, otherwise D = 0); *SUM, JAVA, KAL, SUL* respectively is regional dummy variable for Sumatera, Java, Kalimantan and Sulawesi. Parameters are estimated by maximum likelihood method using Eviews software 7.1 version. Since the dataset does contain capital variable we assume capital separability in the interval of our analysis.

Results and discussion

1. Descriptive statistics of variables

Table 1 represents summary statistics of variables. The first five variables in Table 1 are the output and inputs used in the DEA models. Meanwhile, nine other variables are the specific factors in rice farming used in Tobit models to explain the variation in technical efficiency and technology gap between the farmers.

Variable	Sumatera		Java		Bali & Nusa Tenggara	
	n=1259		n=3273		n=243	
	Mean	SD	Mean	SD	Mean	SD
Rice (kg)	2514	1949.42	1603	1144.29	2532	1871.84
Harvested area (square meters)	4833	3664.65	2823	1938.45	4043	2827.20
Seed (kg)	27	25.22	13	9.36	24	19.36
Fertilizer (kg)	176	148.04	148	110.59	215	161.24
Labor (person days)	48	39.94	44	27.67	56	37.68
Net income (000 rupiahs)	3927	3519.42	2052	1701.66	3502	2859.38
Age of farmers (year)	49	11	51	10	48	12
Education (dummy)	0.37	0.48	0.31	0.46	0.33	0.47
Land size (square meters)	5897	5037.17	3167	2178.68	4844	4080.76
Type of seed (dummy)	0.50	0.50	0.56	0.50	0.48	0.50
Irrigated rice field (dummy)	0.50	0.50	0.57	0.50	0.70	0.46
Pests & dieses (dummy)	0.57	0.50	0.50	0.50	0.39	0.49
Government assistance (dummy)	0.38	0.49	0.33	0.47	0.45	0.50
Access to credit (dummy)	0.56	0.50	0.54	0.50	0.53	0.50

Source: Author's tabulation based on BPS data

Table 1: Summary statistics of variables used in DEA and Tobit models.

Variable	Kalimantan		Sulawesi		National (pooled data)	
	n=287		n=475		N=5537	
	Mean	SD	Mean	SD	Mean	SD
Rice (kg)	2112	1194.36	3084	2635.11	2004	1650.98
Harvested area (square meters)	4582	2597.94	5589	4926.88	3662	3024.18
Seed (kg)	22	13.53	29	28.5	19	18.36
Fertilizer (kg)	118	74.46	200	203.61	160	133.01
Labor (person days)	68	50.42	50	26.74	47	33.21
Net income (000 rupiahs)	3679	2286.43	3583	3469.27	2757	2629.88
Age of farmers (year)	47	9	47	9	50	11
Education (dummy)	0.33	0.47	0.37	0.48	0.33	0.47
Land size (square meters)	6181	3949.75	8262	7051.99	4455	4149.88
Type of seed (dummy)	0.41	0.49	0.55	0.50	0.54	0.50
Irrigated rice field (dummy)	0.40	0.49	0.51	0.50	0.54	0.50
Pests & dieses (dummy)	0.39	0.49	0.59	0.49	0.51	0.50
Government assistance (dummy)	0.40	0.49	0.28	0.45	0.35	0.48
Access to credit (dummy)	0.31	0.46	0.47	0.50	0.53	0.50

Source: Author's tabulation based on BPS data

Table 1: Summary statistics of variables used in DEA and Tobit models (continuation).

2. Technical efficiency and technology gap

Table 2 reports summary statistics of the regional technical efficiency (TE-K), meta technical efficiency (TE-MF) and metatechnology ratio (MTR) obtained from DEA estimation. The TE-K, TE-MF and MTR are varying between the regions. The average of TE-K is 0.767 in Java and 0.807 in Bali & Nusa Tenggara, for example, indicate that the maximum output obtained using the production inputs with the existing technology in Java, and Bali is around 77% and 80% of the output potential in both regions respectively. Meanwhile, the average of MTR 0.838 in Java and 0.870 in Bali & Nusa Tenggara indicate that the maximum output which achieved in Java and Bali & Nusa Tenggara using the production inputs in those regions respectively with metatechnology is approximately 87% and 72% of the maximum output represented by metafrontier.

In all regions, the TE-MF is slightly lower than

the TE-K. For example, the average TE-MF 0.630 for Java is lower than the average TE-K 0.767 for this region. Based on TE-MF, it can be said that the technical efficiency in Bali and Nusa Tenggara region is the highest compared to any other region. In contrast, technical efficiency in Kalimantan is the lowest than in any other regions.

Based on the DEA estimation of regional frontiers, metafrontier and metatechnology ratio, TE-K, TE-MF and MTR for fifteen provinces covered by the five groups of region can also be obtained. Descriptive statistics of the TE-K, TE-MF and MTR by province are presented in Table 3. In this context, the table 3 is basically describing

Region	Statistics	Mean	SD	Minimum	Maximum
Sumatera	TE-K	0.768	0.167	0.270	1.000
(n =1259)	MTR	0.818	0.102	0.489	1.000
	TE-MF	0.624	0.140	0.227	1.000
Java	TE-K	0.767	0.139	0.270	1.000
(n = 3273)	MTR	0.838	0.132	0.579	1.000
	TE-MF	0.630	0.096	0.225	1.000
Bali & Nusa Tenggara	TE-K	0.807	0.136	0.519	1.000
(n = 243)	MTR	0.870	0.077	0.587	1.000
	TE-MF	0.698	0.118	0.489	1.000
Kalimantan	TE-K	0.787	0.138	0.445	1.000
(n = 287)	MTR	0.717	0.138	0.457	1.000
	TE-MF	0.563	0.150	0.380	1.000
Sulawesi	TE-K	0.801	0.114	0.444	1.000
(n = 475)	MTR	0.846	0.060	0.573	1.000
	TE-MF	0.678	0.115	0.402	1.000
National	TE-K	0.773	0.144	0.270	1.000
(N=5537)	MTR	0.829	0.123	0.457	1.000
	TE-MF	0.633	0.116	0.225	1.000

Source: DEA estimation

Table 2: Summary statistics of the technical efficiencies and metatechnology ratios by region.

Province	n	TE-K		MTR		TE-MF	
		Mean	SD	Mean	SD	Mean	SD
Nanggroe Aceh Darussalam	155	0.739	0.184	0.813	0.084	0.598	0.152
North Sumatera	390	0.772	0.129	0.870	0.067	0.667	0.103
West Sumatera	212	0.648	0.198	0.749	0.110	0.479	0.152
South Sumatera	261	0.836	0.144	0.776	0.123	0.636	0.096
Lampung	241	0.813	0.141	0.844	0.067	0.684	0.121
West Java	1116	0.707	0.119	0.861	0.059	0.606	0.095
Central Java	958	0.907	0.061	0.662	0.044	0.600	0.063
East Java	990	0.695	0.116	0.971	0.042	0.673	0.102
Banten	209	0.784	0.113	0.892	0.068	0.696	0.092
Bali	89	0.862	0.091	0.839	0.064	0.722	0.085
West Nusa Tenggara	154	0.775	0.147	0.889	0.079	0.685	0.132
West Kalimantan	110	0.764	0.170	0.871	0.082	0.666	0.168
South Kalimantan	177	0.801	0.111	0.621	0.053	0.498	0.091
Central Sulawesi	84	0.803	0.161	0.829	0.081	0.666	0.151
South Sulawesi	391	0.800	0.101	0.681	0.105	0.850	0.054

Source: DEA estimation

Table 3: Summary statistics of the technical efficiencies andmetatechnology ratios by province.

the distribution of the TE-K, TE-MF and MTR regions to the province. Therefore, the interpretation of the score TE-K, TE-MF and MTR is not different from the previous paragraph.

3. The determinants of technical efficiency and technology gap

The maximum likelihood estimation results of such determining factors to the TE-K, TE-MF and MTR are shown in Table 4.

Variable	Symbol	TE-K	TE-MF	MTR
Constant		0.6660***	0.3730***	0.6436***
		(0.0233)	(0.0185)	(0.0208)
Net income	INCOME	0.0313***	0.0680***	0.0515***
		(0.0034)	(0.0027)	(0.003)
Age	AGE	0.0009***	-0.0001***	-0.0008***
		(0.0002)	(0.0001)	(0.0002)
Education	EDU	0.0542***	0.0411***	0.0094***
		(0.0038)	(0.0028)	(0.0036)
Land size	SIZE	-0.0253***	-0.0322***	-0.0169***
		(0.0035)	(0.0029)	(0.0032)
Type of seed	SEED	0.0799***	0.0316***	-0.0411***
		(0.0036)	(0.0024)	(0.0034)
Irrigated rice field	FIELD	0.0480***	0.0498***	0.0122***
		(0.0034)	(0.0024)	(0.0033)
Pests & diseases	PEST	-0.0631***	-0.0325***	0.0169***
		(0.0035)	(0.0025)	(0.0034)
Government assistance	GOV	0.0607***	0.0335***	-0.0135***
		(0.0038)	(0.0027)	(0.0035)
Access to credit	CREDIT	-0.0391***	-0.0146***	0.0167***
		(0.0034)	(0.0024)	(0.0033)
Sumatera	SUM	-0.0192***	-0.0570***	-0.0537***
		(0.0071)	(0.0062)	(0.0056)
Java	JAVA	-0.0297***	-0.0328***	-0.0071
		(0.0067)	(0.0057)	(0.0055)
Kalimantan	KAL	-0.0025	-0.1176***	-0.1505***
		(0.0082)	(0.0086)	(0.0092)
Sulawesi	SUL	0.0268***	0.0128*	-0.0158***
		(0.0077)	(0.0068)	(0.0061)
Likelihood ratio		2937.421***	3170.937***	913.6276***

Notes: the number in the parentheses is standard error; ***, **, and * indicates statistically significant at 1%, 5%, and 10% level of significance, respectively.
Source: own calculation

Table 4: Maximum likelihood estimation results for Tobit models.

Net income from rice farming has a positive and significant effect to the TE-K, TE-MF and MTR mean that the TE-K, TE-MF and MTR will increase as the net income increase. The age of farmers has a positive and significant effect on the TE-K which support the previous studies [such as Llewelyn and Williams (1996); Fabiosa et al. (2004); Kusnadi et al. (2011); Suharyanto et al. (2013)]. This suggests that old farmers are more efficient than young farmers because their experiences in rice cultivation are more than young farmers. In contrast, effect of age to the TE-MF and MTR is negative. This situation may occur because of the old farmers are usually reluctant to adopt and use the new technologies or more efficient production methods.

All the coefficients of formal education are positive and significant, indicating that the average TE-K, TE-MF and MTR of the farmers who had senior high school education and higher education is greater than farmers who had junior school education and lower education. The positive and significant effect of formal education on technical efficiency also support previous studies [such as Widodo (1986); Fabiosa et al. (2004)]. Land size has a negative and significant effect on the TE-K, TE-MF and MTR indicate that small farmers are more efficient than the large farmer. Based on literature this case is common in developing countries.

Coefficients of seed types are positive and significant to the TE-K and TE-MF, meaning that the average of TE-K and TE-MF obtained from the use of certified high-yielding seed is greater compared to non certified high-yielding seed. In fact, there are many farmers in Indonesia who do not use certified high-yielding seed due to constraints such as purchasing power, price, and location. This may cause a negative effect of the certified high-yielding seed to the MTR as shown in Table 4. Irrigated rice field dummy variable has a positive and significant effect on the TE-K, TE-MF and MTR. These indicate that the average TE-K, TE-MF and MTR of rice cultivation in irrigated rice field is greater compared to non irrigated rice field. The presence of pest and diseases reduced the technical efficiency of rice farming. However, a decrease in the average TE-K caused by pests and diseases is greater than a decrease in the average TE-MF, and therefore the effect on the MTR is positive.

Government assistance in the form of inputs which are provided free to the farmers has a positive and significant effect to the technical efficiency of rice arming. However, its effect to MTR is negative and significant, meaning that the technology

gap tends to widened due to not all farmers could access such assistance. Access to credit has a negative and significant effect to the technical efficiency, but its effect to the MTR is positive and significant. However, not all the farmers in Indonesia could access credit because of several reasons, for example, farmers may not have collateral, credit application procedures maybe complicated, farmers do not have any information about credit procedures, the distance between the location of farmers and the credit institutions might be quite far (BPS, 2008). Most of these farmers rely on self-financing in operating of rice farming. This situation may cause a negative effect of access to credit on technical efficiency.

Finally, the positive coefficient of Sulawesi for TE-K and TE-MF indicates that rice farming in this region is more efficient to the other regions including Bali & Nusa Tenggara. Furthermore, the negative coefficient of the regional dummy variables showed that the average MTR for the regions is slightly less than the average MTR for Bali & Nusa Tenggara. In other word, this indicates that technology gap of rice farming in Sumatera, Java, Kalimantan and Sulawesi is wider than in Bali and Nusa Tenggara.

Conclusions

The technical efficiency based on metafrontier analysis (TE-MF) can be decomposed into regional technical efficiency (TE-K), and metatechnology ratio (MTR) which measure technology gap. The average TE-MF of rice farming in Indonesia is slightly lower than TE-K, so that the average of MTR is quite high. This indicates that technology gap between the technology adopted by the farmers and the best available technology is quite small. A number of factors have a positive and significant effect on the technical efficiency and technology gap, namely net income from rice farming, education, and irrigated rice field. Land size showed a negative effect on technical efficiency and technology gap. Meanwhile, the effect of other factors such as age of farmers and access to credit on the technical efficiency as well as the effect of seed type and government assistance on technology gap is ambiguous.

In term of policy, an increase in the technical efficiency as well as reduction in the technology gap (or increase in the MTR) is necessary. Therefore, net income, education and irrigated fields should be considered in the policy to increase technical efficiency and reducing the technology gap. Net income obtained by farmers from rice farming should rise not only to improve their standard of living worthily, but also improved their capability to reinvest part of the net income on productive assets for increased rice production. However, the net income can be influenced by a number of factors which are not addressed in this study.

Formal education either general education and vocational education for the farmers should be increased at least up to the senior high school through the 12-years compulsory education program to improve farmers' knowledge on information and technology relating to agricultural practice, make farmers becomes more creative, and innovative. In addition, non-formal education for the farmers is also important to encourage the use a better agricultural practice. Hence, the existence of field school in integrated crop management should be maintained and developed to improve the knowledge and skills of the farmers through direct practice.

Furthermore, the existing irrigated rice field ought to be maintained. Accordingly, the government must be able to prevent the conversion of agricultural land for non-agricultural activities through enforcement of the related laws and regulations. The existing irrigation infrastructures which still function properly must be maintained, while the damaged irrigation infrastructure should be repaired and constructed. These are very importance to guarantee the adequate water supply for rice cultivation in normal weather condition, and especially in extreme weather conditions. The construction of irrigation infrastructure is also needed to support the new rice field expansion in areas that have been designated as agricultural areas for food commodity outside Java.

Corresponding author:
Tri Haryanto
Department of Economics, Airlangga University, Kampus B-Jalan Airlangga 4, Surabaya 60286, Indonesia
Phone: +62-813-3040-6631. Fax: +62-31-5026288, E-mail: tri.h@feb.unair.ac.id; soemantri2@yahoo.com

References

[1] Aigner, D. J., and Chu, S. F. (1968) "On estimating the industry production function", *The American Economic Review*, Vol. 58, No. 4, pp. 826-829. ISSN 00028282.

[2] Alston, J. M., Chan-Kang, C., Marra, M.C., Pardey, P. G. and Wyatt, T. J. (2000) "Research return redux: a meta-analysis of the return to agricultural R&D", *The Australian Journal of Agricultural and Resource Economics*, Vol. 44, No. 2, pp. 185–215. ISSN 1364985X. DOI 10.1111/1467-8489.00107.

[3] Battese, G. E., Rao, D. S. P., O'Donnell, C. J. (2004) "A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies", *Journal of Productivity Analysis,* Vol. 21, pp. 91–103. ISSN 0895562X. DOI 10.1023/B:PROD.0000012454.06094.29.

[4] Battese, G. E . and Rao, D. S. P. (2002) "Technology gap, efficiency, and a stochastic metafrontier function", *International Journal of Business and Economics*, Vol. 1, No. 2, pp. 87–93. ISSN 1544-8037.

[5] Brázdik, F. (2006) "Non-parametric analysis of technical efficiency: Factors affecting efficiency of West Java rice farms". Working paper series. Center for Economic Research and Graduate Education Academy of Sciences of the Czech Republic Economics Institute, Vol. 286, pp.1–45. ISSN 1211-3298.

[6] Cechura, L., Hockmann, H., Malý, M. and Žáková Kroupová, Z. (2015) "Comparison of technology and technical efficiency in cereal production among EU countries", *Agris on-line Papers in Economics and Informatics*, Vol. VII, No. 2, pp. 27-37. ISSN 18041930.

[7] Chavas, J. P. and Aliber, M. (1993) "An analysis of economic efficiency in agriculture: A nonparametric approach", J*ournal of Agricultural and Resource Economics*, Vol.18, No. 1, pp. 1–16. ISSN 10685502.

[8] Chavas, J. P., Petrie, R. and Roth, M. (2005) "Farm household production efficiency: Evidence from the Gambia", *American Journal of Agricultural Economics*, Vol. 87, No. 1, pp. 160-179. ISSN 00029092.

[9] Chen, Z. and Song, S. (2008) "Efficiency and technology gap in China's agriculture: A regional meta-frontier analysis", *China Economic Review*, Vol. 19, pp. 287–296. ISSN 1043951X. DOI 10.1016/j.chieco.2007.03.001.

[10] Fabiosa, J. F, Jensen, H. H. and Yan. D. (2004) "Do macroeconomic shocks impact the economic efficiency of small farmers? The case of wetland rice farmers in Indonesia", Working Paper 04-WP 364, Center for Agricultural and Rural Development Iowa State University, May 2004. [Online]. Available: www.card.iastate.edu [Accessed: 25 May 2011].

[11] Fulginiti, L. E. and Perrin, R. K. (1998) "Agricultural productivity in developing countries", *Agricultural Economics*, Vol. 19, pp. 45–51, ISSN 01695150.

[12] Gunaratne, L. H. P. and Leung, P. S. (2000) "Asian black tiger shrimp industry: a meta-production frontier analysis", In:. Leung, PingSun and Khem R. Sharma (eds): A Collections of Research Paper Based on the ADB/NACA Farm Performance Survey, Bangkok: Network of Aquaculture Centers in Asia Pacific, pp. 55–68. ISBN 000000000.

[13] Hayami, Y. (1969) "Sources of agricultural productivity gap among selected countries", *American Journal of Agricultural Economics*, Vol. 51, No. 3, pp. 564–575. ISSN 00029092.

[14] Hayami, Y. (1970) "On the use of the Cobb-Douglas production function on the cross-country analysis of agricultural production", *American Journal of Agricultural Economics*, Vol. 52, No. 2, pp. 327–329. ISSN 00029092.

[15] Hayami, Y. (1969) "Sources of agricultural productivity differences among countries resource accumulation, technical inputs and human capital", Staff Paper Series P69-24 University of Minnesota Institute of Agriculture, November 1969. [Online]. Available: http://ageconsearch.umn.edu/bitstream/14272/1/p69-24.pdf [Accessed: 7 September 2012]. DOI 10.2307/1237909

[16] Hayami, Y. and Ruttan, V. W. (1970) "Agricultural productivity differences among countries", *The American Economic Review*, Vol. 60, No. 5, pp. 895–911. ISSN 00028282.

[17] Hayami, Y. and Ruttan, V. W. (1972) "Agricultural productivity differences", *Journal of Northeastern Agricultural Economics Council*, Vol.1, No. 1, pp. 1–13.

[18] Hayami, Y. and Ruttan, V. W. (1985) "*Agricultural development: An international perspective revised and expanded edition*", Johns Hopkins University Press. ISBN 978-0801823763.

[19] Kawagoe, T., Hayami, Y. and Ruttan, V. W. (1985) "The intercountry agricultural production function and productivity differences among countries", *Journal of Development Economics*, Vol. 19, pp. 113–132, ISSN 0304-3878. DOI 10.1016/0304-3878(85)90041-0.

[20] Kawagoe, T. and Hayami, Y. (1983) "The production structure of world agriculture: An intercountry cross-section analysis", *The Developing Economies*, Vol. 21, pp. 189–206. ISSN 1746-1049. DOI 10.1111/j.1746-1049.1983.tb01082.x.

[21] Kramol, P., Villano, R., Kristiansen, P. and Fleming, E. (2015) "Productivity differences between organic and other vegetable farming systems in Northern Thailand", *Renewable Agriculture and Food Systems*, Vol. 30, No. 02, pp. 154-169. ISSN 17421705. DOI http://dx.doi.org/10.1017/S1742170513000288.

[22] Kudaligama, V. P. and Yanagida, Y. F. (2000) "A comparison of intercountry agricultural production functions: A frontier function approach", "*Journal of Economic Development*", Vol. 25, No. 1, pp. 57–74. ISSN 0254-8372.

[23] Kusnadi, N., Tinaprilla, N., Susilowati, S. H. and Purwoto, A. (2011) "Rice farming efficiency analysis in some rice producing areas in Indonesia", J*urnal Agro Ekonomi*, Vol. 29, No. 1, pp. 25– 48. ISSN 0216-9053.

[24] Latruffe, L., Fogarasi, J. and Desjeux, Y. (2012) "Efficiency, productivity and technology comparison for farms in Central and Western Europe: The case of field crop and dairy farming in Hungary and France", *Economic Systems*, Vol. 36. No. 2, pp. 264-278. ISSN 0939-3625. DOI 10.1016/j.ecosys.2011.07.002.

[25] Lau, L. J. and Yotopoulos, P. A. (1971) "A test of relative efficiency and application to Indian Agriculture", *The American Economic Review*, Vol. 61, No. 1, pp. 94–109. ISSN 00028282.

[26] Lau, L. J. and Yotopoulos, P. A. (1989) "The meta-production function approach to technical change in world agriculture", *Journal of Development Economics*, Vol. 31, pp. 241–269. ISSN 0304-3878.

[27] Llewelyn, R. V. and Williams, J. R. (1996) "Nonparametric analysis of technical, pure technical, and scale efficiencies for food crop production in East Java, Indonesia", *Agricultural Economics*, Vol. 15, pp. 113–126. ISSN 01695150. DOI 10.1016/S0169-5150(96)01202-9.

[28] Makki, M. F. and Suslinawati, Y. F. R. (2012) "Impacts of climate change on productivity and efficiency paddy farms: Empirical evidence on tidal swamp land South Kalimantan Province – Indonesia" *Journal of Economics and Sustainable Development*, Vol. 3, No. 14, pp. 66–72. ISSN 2222-1700.

[29] Marra, M. C. and Schurle, B.W. (1994) "Kansas wheat yield risk measures and aggregation: A meta-analysis approach", *Journal of Agricultural and Resource Economics,* Vol. 19, No. 1, pp. 69–77. ISSN 10685502.

[30] Moreira, V. H. and Bravo-Ureta, B. E. (2010) "Technical efficiency and metatechnology ratios for dairy farms in three southern cone countries: a stochastic meta-frontier model", *Journal of Productivity Analysis*, Vol. 33, pp. 33–45. ISSN 0895562X. DOI 10.1007/s11123-009-0144-8.

[31] Mulwa, R., Emrouznejad, A., and Muhammad, L. (2009) "Economic efficiency of smallholder maize producers in Western Kenya: A DEA meta-frontier analysis", *International Journal of Operational Research*, Vol. 4, No. 3, pp. 250-267. ISSN 17457645. DOI http://dx.doi.org/10.1504/IJOR.2009.023284.

[32] Nguyen, K. T. and Fisher, T. C. G. (2014) "Efficiency analysis and the effect of pollution on shrimp farms in the Mekong river delta", *Aquaculture Economics & Management*, Vol. 8, No. 4, pp. 325-343. ISSN 13657305. DOI 10.1080/13657305.2014.959209.

[33] Nkamleu, G. B., Nyemeck, J. and Sanogo, D. (2009) "Metafrontier analysis of technology gap and productivity difference in African agriculture", MPRA Paper No. 15103, May 2009. [Online]. Available: http://mpra.ub.uni-muenchen.de/15103 [Accessed: 13 November 2013]

[34] O'Donnell, C. J., Rao, D. S. P. and Battese, G. E. (2008) "Metafrontier frameworks for the study of firm-level efficiencies and technology ratios", *Empirical Economics*, Vol. 34, pp. 231–255. ISSN 03777332. DOI 10.1007/s00181-007-0119-4.

[35] Rao, D. S. P., O'Donnel, C. J. and Battese, G. E. (2003) "Metafrontier functions for the Study of interregional productivity differences", Working Paper Series No. 01/2003. Centre for Efficiency and Productivity Analysis, School of Economics University of Queensland, September 2003. [Online]. Available: http://www.uq.edu.au/economics/cepa/docs/WP/WP012003.pdf [Accessed: 13 November 2013].

[36] Squires, D. and Tabor, S. (1991) "Technical efficiency and future production gains in Indonesian agriculture", *The Developing Economies*, Vol. XXIX-3, pp. 258–270. ISSN 1746-1049. DOI 10.1111/j.1746-1049.1991.tb00211.x.

[37] Suharyanto Mulyo, J. H., Darwanto, D. H. and Widodo, S. (2013) "Technical efficiency analysis of integrated crop management (ICM) of rice in Bali, Indonesia", *SEPA*, Vol. 9, No. 2, pp. 219–230. ISSN 1829-9946.

[38] Tung, D. T. (2014) "Regional differences in measuring the technical efficiency of rice production in Vietnam: A metafrontier approach", *Journal of Agricultural Science",* Vol. 6, No. 10, pp. 147-157. ISSN 1916-9752. DOI 10.5539/jas.v6n10p147.

[39] Uddin, M. M., Brümmer, B. and Peters, K. J. (2014) "Technical efficiency and metatechnology ratios under varying resource endowment in different production systems: A stochastic metafrontier model in Bangladesh dairy farms", *China Agricultural Economics Review*, Vol. 6, No. 3, pp. 485-505. ISSN 1756-137X. DOI 10.1108/CAER-06-2013-0088.

[40] Widodo, R. (1986) "An econometrics study of production efficiency among rice farmers in irrigated lowland villages in Java, Indonesia", *Ilmu Pertanian*, Vol. 4, No. 3, p. 121–145.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Trade Impacts of Selected Free Trade Agreements on Agriculture: The Case of Selected North African Countries

B. M. Hndi, M. Maitah, J. Mustofa

Faculty of Economics and Management, Czech university of Life Science Prague, Czech Republic

Abstract

The objective of the study is to examine the impact of free trade agreements (FTA) with agricultural trade flow in general and dairy, vegetable, live animals, meat and sugar in particular. To achieve the objective the paper employs gravity model through compiling panel data. The study focuses on selected North African countries (Algeria, Egypt, Morocco and Tunisia) as reporting countries and the rest of the world as partner countries. Accordingly, the study finds that being a member of trade agreement (FTA) is positively associated with aggregate agricultural trade flow. In fact, trade agreement could increase agricultural trade flow by around 39 percent in trade volume (USD). Further, the study finds the potential of trade creation. In fact, the trade agreement with EU created a market for former Soviet countries (Latvia and Lithuania). Notably, due to the trade accord, the countries start exporting commodities such dairy and vegetable products. However, despite the results, the disaggregate agriculture fails to have a similar association. For instance, vegetable trade flow is positively influenced by FTA while live animals trade is affected negatively by FTA. Therefore, it requires vigilance when making a conclusion regarding the effect of FTA on disaggregates agriculture trade flow.

Keywords

Agriculture, panel data, gravity model, trade flow.

Hndi, B. M., Maitah, M. and Mustofa, J. (2016) “Trade Impacts of Selected Free Trade Agreements on Agriculture: The Case of Selected North African Countries", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 39 - 50. ISSN 1804-1930, DOI 10.7160/aol.2016.080304.

Introduction

There have been several types of research regarding the effect of trade agreement (TA) on the economy. More specially, the previous study includes the TAs effect on the volume of trade, economic growth, well-being, foreign directed investment (FDI), environment, prices, industries, and agriculture sector. However, the debate on the effect of a trade agreement to the economy remains controversial. In fact, the finding seems to differ based on the studies use of methodology, data, region and countries, and commodities considered. For instance, the impact of the trade agreement on agriculture differs depending the area and countries (Svatoš et al., 2014; Smutka, and Burianová, 2013). Therefore, the impact of the trade agreement on agriculture receives considerable attention in the case of developing countries. Developing countries are concerned because they heavily depend on agriculture, and developed countries tend to protect the agriculture sector (Svatoš et al., 2010; Svatoš and Smutka, 2009) through subsidy and import barriers (Hoekman and Olarreaga, 2004).

Hence, taking into account the prominent of the agriculture sector in creating employment, input to other industries, and saving and generating foreign currency, many developing countries used to protect their agriculture sector through high tariff. Consequently, exploring the impact of trade agreements on both exports and imports of agriculture is vital. However, surprisingly the area is relatively unexplored, despite the relevance of the issue to low-income countries.

Therefore, this paper aspires to add an input, to this relatively unexplored empirical literature. Accordingly, the research is conducted with the objective of providing a policy input to policy and decision maker through identifying the causal effect of trade agreement and agriculture. Further, the paper aims to contribute to the existing empirical literature through examining the effect of the trade agreement on the agricultural

exports and imports of Algeria, Egypt, Morocco, and Tunisia. The selection of the countries is based on the relevance of agriculture sector to their respective economy and the fact that this study is relatively unexplored in the region make it a valuable addition to the literature. Additionally, the similarity of countries in culture, religion, language, and geography make them a natural control and treatment countries in examining the effect of trade policy.

The next section discusses the key theoretical and empirical issues in the influence of the trade agreement on some macroeconomic variables and agriculture trade flow. Next to the practical and theoretic issues, gravity model specification and data will be discussed. Following methodology and data, the empirical result from gravity model will be analysed. In the last section, policy implication and conclusions will be discussed.

Review of literature

There are several empirical papers trying to examine the effect of trade agreement. One from them is (Grant and Lamber, 2008) using modified gravity model examines the effect of regional trade agreements (RTA) on agricultural trade flow. Unlike the traditional gravity studies, which applies aggregate data, in this study the authors take separate data for agriculture and non-agriculture trade flow, conceding the effect could be different based on the type of products. Accordingly, the authors examine if trade agreement increases agricultural trade flow more than non-agricultural products. Further, the study examines whether phases in the RTA agreement have a significant impact. The ex-post finding shows that there is an evidence confirming trade-flow of agriculture increasing more than non-agriculture. Further, it is evident it could take several years for a trade agreement to take an effect on agricultural trade flow.

In a similar vein, (Sun and Reed 2010) through employing both Poisson Pseudo-Maximum-Likelihood (PPML) and gravity model they examine the effect of free trade agreements (FTA) on agriculture. Particularly, the study focuses on trade creation and diversion in response to trade agreements (FTA). In the outset, the paper finds that PPML estimation gives a different result to OLS estimation. Notably, when the zero trade is taken into the study the finding from PPML fundamentally differ from OLS. Accordingly, the study finds that free trade agreements (FTA) such as ASEAN-China, EU-15, EU-25, and SADC increased agricultural trade among member countries. More specifically, EU-15 increases agricultural trade among members through diversion of trade while in the SADC it increases through trade creation. In fact, in the case of SADC non-member countries were also beneficial from the trade agreement. On a contrary, NAFTA created trade diversion only. For that matter, NAFTA failed to establish trade.

Similar to Sun and Reed (2010), Koo et al. (2006) take trade agreements such as the Caribbean community and common market (CARICOM), EU-15, the southern common market (MERCOSUR), and the North American free trade agreement (NAFTA), examine the effect of trade agreements on agricultural trade. However, uniquely from the previous papers, the authors study the externality of the trade agreements as well. More specifically, the study examines the diversion effect of the trade agreement to non-members as well. The diversion is studied through employing dummy variables. Accordingly, the finding shows that on one hand NAFTA failed to have a significant effect in increasing agricultural trade flow between members. On other hands, the agricultural trade diversion from non-member countries into member countries is insignificant. The possible explanation, for the insignificance of the NAFTA, is that the countries have already an established trade flow because of the proximity. The non-existence of diversion effect shows that non-members countries may not be affected by trade agreements.

Lambert and McKoy (2009), admitting non-existence of the effect of sectoral analysis on agriculture, examine the effect of PTA on agriculture and food products. To achieve the objective, the paper employs gravity model and both inter-bloc and extra-bloc agricultural trade. Accordingly, the study shows that intra-bloc agricultural trade increasing due to a preferential trade agreement (PTA). This finding confirms that PTA results in a creation of trade among signatory countries. However, the result also confirms that it results in trade diversion from extra-bloc to intra-bloc countries. The diversion is particularly prevalent in developing countries.

In another seminal paper (Anderson and Valenzuela, 2007) estimates the effect of trade distortions on value-added agricultural output in different countries. The study reveals that moving towards free trade farm income in developing countries increases. The move towards free trade results in alleviating poverty in developing countries. Further, the study found net food importers are

also benefiting despite the term of trade distortions. However, the finding does not show each and every developing country farmers income improves from the globalisation. Last but not least, own countries trade distortion policies tend to harm the agriculture sector more than the non-agriculture sector. In a nutshell, the research concludes that multilateral trade among countries is beneficial in improving farmer's net income.

Medvedev (2006) in his article studies the effect of preferential trade agreements (PTA) on the trade flow of member countries. To achieve the objective, the author employs world trade matrix and detailed enforced preferential trade agreements (PTA). In compiling the essential database, the author considers trade pattern between PTA countries is a weak measure of preferential trade. In fact, using gravity model and total trade to estimate the effect of PTA on Trade flow between signatory countries will result in a biased PTA coefficient. More specifically, the coefficient would be downward biased. Therefore, the author aspires to solve the problem through using world trade matrix and detailed enforced preferential trade agreements (PTA). Accordingly, the author finds the aggregate trade agreements have a significant effect on trade flow. However, the marginal impact of trade agreements differs. For instance, the impact of south-south preferential trade agreements is more than north-south preferential trade agreements. Further, the finding shows that the north-north agreement to have affecting significantly.

Another important article by Miljkovic and Shaik, (2010) estimate the impact of trade openness on technical efficiency of agriculture sector in the US. The study is conducted using stochastic frontier analysis (SFA). The finding shows that trade openness fails to influence the technical efficiency of the agriculture sector in the US significantly. Further, there is no difference even after dividing the trade openness into the share of export and import. The finding means that importing agricultural commodities after removing some tariff barriers fails to boost the agriculture productivity in the US. Similarly, an export increase due to fewer restrictions in trading countries fails to improve the technical efficient of agriculture in the US. Therefore, the trade openness does not have a positive effect on the technical efficiency of the agriculture sector.

In more particular and relevant article, Aghrout (2007) examines the impact of a bilateral trade agreement. More specifically, the author examines Algerian trade association agreement with European Union (EU). The finding shows that the new partnership agreement results in eliminating the preferential status of Algeria with European countries (EU). However, Algeria remains to benefit from the trade agreement for the export items. Last but not least, the author also examines the potential effect of the trade agreement on foreign directed investment (FDI) flow into Algeria. Accordingly, the result shows that the effect is minimal. The potential effect is that the agreement affects the FDI slightly, and this is also in line with the general FDI flow into the region.

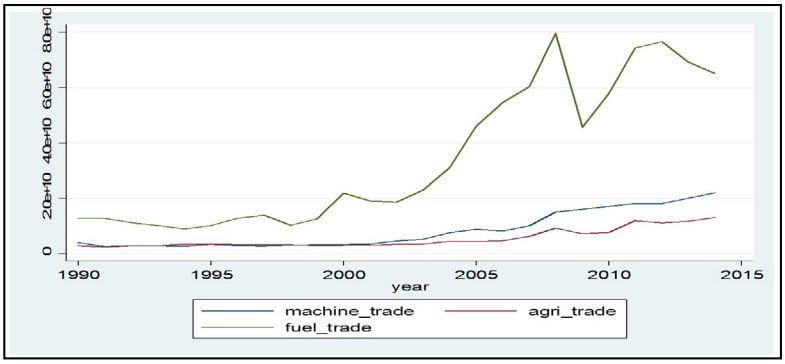
Trade structure of selected countries

As we can observe in the figure below the main export and import commodities of Algeria includes machinery, agriculture, and petroleum. Particularly, from 2000 onwards the trade flow increases. For instance in 2014, Algeria trade balance was $3.62B with $63.7B export and $60B import. The top export items include petroleum ($60.7B), coal ($1B), Ammonia ($603M) and others. On other hand, the top import includes cars and trucks ($4.18B), wheat ($2.3B), petroleum ($2.06B), medicaments ($1.91B) (Figure 1).

Similarly, agriculture trade consists the majority of the traded commodes from 1990 to 2000. However, after 2000 petroleum trade over takes the agriculture trade. While it over takes machinery trade. For instance, in 2014, Egypt trade balance was negative $49.2B with $33.2B export and $82.4B import. The top export commodities include petroleum ($8.14B), wire ($996M), video displays ($757M), and gold ($667M). While the top imports constitute refined petroleum ($10.26B), wheat ($5.36B), iron ($2.9B) and cars ($2.27B). AS can be seen from the figure Algeria and Egypt import a significant amount of wheat from abroad (Figure 2).

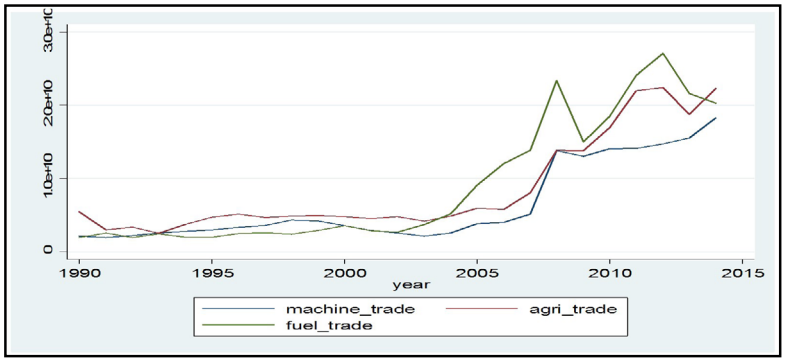
From 1990 to 2000 agriculture takes the lion's share of trade in case of morocco and followed by machinery and petroleum trade. However, after 2000 the share of agricultural trade decreased proportionally as compared to machinery and petroleum trade. For instance in 2014, Morocco trade balance was negative $17.1B with $27.8B export and $44.9N import. The exports includes wire ($3.02B), minerals and chemicals ($5.62B), and suits ($1.35B). on the other hand, petroleum consists ($8.77B), cars ($1.64B), and wheat ($1.42B) (Figure 3).

Similarly, to the previous North African countries,



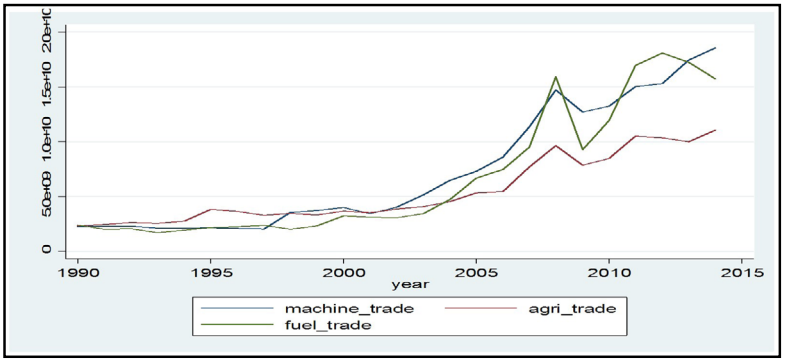
Source: Authors own stata plot

Figure 1: Algeria trade flow.



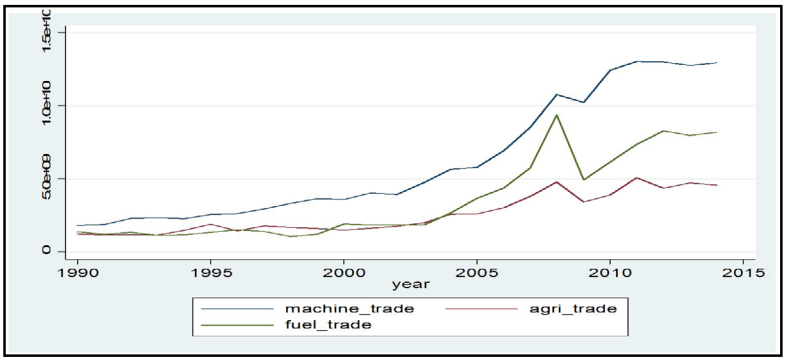
Source: Authors own stata plot

Figure 2: Egypttrade flow.



Source: Authors own stata plot

Figure 3: Morocco trade flow.



Source: Authors own stata plot

Figure 4: Tunisia trade flow.

Tunisia's trade structure shows that agriculture plays an import role following machinery and petroleum trade flow. If we examine the trade flow it shows a significant increase from 1990 to 2015. If we observe the dynamics, for instance in 2014, Tunisia imported $22.7B and exported $16.1B remaining with $6.54B negative trade balance. The export constitutes, wire ($1.78B), suits ($1.76B), petroleum($1.33B), and others. While the top imports constitute petroleum ($4.02B), cars ($603M), wheat ($464M) and others agriculture and non-agriculture commodities (Figure 4).

Materials and methods

Methods

According to the gravity model, the pattern of trade among nations is determined primarily by distance and economic size of trading countries. The model stipulates that countries with large economy are likely to produce, consume and export more. These countries will be able to generate more revenue and spending it by importing other commodities. Further, the model assumes geographical location between countries have an impact on both cost of export and import. The basic gravity model assumes only economy size and distance between countries determine trade.

After some refinements and extensions, the gravity model is heavily used in studying the effect of trade agreements. Further, empirically it is proven to be useful in identifying the effect of trade agreements on agricultural trade, economic growth, foreign directed investment, human development, price stability, employment, women's decision making power and so on. Therefore, following works of Anderson (1979), Deardorff (1998), Baier and Bergstrand (2001), Eaton and Kortum (2002), Anderson and van Wincoop (2003) and Baier and Bergstrand (2007) we will estimate the causality between free trade agreement (FTA) and Agricultural trade flow.

According to this model, the impact of trade agreement can be estimated using the gravity model as follows:

$$lnAGR_{ij} = \gamma_0 + \gamma_1 lnGDP_i + \gamma_2 lnGDP_j + \gamma_3 lnPOP_i + \gamma_4 lnPOP_j + \gamma_5 DIST_{ij} + \gamma_6 LANG_{ij} + \gamma_7 COLONY_{ij} + \gamma_8 FTA_{ij} + \varepsilon_{ij} \quad (1)$$

Where: AGR_{ij} is the value of agricultural trade flow from country i to country j. GDP_i and GDP_j represent nominal domestic product in both country i and j respectively. The variables $nPOP_i$ and $lnPOP_j$ show the growth in the population in both reporting and partner countries respectively. While $DIST_{ij}$ measures the geographical distance between country i and j from their economic centre (capital city in most cases). Since similarity of language plays an important role in trading a binary variable $LANG_{ij}$ which have a value of one if the language is the same and zero if they have different language is incorporated. Last but not least, membership in to free trade agreement (FTA) is taken in to account that is FTA_{ij}. According to Anderson (1979), Deardorff (1998), Baier and Bergstrand (2001), Eaton and Kortum (2002), Anderson and van Wincoop (2003) and Baier and Bergstrand (2007), this estimation help find unbiased estimate of γ_0, γ_1, γ_2, γ_3, γ_4, γ_5, γ_6, γ_7 and γ_8. Therefore, in this research the gravity model will be estimated.

Independent variable	Description	Expected sign
GDP_i	Gross Domestic Product for reporting country i	+
GDP_j	Gross Domestic product for partner country j	+
POP_i	Population of reporting country i	+
$POPj$	Population of partner country j	-
$DIST_{ij}$	Distance between reporting and partner countries i and j	-
$LANG_{ij}$	Dummy = 1, if country i and j have common language	+
$COLONY_{ij}$	Dummy = 1, if country i and j have colony connection	+

Source: own processing

Table 1: Explanatory variable and expected sign.

Data

The sample used in this study includes selected North African countries and their trade partners. More specifically, Algeria, Egypt, Morocco, and Tunisia are used as reporters and all countries as partner countries. Further, the study employs a sample from 1991 to 2013 and estimate using STATA software. The agriculture data used in the study includes live animals, meat and edible meat offal, dairy, eggs, honey, and ed. Products, edible vegetables, cereals, and sugars and sugar confectionery. For detail component of the agriculture data, one can refer the appendix part. The trade value of the stated agricultural products comes from the United Nations Commodity Trade Statistics Database (COMTRADE). The AGR trade flow variable is generated

by summing the stated agricultural products trade flow.

The study uses the size of an economy and population in the gravity model. To capture the effect of the size of the economy and population for both reporter and partner countries data from World Bank Development Indicators database is employed. Further, taking into account historical factors and geography could play a role in the international trade, variables such as distance, common language, and colonial ties are considered. The geographic and historical data comes from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).

Last but not least, the study uses free trade agreement (FTA) with EU and AGADIR. The trade agreement with European Union countries is included in the variable eu_fta and trade agreement among Algeria, Egypt, Morocco, Tunisia, and Jordan is included in the agadir_fta. The trade agreement data comes from The WTO Regional Trade Agreements database. For estimation convenience, I have created the dummy variable FTA and include both trade agreements with reporting and partner countries.

For analytical reason, we have presented some basic statistical summaries we have used in our study. In the table below, we have included the mean value, standard deviation, minimum and maximum value of the variables. Last but not least, we incorporated the number of observations we include in the study (Table 2).

Results and discussion

In this section, we will present the set of estimations we made to examine the impact of free trade agreement on agricultural trade flow. The estimation is made for both aggregate and disaggregated agricultural trade flow and trade agreements. First, we will examine the implication aggregate free trade agreement trade agreement (FTA) on Agriculture in general and particularly on dairy, vegetable, live animal, meat, and sugar.

As can be observed from the regression results, we can see several interesting and valuable result in Table 3. Taking the gross domestic product (GDP) terms first, we see both reporter and partner country GDP are positively affecting the agricultural trade flow between North African countries and the rest of the world. More specifically, everything remaining the same as reporter state GDP increases by 1 percent, the agricultural trade flow increases by approximately 0.965 percent. Similarly, as the partner country GDP increases by 1 percent the agricultural trade flow between reporter and partner country increases by about 0.532 percent. The difference in the magnitude is expected, taking into account the level of protection the North African countries (reporting countries) have to non-members. On the other hand, the partner countries have both lesser protection and trade agreements with several countries. Last but not least, the GDP coefficients for both cases are statistically significant. In fact, the P-values are below 0.001 and it is indicated by three stars.

The second import result is the impact of distance in influencing the agricultural trade between reporting and partner countries. In line with our expectation, everything remaining constant as the distance between reporting and partner countries increase the agricultural trade between the countries is negatively affected. However, the magnitude is weaker. For instance, everything remains the same as the distance between reporting and partner countries increases by 1000 kilometer

Variable	Obs	Mean	Std. Dev.	Min	Max
ln_gdp_rep	9863	24.91476	.5091146	23.58149	25.60625
ln_gdp_par	9863	25.36595	2.102228	18.79031	30.32542
ln_pop_rep	9863	17.34273	.7329548	15.93396	18.31064
ln_pop_par	9859	16.6305	1.579587	11.15138	21.03389
ln_agricul~e	9863	13.3239	3.238161	1.098612	21.72579
ln_dairy	4581	12.69944	3.070172	0	19.86685
ln_vegtable	5957	12.04713	3.050945	0	19.93752
ln_animal	1984	10.97154	3.278014	2.564949	18.74443
ln_meat	1907	11.74744	3.139194	2.197225	20.45946
ln_sugar	5432	11.62056	3.012901	0	20.63956

Source: Authors own estimation

Table 2: Description of data used in the study.

	(1)	(2)	(3)	(4)	(5)	(6)
	ln_agricul~e	ln_dairy	ln_vegtable	ln_animal	ln_meat	ln_sugar
ln_gdp_rep	0.965***	1.226***	0.170	1.131***	0.455	0.908***
	(8.84)	(7.29)	(1.31)	(3.99)	(1.77)	(6.41)
ln_pop_rep	0.175*	-0.494***	1.163***	-1.062***	-0.0724	0.0219
	(2.27)	(-4.19)	(12.81)	(-5.39)	(-0.42)	(0.22)
ln_gdp_par	0.532***	0.452***	0.669***	0.562***	0.292***	-0.00853
	(26.04)	(14.98)	(26.47)	(10.46)	(5.44)	(-0.32)
ln_pop_par	0.0164	-0.404***	-0.0872**	-0.399***	-0.143*	0.494***
	(0.62)	(-10.40)	(-2.82)	(-5.41)	(-2.29)	(13.53)
contig	0.0232	0.0353	0.00101	0.185	-1.108*	0.810***
	(0.13)	(0.14)	(0.01)	(0.57)	(-2.56)	(4.11)
comlang_off	0.270***	0.529***	0.842***	0.648***	-0.416*	0.0641
	(3.50)	(4.84)	(9.38)	(3.38)	(-2.11)	(0.64)
colony	2.134***	0.205	1.677***	1.093***	0.921**	1.784***
	(11.80)	(0.93)	(9.78)	(3.99)	(3.19)	(9.34)
dist	-0.0000567***	0.0000876***	-0.000103***	-0.000126***	0.000135***	-0.000102***
	(-6.03)	(6.79)	(-9.51)	(-4.21)	(7.76)	(-7.52)
fta	0.391***	0.122	0.599***	-0.713***	-0.335	-0.0346
	(4.32)	(0.97)	(6.03)	(-3.73)	(-1.63)	(-0.31)
_cons	-27.46***	-14.75***	-28.30***	-6.435	-4.192	-19.21***
	(-15.23)	(-5.28)	(-12.87)	(-1.43)	(-0.95)	(-8.36)
N	9859	4580	5954	1983	1906	5430

Note: t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001.
Source: author's own estimation using stata

Table 3. Aggregate trade agreement effect on agriculture and selected variables.

agricultural trade decreases by only 0.0567 percent. Despite the magnitude being weak, the result is both statistically significant and coherent with the trade theories. Although, it requires further research one can give credit to globalization and technology in reducing transportation costs and reducing the importance of distance in agriculture trade.

The other historical and social variable influencing trade pattern is having common colonial tie and language. In line with previous research results both have a positive effect on agricultural trade flow between reporting and partner countries. For instance, citrus Paribas having similar colonial tie increases the trade flow by approximately 2.134 percent as compared to partner country without a colonial tie. Further, having the same language increases the trade flow by around 0.27 percent. Both results are statistically significant, and the P-value is below 0.001.

The last but, valuable result is the effect of the trade agreement on the aggregate agriculture and disaggregated agricultural trade flow. The result for aggregate agriculture shows that everything remaining constant free trade agreement between reporter and partner countries increases the trade flow by approximately 39.1 percent. The result is both coherent with our expectation and statistically significant. In fact, similar to our previous coefficients it has a p-value of less than 0.001.

To capture the specific effect of FTA on agriculture, we have estimated the impact of FTA on dairy, vegetable, live animals, meat, and sugar. Accordingly, the result shows that trade agreement have a positive effect on dairy and vegetable products while it has an adverse effect on live-animal, meat, and sugar. However, from these results only coefficient for vegetable and live animal are statistically significant. More specifically, everything remaining constant trade agreement increases vegetable trade flow between partner countries by approximately 60 percent. In contrast, trade agreement decreases live animal trade by around 71 percent. The result for the later indicates that other factors are determining live-animal trade between reporter and partner countries. In fact, it is valuable to see if the result differs among different trade agreements and North African countries.

Therefore, to make sure different trade agreements have a similar impact on agricultural trade flow we estimated aggregated and disaggregated agriculture trade flow on EU and AGADIR trade agreements. Accordingly, the result for aggregate agriculture

shows that both EU and AGADIR trade agreement have a positive effect on agriculture trade flow. However, the magnitude of the effect shows us there is exists a difference. For instance, free trade agreement with EU countries increases agricultural trade flow by approximately 35 percent. The result is coherent with empirical literature results, and it is statistically significant with p-value of 0.001. Similarly, the trade agreement among Algeria, Egypt, Tunisia, Morocco and Jordan (AGADIR) positively influence the agricultural trade flow between signatory countries. In fact, the trade agreement affects the trade flow by more than 70 percent everything remaining constant. Further, the result is found to be statistically significant with a p-value of below 0.05.

In Table 4 below we further examined the effect of EU and AGADIR trade agreements on dairy, vegetable, live animal, meat and sugar trade flows. Accordingly, EU trade agreement affects vegetable and live animal trade significantly. While AGADIR trade agreement influencing dairy and live animal trade flow.

More specifically, dairy trade is influenced positively by AGADIR trade agreement. In fact, as a result of AGADIR trade agreement the milk trade flow between signatory countries increases by more than 100 percent. The result is in line with our expectation, and it is statistically significant with a p-value of below 0.001. However, we have to be vigilant in interpreting this result because the change may not necessarily reflect the volume of agricultural trade.

The other significant causality we can observe is between EU and AGADIR trade agreement and vegetable trade flow between reporting and partner countries. The estimation shows that both EU and AGADIR trade agreement positively influence vegetable trade flow. More specifically, EU trade agreement causes vegetable trade to increase by 48 percent while AGADIR trade agreement increases the trade flow by around 155 percent. Both coefficients are statistically significant with a p-value of 0.001.

Contrary, to the previous results trade agreement, negatively affect live animal trade. More specifically, in response to a trade agreement with EU countries agricultural trade decreased

	(1)	(2)	(3)	(4)	(5)	(6)
	ln_agricul~e	ln_dairy	ln_vegtable	ln_animal	ln_meat	ln_sugar
ln_gdp_rep	0.967***	1.241***	0.182	1.137***	0.455	0.910***
	(8.86)	(7.38)	(1.39)	(4.01)	(1.77)	(6.42)
ln_pop_rep	0.171*	-0.517***	1.146***	-1.069***	-0.0728	0.0191
	(2.22)	(-4.38)	(12.61)	(-5.41)	(-0.42)	(0.19)
ln_gdp_par	0.535***	0.466***	0.683***	0.566***	0.292***	-0.00661
	(25.99)	(15.30)	(26.69)	(10.43)	(5.33)	(-0.24)
ln_pop_par	0.0115	-0.426***	-0.106***	-0.405***	-0.144*	0.491***
	(0.43)	(-10.82)	(-3.37)	(-5.42)	(-2.25)	(13.25)
contig	0.0385	0.0887	0.0514	0.198	-1.107*	0.818***
	(0.22)	(0.36)	(0.27)	(0.61)	(-2.55)	(4.13)
comlang_off	0.245**	0.424***	0.758***	0.624**	-0.418*	0.0509
	(3.07)	(3.73)	(8.14)	(3.17)	(-2.03)	(0.49)
colony	2.148***	0.273	1.721***	1.112***	0.923**	1.791***
	(11.85)	(1.24)	(10.02)	(4.02)	(3.16)	(9.35)
dist	-0.0000576***	0.0000834***	-0.000106***	-0.000127***	0.000135***	-0.000102***
	(-6.11)	(6.44)	(-9.77)	(-4.23)	(7.69)	(-7.53)
eu_fta	0.355***	-0.0362	0.487***	-0.741***	-0.338	-0.0541
	(3.73)	(-0.27)	(4.65)	(-3.73)	(-1.52)	(-0.45)
agadir_na	0.708*	1.095***	1.554***	-0.408	-0.318	0.0835
	(2.57)	(3.34)	(5.15)	(-0.65)	(-0.60)	(0.29)
_cons	-27.43***	-14.68***	-28.28***	-6.481	-4.195	-19.19***
	(-15.21)	(-5.26)	(-12.88)	(-1.44)	(-0.95)	(-8.35)
N	9859	4580	5954	1983	1906	5430

Note: t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001.
Source: author's own estimation using stata

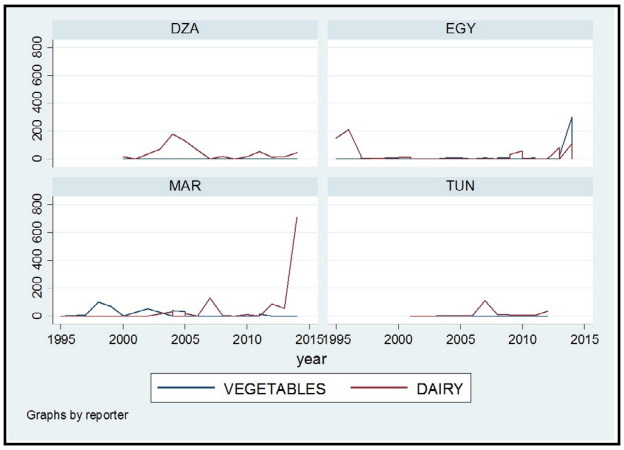
Table 4:. EU and AGADIR trade agreement effect on Agriculture and selected variables.

by more than 74 percent. However, the AGADIR trade agreement fails to impact the live animal trade.

Last but not least, an interesting finding from examining the trade flow is the potential of trade creation. This trade creation is particularly true between North African countries and former soviet countries (Latvia and Lithuania). More specifically, the trade flow of Algeria, and Tunisia with Lithuania sharply increased in both dairy and vegetable products in response to EU trade agreement. This trade creation could be seen in the second and third quadrant of figure 5. Similarly, in figure 6 it observable the trade creation particularly with Algeria (DZA), Egypt (EGY), and Tunisia (TUN).

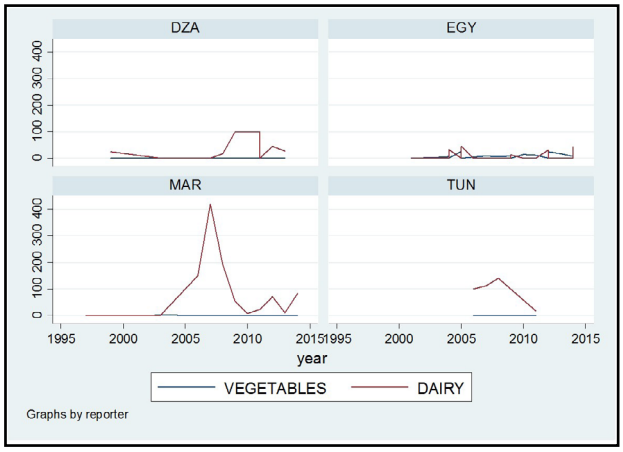
In summary, the empirical result shows that trade agreement boosts trade flow between partner countries. This result is in line with the summary of our data. For instance, if we see the trade before and after the trade agreement on average we observe trade flow increasing. This result is presented in the following table 4. However, we have to be careful not to overstate the implication of the summary result. Because, the increase in trade flow could also be due to other factors such as economic growth, foreign aid, and other factors which could affect agricultural trade flow.

If we observe the mean value for all countries,



Note: the y-axis (trade flow) is in 10,000 dollars
Source: Authors own stata plot

Figure 5: Lithuania Trade Creation with selected North African countries.



Note: the y-axis (trade flow) is in 10,000 dollars
Source: Authors own stata plot

Figure 6: Latvia Trade Creation with selected North African countries.

Algeria					
Agriculture	Obs	Mean	Std. Dev.	Min	Max
Before TA	908	2.99e+07	8.60e+07	3	6.78e+08
After TA	941	5.47e+07	2.06e+08	38	2.73e+09
Egypt					
Agriculture	Obs	Mean	Std. Dev.	Min	Max
Before TA	1764	1.58e+07	8.17e+07	57	1.44e+09
After TA	1918	3.67e+07	1.56e+08	10	2.18e+09
Morocco					
Agriculture	Obs	Mean	Std. Dev.	Min	Max
Before TA	1406	1.03e+07	3.28e+07	62	3.18e+08
After TA	1394	2.21e+07	8.55e+07	13	9.86e+08
Tunisia					
Agriculture	Obs	Mean	Std. Dev.	Min	Max
Before TA	1107	5888018	1.61e+07	4	1.30e+08
After TA	915	1.14e+07	3.29e+07	4	2.90e+08

Source: Authors own summary

Table 5: Average Trade flow before and after trade agreement.

the agricultural trade flows after trade agreement show a significant increase. For instance, the agricultural trade flow of Algeria increased from 29.9 million USD to 54.7 million USD.

Conclusion

In our study similar to Grant and Lamber (2008) we found trade agreement have a significant impact on agricultural trade flow although the full impact could lag for some time. Further, the study finds the impact could differ based on the commodities considered. Therefore, the finding in our current article coincides with Grant and Lamber (2008). In a similar vein, our finding regarding trade creation is coherent with what Sun and Reed (2010) found in their study. In their study, Sun and Reed (2010) find trade agreement could potentially create trade between partner countries. However, the finding shows that the trade creation could depend on the type of trade agreement and the partner countries.

The objective of this paper is to examine the effect of different trade agreements on trade flows of both aggregate and disaggregate agriculture. To achieve the objective, the article uses selected North African countries (Algeria, Egypt, Morocco, and Tunisia) as reporting countries and the rest of the world as partner countries. Further, the study uses annual nominal agriculture trade flow data from 1991 to 2013 for the selected countries. To correctly identify the causal effect, the article uses gravity model as a workhorse. Accordingly, the study finds that everything remaining constant enforcement of free trade agreement positively influences trade flow of agricultural. This result applies to all trade agreements considered in this study. The disaggregated trade flow data shows that the trade agreement mainly impacts commodities such as vegetable and live animals. However, products such as meat and sugar are failed to be influenced by the trade agreement. This lack of free trade impact on meat and sugar could be because those products are either exported or imported to or from non-member countries. Another possible explanation is the trade for commodities such as dairy, meat and sugar are influenced by other exogenous factors. Therefore, the paper advice for further research regarding factors influencing dairy, meat and sugar trades. However, fortunately, our model could explain the causality of trade flow in aggregate agriculture and vegetable and live animal trade.

Last but not least, one important finding is the potential of trade creation. As could be seen in the appendix figure 3 and 4, the trade agreement with EU created a market for former soviet countries. Particularly, Latvia and Lithuania were able to export dairy and vegetable products to the North African countries. However, in this study we cannot conclude if there exists trade diversion at the cost of the new trade creation.

Acknowledgments

This article was prepared on the materials of the research project “Is there any possibility for functional co-operation of the post-soviet countries?” performed within the internal grant No. 20161014, provided by the Internal Grant Agency of the Faculty of Economics and Management, Czech University of Life Sciences Prague.

Corresponding author:
Jehar Mustofa
Department of Economics, Faculty of Economics and Management, Czech University of Life Science Prague, Kamýcká 129, 165 21 Prague 6 - Suchdol, Czech Republic
E-mail: mustofa.seid@gmail.com

References

[1] Aghrout, A. (2007) "Embracing free trade: The EU's economic partnership with Algeria", *Intereconomics*, Vol. 42, No. 2, pp. 96-104. ISSN 1613-964X. DOI 10.1007/s10272-007-0212-0.

[2] Anderson, J. (1979) "A Theoretical Foundation for the Gravity Equation", *The American Economic Review*, Vol. 69, No. 1, pp. 106-116. [Online] Available: http://www.jstor.org/stable/1802501 [Accessed: April 25, 2016]. ISSN 0002-8282.

[3] Anderson, J. E. and van Wincoop, E. (2003) "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, Vol. 93, pp. 170-192. ISSN 0002-8282. DOI 10.1257/000282803321455214.

[4] Anderson, K. and Valenzuela, E. (2007) "Do global trade distortions still harm developing country farmers?", *Review of World Economics*, Vol. 143, No. 1, pp. 108-139. ISSN 1610-2886. DOI 10.1007/s10290-007-0100-5.

[5] Baier, S. L. and Bergstrand, J. H. (2001) "The growth of world trade: tariffs, transport costs, and income similarity", *Journal of International Economics*, Vol. 53, No. 1, pp. 1-27. ISSN 0022-1996.

[6] Baier, S. L. and Bergstrand, J. H. (2007) "Do free trade agreements actually increase members' international trade?", *Journal of International Economics*, Vol. 71, No. 1, pp. 72-95. ISSN 0022-1996.

[7] Deardorff, A. (1998) "Determinants of bilateral trade: does gravity work in a neoclassical world?", In: *The regionalization of the world economy* (pp. 7-32), University of Chicago Press. [Online] Available: http://www.nber.org/books/fran98-1 [Accessed: May 10, 2016]. ISBN 0-226-25995-1.

[8] Eaton, J. and Kortum, S. (2002) "Technology, geography, and trade",.*Econometrica*, Vol. 70, No. 5, pp. 1741-1779. E-ISSN 1468-0262, ISSN 0012-9682. DOI 10.1111/1468-0262.00352.

[9] Grant, J. H. and Lambert, D. M. (2008) „Do regional trade agreements increase members' agricultural trade?", *American Journal of Agricultural Economics*, Vol. 90, No. 3, pp. 765-782. E-ISSN 1467-8276, ISSN 0002-9092. DOI 10.1111/j.1467-8276.2008.01134.x.

[10] Hoekman, B., Ng, F. and Olarreaga, M. (2004) "Agricultural tariffs or subsidies: which are more important for developing economies?", *The World Bank Economic Review*, Vol. 18, No. 2, pp. 175-204. E-ISSN 1564-698X, ISSN 0258-6770. DOI 10.1093/wber/lhh037.

[11] JinLambert, D. and McKoy, S. (2009) „Trade creation and diversion effects of preferential trade associations on agricultural and food trade", J*ournal of Agricultural Economics*, Vol. 60, No. 1, pp. 17-39. [Online] Available: http://etd.lsu.edu/docs [Accessed: July 10, 2016]. E-ISSN 1477-9552, ISSN 0021-857X.

[12] Medvedev, D. (2006) "Preferential trade agreements and their role in world trade", World Bank Policy Research Working Paper, (4038). [Online] Available: http://ssrn.com/abstract=938031 [Accessed: July 15, 2016]. ISSN 1610-2878. DOI 10.1596/1813-9450-4038.

[13] Medvedev, D. (2006) „Beyond trade: The impact of preferential trade agreements on foreign direct investment inflows" (Vol. 4065). World Bank Publications. [Online] Available: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2006/11/09/000016406_20061109154341/Rendered/PDF/wps4065.pdf [Accessed: July 15, 2016]. DOI 10.1596/1813-9450-4065.

[14] Miljkovic, D. and Shaik, S. (2010) "The impact of trade openness on technical efficiency in US agriculture", Agribusiness & Applied Economics Report, 95749. [Online] Available: http://agecon.lib.umn.edu/. [Accessed: July 12, 2016].

[15] Svatoš, M., Smutka, L. and Ishchukova, N. (2014) "The position of agriculture in the Russian Federation – the last two decades development overview", *Agricultural Economics* (Czech Republic), Vol. 60, No. 11, pp. 489-502. ISSN 0139-570X.

[16] Svatoš, M., Smutka, L. and Miffek, O. (2010) "Competitiveness of agrarian trade of EU-15 countries in comparison with new EU member states", *Agricultural Economics* (Czech Republic), Vol. 6, No. 12, pp. 569-582. ISSN 0139-570X.

[17] Svatoš, M. and Smutka, L. (2009) "Influence of the EU enlargement on the agrarian foreign trade development in member states", *Agricultural Economics* (Czech Republic), Vol. 55, No. 5, pp. 233-249. ISSN 0139-570X.

[18] Smutka, L. and Burianova, J. (2013) "The competitiveness of Czech agrarian trade within the context of the global crisis", *Agricultural Economics* (Czech Republic), Vol. 59, No. 4, pp. 183-193. ISSN 0139-570X.

[19] Sun, L. and Reed, M. R. (2010) „Impacts of free trade agreements on agricultural trade creation and trade diversion", *American Journal of Agricultural Economics*, Vol. 92, No. 5, pp. 1351-1363. [Online] Available: http://www.iari.res.in/files/Divisions [Accessed: June 20, 2016]. E-ISSN 1467-8276, ISSN 0002-9092. DOI 10.1093/ajae/aaq076.

Volume VIII Number 3, 2016

Variational Online Budgeting Taking into Account the Priorities of Expense Items

A. V. Ilyin, V. D. Ilyin

Laboratory of Methodological Basics of Information Technology Implementation, Institute of Informatics Problems, Federal Research Center "Computer Science and Control", Russian Academy of Sciences, Russia

Abstract

The paper describes the methodology of variational interval budgeting in a system with hierarchical structure of expense items. The priorities of expense items can be specified at any level of hierarchy. To account for the actually existing information incompleteness, the methodology provides the ability to input data and receive the results as numeric segments. The ability to clarify the budget plan in the course of its implementation is also provided. The article presents main characteristics of the working online service “Cost Planning” and example of the farm budget planning.

Keywords

Variational Online Budgeting, Priorities of Expense Items, Interval Cost Planning, Resource Planning Online Services, SaaS.

Ilyin, A. V. and Ilyin, V. D. (2016) “Variational Online Budgeting Taking into Account the Priorities of Expense Items", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 51 - 56. ISSN 1804-1930, DOI 10.7160/aol.2016.080305.

Introduction

The planned revenues of states, corporations and most of individuals depend on sales volumes, market prices, exchange rates and other factors that determine the changes in economic situation. The greater anticipation of the forecast, the less reason to represent the result as a point, i.e. exact number. However, even for the state budgets expenditures are planned on the basis of point assumptions about the amount of income. The requests of expense items and the planning results also have a point representation. Therefore, the budget plans are inevitably inaccurate and need to be remade in the course of implementation. Furthermore, sometimes a set of income sources and expense items changes at different levels of hierarchical details of the planned budget. All these factors should be considered when developing the budget planning methodology (Ilyin, 2013).

The software products known to the authors provide point representation of data and results: in particular, BizBudg Online (BizBudg Online, 2016), Budget Cruncher 3.10 (Budget Cruncher, 2016), PlanGuru (PlanGuru, 2016), Questica Budget (Questica Budget, 2016), etc. One of the lists of modern products, which include means for solving problems of budgeting, can be found in (Capterra, 2016).

The authors perform the scientific research "Creating the methodology of informatization of normalized economic mechanism and software implementation of expert resource planning based on e-services" in the Federal Research Center “Computer Science and Control“ of the Russian Academy of Sciences. The first phase of software implementation includes a set of Resource Planning Online Services (www.res-plan.com). In 2015 creation of theoretical foundations of the informatization methodology was finished (Ilyin, Ilyin, 2013; Ilyin, Ilyin, 2014b) and the interval cost planning method (Ilyin, Ilyin, 2014a; Ilyin, Ilyin, 2015) was implemented in the first online service. The method takes into account the actual incompleteness of information for planning budgets.

When planning a farm budget, it is especially important to take into account the information incompleteness, because the projected values of income and expenses depend not only on the market situation, but also on environmental factors.

The presented methodology of the variational interval budgeting in a system with hierarchical

structure of expense items, where priorities may be set at any level of hierarchy, and the online service “Cost Planning”, which implements this methodology, have no known analogues.

Materials and methods

The approach to budgeting

The problem of budget planning is considered as a specialization of the more general problem of interval planning the costs of an arbitrary resource. The problem has the informal statement, containing the mandatory and orienting rules. The mandatory rules include restrictions on the consumption of the resource to ensure the feasibility of solution, and limitations that define non-redundant satisfaction of the requests for resource. The orienting rules define the direction of the search for solution. A solution always satisfies the mandatory rules and satisfies the orienting rules in the extent defined by the interval specifics of the problem. If fulfillment of the orienting rules is possible, the solution corresponding to them is treated as more efficient than any other. A set and form of the rules can be changed by an expert during the search for acceptable plan.

The interval cost planning method taking into account the priorities of expense items is implemented in the working online service which drastically enhances efficiency and flexibility of budget planning.

The concept of Resource Planning Online Services, suggested by Alexander Ilyin, is similar to the “Software as a Service” concept, known as SaaS (Ardagna et al., 2014; Armbrust et al., 2010; Benlian et al., 2009; Chunlin, LaYuan, 2015; Jamsa, 2013; Jede, Teuteberg, 2016; Katzmarzik, 2011; Kavakli et al., 2015; Petcu et al., 2013; Rogers, Cliff, 2012; Sandholm, Lee, 2014; Trumba Corporation, 2007; Wang et al., 2010; Wei, Blake, 2010). The first difference is that res-plan.com does not store data of the users’ tasks on server (this is stipulated by the reasons of security and privacy), and the second one is that res-plan.com users work in special client applications (because stability and performance of web applications depend on the browsers where they work).

In a client application of the “Cost Planning” service user specifies minimum amount of the resource as the sum of opening balance and expected income in the worst case scenario. The maximum amount of the resource should be specified as the sum of opening balance and expected income in the optimal scenario.

User also specifies a table of expense items, and for each row the lowest and the highest expected costs (or exact value) can be entered - the requests of the expense items. A separate table of details can be created for any expense item: for example, the expense item “Communications” can be detailed by the items “Internet”, “Mobile phones”, “Landline phone”, etc. Amount of the resource allocated to the expense item will be distributed between expense items that form its details. The number of detail levels is not limited. The priorities (the weighting coefficients) can be specified for any table. Some requests can be marked as obligatory (e.g. wages or rents can rarely be reduced). Different applied precision (minimal significant value) can be set for data and results for any table.

Then, when user commands 'Allocate' from client application, it connects to the service via Internet and sends it a query for resource planning. The service (program which works on reliable server in 24/7 mode) receives the query, performs computations and immediately sends the results back to the client application. The results are the values 'Allocate min.' and 'Allocate max.' for each expense item - the plan for the worst and the best scenarios. Sum of 'Allocate min.' values complies the specified minimum amount of the resource, and sum of 'Allocate max.' values complies the specified maximum. The principle of computation is described below in the chapter “The principle of interval cost planning, taking into account the priorities of expense items“. The application also displays values 'Allocate avg.' (so user can see an approximate resource allocation).

Afterwards, in the course of the plan implementation, when a part of the resource is received or spent, or more precise information on expected income or costs is obtained, user inputs the corresponding data in client application, executes the command 'Allocate' again, and gets the refined results. If the exact resource amount is specified (i.e. minimum = maximum), then the received values 'Allocate max.' can be treated as exact decision of the cost planning task.

The advantages of the variational online budgeting

If user specifies the bounds for resource and requests cautiously and follows the plan prepared with the Service, then the probability of going beyond the budget is drastically reduced.

For each expense item user beforehand sees the bounds for possible costs, and narrows them

in the course of the plan implementation.

If upper bound is less than minimum request for some item, then user can timely attract investments, or exclude the item, or correct other costs.

If the planning results are too "tight", user can temporarily exclude any expense item from consideration: it can be done by setting a "tick" in the corresponding cell of the table.

User can simulate any real cost: set minimum request equal to maximum, mark it as obligatory, execute the command 'Allocate', and see the changes of bounds for the rest of expense items. User can manually adjust the planning results. A client application will indicate if the entered data is inconsistent.

The principle of interval cost planning, taking into account the priorities of expense items

The resource amount and the requests of expense items are specified as numeric segments.

The values of the planned costs are computed as numeric segments also. First, the resource allocation problem is solved for the top-level expense items. Then, if any expense item has the detailing items, part of the resource allocated to the item is considered as the resource amount to be allocated between the detailing items, and the separate resource allocation problem is solved, etc. For example, part of money allocated to the item “Communications” can be allocated between the items “Electricity“, “Internet”, “Mobile phones”, “Landline phone”; after that, part of money allocated to the item “Mobile phones” can be allocated between the items representing the concrete mobile users. Number of the detailing levels is not limited.

The priorities of expense items can be specified and used in solving each particular resource allocation problem in the hierarchy. The problem has the following informal statement.

For a numeric segment $[a, A]$ ($a \geq 0$, $A > 0$), which expresses the expected resource amount, segments $[b_i, B_i]$ ($b_i \geq 0$, $B_i > 0$, $i = 1 \ldots n$), which specify the requests of expense items, and weighting coefficients (priorities) of the expense items $p_i > 0$ ($i = 1 \ldots n$), it is required to find a cost plan $[x_i, X_i]$: $\{0 \leq x_i \leq b_i, X_i \leq B_i, i = 1 \ldots n\}$. Depending on presence of the resource shortage for sum of the left bounds and sum of the right bounds of the requests, one of the following situations takes place:

1) $\{b_1 + \ldots + b_n > a, B_1 + \ldots + B_n > a\}$.

   In this case the problem for the left bounds is to be solved, and then - the problem for the right bounds (see below).

2) $\{b_1 + \ldots + b_n \leq a, B_1 + \ldots + B_n > a\}$.

   In this case the left bounds are set equal to the minimum requests ($x_i = b_i$), and the problem for the right bounds is to be solved.

3) $\{b_1 + \ldots + b_n > a, B_1 + \ldots + B_n \leq a\}$.

   In this case the problem for the left bounds is to be solved, and the right bounds are set equal to the maximum requests ($X_i = B_i$).

4) $\{b_1 + \ldots + b_n \leq a, B_1 + \ldots + B_n \leq a\}$.

   In this case there is no problem: the left bounds are set equal to the minimum requests ($x_i = b_i$), and the right bounds are set equal to the maximum requests ($X_i = B_i$).

The mandatory rule for solving the problem for the left bounds:

$x_1 + \ldots + x_n = a$.

The orienting rules for solving the problem for the left bounds are the proportions

$x_i : x_j = p_i b_i : (p_j b_j)$ for each $1 \leq i \leq n$, $1 \leq j \leq n$, where $b_j > 0$ (for $b_j = 0$ obviously $x_j = 0$).

The mandatory rule for solving the problem for the right bounds:

$X_1 + \ldots + X_n = A$.

The orienting rules for solving the problem for the right bounds are the proportions

$(X_i - x_i) : (X_j - x_j) = p_i(B_i - b_i) : (p_j(B_j - b_j))$ for each $1 \leq i \leq n$, $1 \leq j \leq n$, where $\{B_i > b_i, B_j > b_j\}$, and $X_i : x_j = p_i B_i : (p_j B_j)$ for each $1 \leq i \leq$ n, $1 \leq j \leq n$, where $\{B_i = b_i, B_j = b_j\}$.

The iterative algorithms for solving the problems for the left and right bounds are described in (Ilyin, Ilyin, 2015).

Results and discussion

The methodology of variational interval budgeting and the online service in which it is implemented, received a positive assessment in the course of discussions in the Federal Research Center “Computer Science and Control” of the Russian Academy of Sciences, in the Moscow Technological University (MIREA), in the ResearchGate

professional network. The Support page of the res-plan.com also allows to write questions, suggestions and comments on the service.

There are no restrictions on scale of the budgeting tasks. The samples for enterprise and family budgets are delivered within client application package (it can be downloaded and used for free during 21 days). The following simple example for a farm budget demonstrates the efficiency of the service (the example purposely contains few expense items to be clear and observable).

The budgeting example

Suppose a farmer plans a budget for the coming month, wanting to hire new worker and buy some new agricultural equipment. He has 11 000 EUR as opening balance and expects to earn 14 000 EUR during the month (total 25 000). The minimal price of equipment is 9 000, the price of the perfect one is 12 000. The minimal cost of a new worker is 1 300, the cost of the optimal one is 1 500.

Without the service

Using a standard approach with point assumptions for income and expenses (AACE International, 2012; Barrett, 2007), a farmer gets a plan like in Table 1.

Following this plan, a farmer buys the equipment for 10 000 EUR, hires a new worker with the minimum salary, and expects the small closing balance. Then, the market situation worsens, and the real income received for the month becomes 11 000 EUR instead of the expected 14 000. As a result, at the end of the month even for zero closing balance the farmer can be faced with the need to borrow 2 000 EUR to pay wages.

Expense item	Allocate money (EUR)
Wages and taxes on it	11 100
Communications	200
Fodder	1 000
Fertilizers	400
New worker	1 300
New equipment	10 000
Accumulation of capital (closing balance)	1 000
TOTAL	25 000

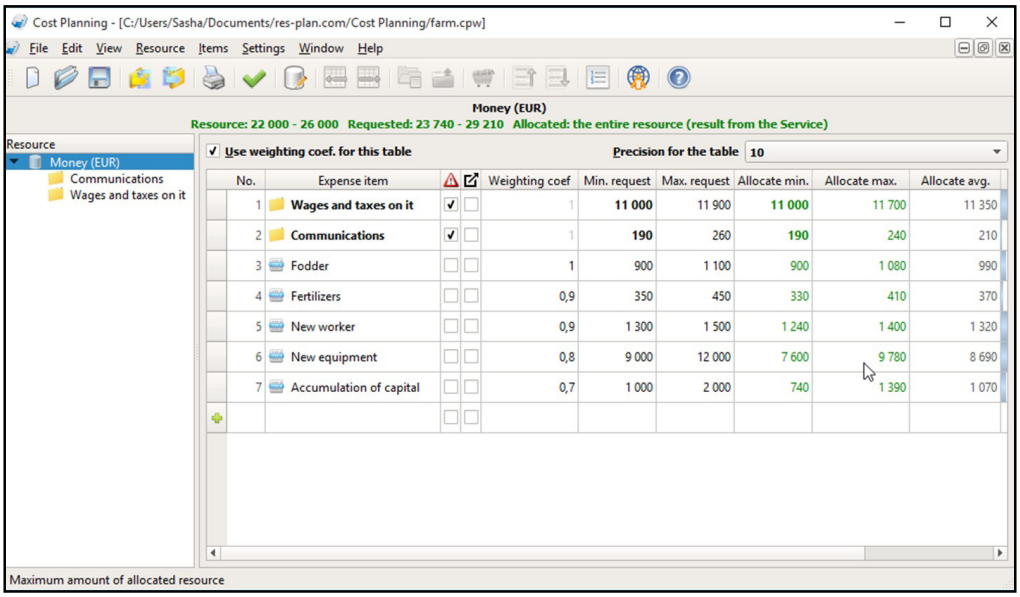
Source: own processing

Table 1: Rigid cost plan – threat to go beyond the budget.

With the service

Using the flexible interval approach of the online service “Cost Planning”, a farmer could estimate the expected resource amount (sum of the opening balance and future income) as a segment, e.g. [22 000, 26 000], specify the requests of expense items (the lowest and the highest expected costs) and their priorities (the weighting coefficients); press the ‘Allocate’ button and receive the following results (the applied precision is set to 10 EUR) (Figure 1).

The results ('Allocate min.', ‘Allocate max.’) show that new equipment should be bought for 9 780 only in the case of the maximum income. The average value ‘Allocate’ for the item ‘New worker’ is



Source: own processing

Figure 1: Flexible cost plan – to be clarified step-by-step, not going beyond the budget.

1 320, so the logical decision can be to hire a worker, but wait with the purchase of equipment.

In the course of the plan implementation, when a farmer makes the real costs, he periodically uses the 'Subtract actual cost…' command from the 'Items' menu, presses 'Allocate' again and gets the refined results. When a part of revenues is received, he can modify the resource specification and re-allocate money again to get more precise plan. If things go well, the equipment can be purchased closer to the end of the month.

So the service user step-by-step narrows the bounds in the data and in the results, staying within the budget.

Conclusion

With innovative interval algorithms implemented in the online service "Cost Planning", it is possible to solve the budgeting problems much more efficiently than using other software. The implemented methodology drastically reduces a probability to go beyond a budget. User specifies the expected minimum and maximum amounts of money, minimum and maximum requests for expense items and their priorities. The service computes minimum and maximum values 'Allocate' for each expense item, which comply the specified data. When user beforehand sees the bounds for possible costs and narrows them in the course of the plan implementation, it is really possible to avoid critical costs, temporarily exclude some expense item from consideration; to correct the planned costs, to attract investments timely.

Usage of the service is significantly cheaper than usage of other budgeting software products (Capterra, 2016). User pays only for that periods, when he/she actually uses a Service. It is advisable to use the service for any entrepreneurs. For farms, it is especially important to compute implementable budgets in condition of information incompleteness.

Corresponding author:
Prof. Vladimir Ilyin, DrSc,
Laboratory of Methodological Basics of Information Technology Implementation,
Institute of Informatics Problems, Federal Research Center "Computer Science and Control" of the Russian Academy of Sciences, 44 Bld. 2 Vavilova st., Moscow, 119333, Russia
Phone: +79164073332, E-mail: vdilyin@ipiran.ru

References

[1] AACE International (2012) "Total Cost Management Framework". [Online] Available: http://www.aacei.org/resources/tcm [Accessed May 25, 2016].

[2] Ardagna, D., Casale, G., Ciavotta, M., Pérez, J. F. and Wang, W. (2014) "Quality-of-service in cloud computing: modeling techniques and their applications", *Journal of Internet Services and Applications*, Vol. 5, No. 11. ISSN 1869-0238. DOI 10.1186/s13174-014-0011-3.

[3] Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., Lee, G., Patterson, D., Rabkin, A., Stoica, I. and Zaharia, M. (2010) "A view of cloud computing", *Communications of the ACM*, Vol. 53, No. 4, pp. 50-58. ISSN 0001-0782. DOI 10.1145/1721654.1721672.

[4] Barrett, R. (2007) "*Planning and Budgeting for the Agile Enterprise: A driver-based budgeting toolkit*", CIMA Publishing, 240 p. ISBN 978-0750683272.

[5] Benlian, A., Hess, T. and Buxmann, P. (2009) "Drivers of SaaS-Adoption – An Empirical Study of Different Application Types", *Business & Information Systems Engineering,* Vol. 1, No. 5, pp. 357-369. E-ISSN 1867-0202, ISSN 1867-0202. DOI 10.1007/s12599-009-0068-x.

[6] BizBudg Online (2016) "BizBudg Online". [Online] Available: http://bizbudg.com/budgeting.html [Accessed May 25, 2016].

[7] Budget Cruncher (2016) "Budget Cruncher 3.10". [Online] Available: http://www.budgetcruncher.com/ [Accessed May 25, 2016].

[8] Capterra (2016) "Top Budgeting Software Products". [Online] Available: http://www.capterra.com/budgeting-software/ [Accessed May 25, 2016].

[9] Chunlin, L. and LaYuan, L. (2015) "Context-Aware Integrated Scheme for Mobile Cloud Service Allocation", *The Computer Journal*, Vol. 59, No. 1, pp. 47-63. E-ISSN 1460-2067, ISSN 0010-4620. DOI 10.1093/comjnl/bxv058.

[10] Ilyin, A. V. (2013) "*Ekspertnoe planirovanie resursov*" [Expert Resource Planning]. Institute of Informatics Problems of Russian Academy of Sciences, Moscow, 50 p. ISBN 978-5-91993-022-8.

[11] Ilyin, A. V. and Ilyin, V. D. (2015) "Interval Planning the Supplies of Scarce Product", *Contemporary Engineering Sciences*, Vol. 8, No. 31, pp. 1495–1498. ISSN 1313-6569, E-ISSN 1314-7641. DOI 10.12988/ces.2015.59263.

[12] Ilyin, A. V. and Ilyin, V. D. (2014a) "The Interval Method of Cost Planning and Its Implementation in the Online Service", *Contemporary Engineering Sciences*, Vol. 7, No. 20, pp. 931–938. E-ISSN 1314-7641, ISSN 1313-6569. DOI 10.12988/ces.2014.48114.

[13] Ilyin, A. V. and Ilyin, V. D. (2013) "The Technology of Interactive Resource Allocation in Accordance with the Customizable System of Rules", *Applied Mathematical Sciences*, Vol. 7, No. 143, pp. 7105–7111. E-ISSN 1314-7552, ISSN 1312-885X. DOI 10.12988/ams.2013.311649.

[14] Ilyin, A. V. and Ilyin, V. D. (2014b) "Towards a Normalized Economic Mechanism Based on E-services", *Agris on-line Papers in Economics and Informatics*. Vol. 6, No. 3. pp. 39–49. [Online] Available: http://online.agris.cz/files/2014/agris_on-line_2014_3_ilyin_ilyin.pdf [Accessed May 25, 2016].

[15] Jamsa, K. A. (2013) „*Cloud computing*". Jones & Bartlett Learning, Burlington, 322 p. ISBN 978-1449647391.

[16] Jede, A. and Teuteberg, F. (2016) "Understanding Socio-Technical Impacts Arising from Software-as-a-Service Usage in Companies", *Business & Information Systems Engineering*, Vol. 58, No. 3, pp. 161-176. E-ISSN 1867-0202, ISSN 1867-0202. DOI 10.1007/s12599-016-0429-1.

[17] Katzmarzik, A. (2011) "Product Differentiation for Software-as-a-Service Providers", *Business & Information Systems Engineering*, Vol. 3, No. 1, pp. 19-31. E-ISSN 1867-0202, ISSN 1867-0202. DOI 10.1007/s12599-010-0142-4.

[18] Kavakli, E., Kalloniatis, C., Mouratidis, H. and Gritzalis, G. (2015) "Privacy as an Integral Part of the Implementation of Cloud Solutions", *The Computer Journal*, Vol. 58, No. 10, pp. 2213-2224. E-ISSN 1460-2067, ISSN 0010-4620. DOI 10.1093/comjnl/bxu118.

[19] Petcu, D., Macariu, G., Panica, S. and Craciun, C. (2013) "Portable cloud applications – from theory to practice", *Future Generation Computer Systems*, Vol. 29, No. 6, pp. 1417–1430. ISSN 0167-739X.

[20] PlanGuru (2016) "PlanGuru". [Online] Available: http://www.planguru.com/ [Accessed May 25, 2016].

[21] Questica Budget (2016) "Questica Budget" [Online] Available: http://www.questica.com/solutions/questica-budget-software/ [Accessed May 25, 2016].

[22] Rogers, O. and Cliff, D. (2012) „A financial brokerage model for cloud computing", Journal of Cloud Computing, Vol. 1, No. 1, pp. 1–12. E-ISSN 2192-113X. DOI 10.1186/2192-113X-1-2.

[23] Sandholm, T. and Lee, D. (2014) "Notes on Cloud computing principles", *Journal of Cloud Computing*, Vol. 3, No. 21. E-ISSN 2192-113X. DOI 10.1186/s13677-014-0021-5.

[24] Trumba Corporation (2007) "Five benefits of Software as a Service". [Online] Available: http://www.trumba.com/connect/knowledgecenter/pdf/Saas_paper_WP-001.pdf [Accessed May 25, 2016].

[25] Wang, L., Laszewski, G., Younge, A., He, X., Kunze, M., Tao, J. and Fu, C. (2010) "Cloud computing: a perspective study", *New Generation Computing*, No. 28, pp. 137-146. E-ISSN 1882-7055, ISSN 0288-3635. DOI 10.1007/s00354-008-0081-5.

[26] Wei, Y. and Blake, M. B. (2010) "Service-oriented computing and cloud computing: challenges and opportunities", *IEEE Internet Computing*, No. 14, pp. 72-75. E-ISSN 1541-4922, ISSN 1089-7801.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Analysis of Open Data Availability in Czech Republic Agrarian Sector

J. Jarolímek, R. Martinec

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

Abstract

In the agrarian sector several tens of billions Czech crowns of state and European aid is redistributed annually. The openness of related data and any other that can support economic stability and competitiveness of Czech agrarian sector is a challenge not only for officials but also for research and non-profit sector.

In order to determine the current state of availability of open data in agrarian sector 10 departmental institutions have been selected, which are the main producers of agricultural data in the Czech Republic, along with the CZSO (Czech Statistical Office) which is another significant source of agricultural data. The evaluation took place in the first quarter of 2016. The result is a statement that data in formats that allow further processing is published only by two out of ten surveyed departmental organizations. A similar situation prevails in the National Catalog of Open Data where there is no data coming from regarding the agricultural sector.

It is proven that making the data open can bring benefits to both farmers themselves, end consumers and other commercial entities. On the other hand, it is necessary to ensure the safety of data providers, data creators and in turn, the national security.

Keywords

Open data, agrarian sector, Ministry of Agriculture, standardization, agriculture, food industry.

Jarolímek J., and Martinec, R. (2016) “Analysis of Open Data Availability in Czech Republic Agrarian Sector", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 57 - 67. ISSN 1804-1930, DOI 10.7160/aol.2016.080306.

Introduction

Open data may be, in addition to the most frequently mentioned benefits such as transparency of public administration, public awareness, etc. also very beneficial for the economy of the sector and the entire country. It opens up new economic opportunities and possibilities for further development of job offers and new services. It is important for discovering new connections and knowledge in the sector (Atenas et al., 2015). It can be used in virtually all sectors of the national economy, including agricultural enterprises (Vanek et al., 2010), (Stočes et al., 2015).

Data are holding role of an unlimited and reusable "raw material" for further processing, creating applications that generate added value, profit and new jobs. (Ministry of Interior, 2015).

The main economic benefits are as follows (Janssen et al., 2012):

- stimulating economic growth and competitiveness
- innovation stimulation
- methods of improving processes, products and services
- development of new products and services
- harnessing the collective wisdom
- creation of new industries
- the availability of information for investors and companies

Another benefit of data openness is also the improvement of data infrastructure in the public administration. Individual institutions will have more “order” in their data, the possibilities for data analysis will increase, and data will be cataloged. Its publication also allows better organizing and optimizing of the institutions’s own internal processes (Lassinantti et al., 2014). Processes and data quality of public administration should

improve as well. It will bring a higher level of communication and cooperation between public administration institutions. Opening up data helps to replace unnecessarily complex data exchange between different institutions (Ministry of Interior, 2015).

Open data is the path to open government. It is the next step from bureaucratic governance towards greater involvement of citizens in the management of the country. Open government should increase the overall operating efficiency of the state administration and introduce a noticeable reduction in bureaucracy, which is considered as the future of all democratic countries. One of the tools of open government are currently open data (Zuiderwijk et al., 2015). To accomplish this goal, it is necessary for all areas of government to be involved in the project. This greatly concerns the agrarian sector. It is proven that open data can bring certain benefits to farmers themselves, end consumers and also other commercial entities (Bellon-Maurel et al., 2015). On the other hand, it is necessary to further ensure the safety of both data providers, data creators and last but not least, national security. Therefore, it is necessary to follow the laws and regulations which regulate this and related issues. It is more than obvious that open data, and in turn open government has its place in the future in most areas of the national economy.

Situation in the Czech Republic

In 2014, in the rating the openness of data conducted by the nonprofit organization Open Knowledge, the Czech Republic took 13th place with a score of 66%. The organization assesses the openness of data based on the following criteria:

- publishing under an open license
- machine-readability
- data cost
- bulk processability
- data freshness
- online availability
- level of digitization
- public access to data
- unavailability of similar data elsewhere.

All these criteria are met in the Czech Republic in only two areas, which are area maps and national election results. National budgets and statistics also score almost 100 percent with minor exceptions. Data being outdated and not readily available is a common problem at departmental organizations and local (municipal, city) datasets don not have finalized license agreements. Worst of all the reviews were data on government expenditure, indicating a low level of transparency in this area (Open Knowledge, 2014). The situation in the availability of agricultural data in the European Union is described by (Holster et al., 2011). In the agrarian sector several tens of billions crowns of state and European aid is annually redistributed. The openness of these data and any other that can support economic stability and competitiveness of Czech agrarian sector are a challenge not only for officials but also for researchers and non-profit sector (Hossain et al., 2016).

Legislative framework

When publishing data from state institutions it is necessary to deal with it first in terms of legislation of the State. In the world there are different approaches concerning the open data in terms of legislation. Czech Republic, like other countries of the European Union, is bound to follow the regulations and directives of the European Commission. Czech government is then obliged to integrate these regulations into Czech legislation. But the access to information by citizens is however already engraved in the Charter of Fundamental Rights and Freedoms.

The most important law on the subject in the Czech Republic is the Act no. 106/1999 Coll., on free access to information. It regulates the conditions of access to public sector information and processes directives 2003/98/ES and 2013/37/EU on the reuse of public sector information. The law obliges government institutions to publish information on their own or upon a request (Czech Republic, 1999) (European Parliament and Council, 2013).

The law was supplemented by references to the Act no. 365/2000 Coll. and the statute of obligation to provide information without requests (§4b "Provision of information disclosure") in accordance with the technical and legal standards for open data (Ministry of Interior, 2015).

Other modifications are done by the Decree of the Ministry of Interior about open data and National Open Data Catalog. It adresses:

- the significance of the data sets and their criteria
- standards for publishing open data
- technical standards for the content, structure and method of publication of the National catalog and the local catalogs of open data.

This decree is complemented by the technical manual of open data, which was also issued by the Ministry of Interior. This manual includes the following (Ministry of Interior, 2015):

- detailed specification of individual degrees of openness introduced by the decree
- technical standards for data sets published on degrees of openness 3 and 5
- recommended procedure for opening data up and cataloging
- attributes of a catalog record in the National Catalog of Open Data
- technical standards for recommended data sets
- technical standards for local catalog interfaces.

Area of spatially oriented data is specifically addressed at European level by INSPIRE Directive. The directive came into force in 2007. Its part is also the basis for coordination mechanisms needed for the infrastructure at European level (Thorp and Bronson, 2013) (Kubatova and Faugnerova, n.d.). Into Czech legislation it was transported in 2009 via an amendment to Act no. 380/2009 Coll.

Materials and methods

Evaluation of data openness in agricultural sector was based on a five-star schema compiled by Tim Berners-Lee (Table 1) and the suitability of the formats used (Table 2).

Degree of openness	Conditions	Possible data formats
☆	• Open data licence	PDF
☆☆	• Open data licence • Machine readable data format	Excel
☆☆☆	• Open data licence • Machine readable data format • Open data format	CSV, XML
☆☆☆☆	• Open data licence • Machine readable data format • Open data format • Source identification using URI	RDF without connection to other sources
☆☆☆☆☆	• Open data licence • Machine readable data format • Open data format • Source identification using URI • Links to other relevant information sources	RDF with connection to other sources Linked Open Data

Source: Hausenblas (2012)

Table 1: Data openness level.

From the table 2 it is clear that the most preferred format for publication is RDF. It should however be noted that the path towards this format is still very long. A professional qualification and experience in the field as well as overall knowledge of data connectivity are necessary for its use (Gymrek and Farjoun, 2016). During the first publication of any open data the XML format which excels in simple construction, good clarity and great openness would therefore be a good choice. On its basis it is possible to build a variety of different applications. Within the geographic data GeoJSON format is often used, which is based

Format	Application Independence	Structured	Structure Description	Data Semantics	Creation by linking	Suit-ability 1 = best
PDF	No	No	No	No	No	**5**
DOC(X), RTF	No	No	No	No	No	**5**
TXT	Yes	No	No	No	No	**5**
HTML	Yes	Partial	No	No	No	**4**
XLS(X)	No	Partial	No	No	No	**4**
CSV	Yes	Yes	Partial	No	No	**3**
JSON	Yes	Yes	Partial	No	No	**3**
XML	Yes	Yes	Yes	No	No	**2**
OData	Yes	Yes	Yes	Partial	Partial	**2**
RDF	Yes	Yes	Yes	Yes	Yes	**1**

Source: Chlapek et al. (2012)

Table 2: Suitability of data format for publishing.

on the format for classical JSON data. However, the most widespread format still remains the XLS(X), which is due to the global widespread of Microsoft products, including Windows operating system and office suite MS Office.

To determine the current state of availability of open data in agrarian sector 11 institutions that are major producers of agricultural data in the Czech Republic were selected. The evaluation took place in the first quarter of 2016.

Analyzed departmental organization:

- Ministry of Agriculture (MA)
- State Agricultural Intervention Fund (SAIF)
- State Land Office (SLO)
- Czech Agriculture and Food Inspection Authority (CZAFIA)
- Institute of Agricultural Economics and Information (IAEI)
- Central Institute for Supervising and Testing in Agriculture (CISTA)
- State Veterinary Administration (SVA)
- Czech Forests, state enterprise (CZF)
- Czech Agrarian Chamber (CZACH)
- Federation of the Food and Drink Industries of the Czech Republic (FFDICZ)
- Czech Statistical Office (CZSO).

An example of the evaluation process

Method of description and assessment of the data availability from individual organizations is shown on example of the State Agricultural Intervention Fund:

SAIF is an entity that is involved in supporting the management of Czech farmers. It is an accredited paying agency, which is responsible for mediating financial support from the EU and national sources (State Agricultural Intervention Fund).

SAIF is responsible for the following payments (State Agricultural Intervention Fund):

- Direct payments (DP)
- Rural Development Programme (RDP) 2007-2013 / 2014-2020
- The Common Market Organisation (CMO)
  - vegetal commodities
  - animal commodities
  - foreign trade
- Operative Programme Fisheries (OPF) 2007-2013 / 2014-2020
- National subsidies
- Quality food brands KLASA and Regional Food.

SAIF collects data from farmers mainly through LPIS (Land Parcel Identification System). A larger portion of data that SAIF analyzes and controls through LPIS has sensitive and personal nature. It is mainly data on the applications for grants of specific individuals, which also contain sensitive personal data. Information on subsidies that are tied to a particular plot is not in the public part of LPIS. It is accessible only after login and only for that plots' owner.

Data published by SAIF:

Available data	Content	Format (export)	Degree of openness (1 to 5)*
List of subsidy recipients	• Name (company registration number) • Total amount received in CZK • List of subsidy programmes of applicant • Ratio of Czech to EU subsidies	Web application	N/A
Market Information System	• Market reports • Pricing service	PDF	1
Regional Food Product	• Registry of products • Recepies • Methodics for applications • Applications • Etc.	Web application	N/A
Law no. 106	• Upon request	PDF, XLS, (ZIP)	1-2

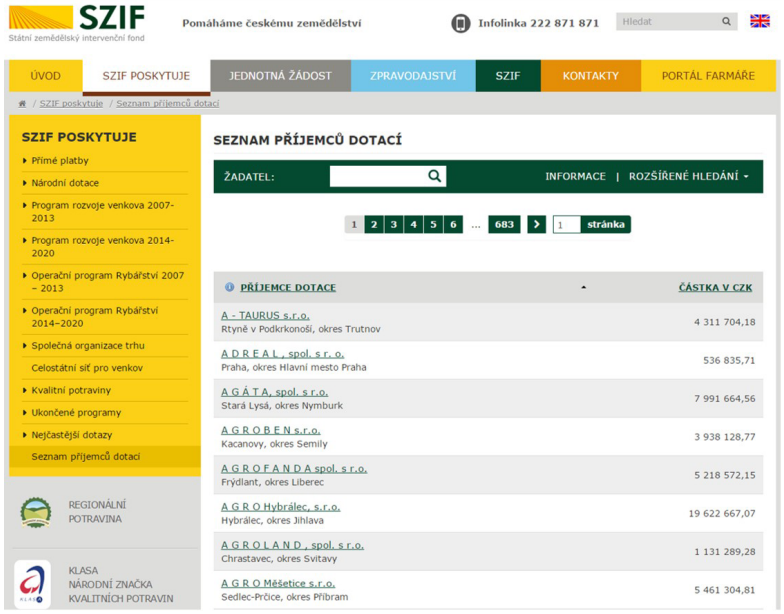
Source: State Agricultural Intervention Fund, List of subsidy receivers, Regional food product

Table 3: Data published by SAIF.

SAIF portal publishes a list of subsidy recipients including the amount paid from the preceding year (Figure 1).

Names of individual recipients refer to a different table, in which the year, fund or support type - purpose of subsidy, resources given by Czech Republic, by EU and a total subsidy amount in CZK are displayed.

A list of subsidy recipients is published in accordance to the Act no. 106/1999 Coll. The listing has however only informative character. Therefore, there is no possibility of its further use for various analyzes and processing. Data is not possible to download or further publish. So in this sense, it is not open data. The data provided has limited information value since surveys of who achieved what amount of subsidy has scant relevance. However, if the fund opened up the data



Source: List of subsidy recipients

Figure 1: List of subsidy recipients shown on SAIF portal.

and allowed them to be further processed, its value would increase tremendously. The result would be the option to create a variety of applications above the data, which could bring insight into the management of the fund to the general public and facilitate the data visualization.

On the basis of law no. 106 SAIF provides other data as well. Some of them are in a format that allows further processing or other use (XLS). The problem lies in the fact that this data must be formally requested, which is a significant obstacle to its immediate use. So again, we can call this an open data. This data can be requested from SAIF by mail, electronically (email) via data box or in person at the office registry. Anyone can ask for any data that does not collide with the Law on Protection of Personal Data. However, as far as state and EU finances are concerned there is only small amount of data that would be protected by this law, because a rule of transparency applies in this situation.

Among other information the fund discloses are information from a market information system. This system delivers current news from the market for agricultural products. The fund regularly publishes monthly newsletters reporting on agricultural commodity markets in the Czech Republic, European Union and other countries.

The portal publishes market reports on these commodities, products or programs (Market Information System):

- Potatoes
- Poultry
- Beef and pork
- Grains and oilseeds
- Fruits
- Rural Development Programs
- Wine and grapes
- Vegetables.

Another part of the market information system is a pricing service. There are regularly published pricing reports for individual agricultural commodities and products, which Czech Republic is required to watch according to the European legislation and send the reports to the European Commission.

The pricing service gives reports for these commodities (Market Information System):

- Bananas
- Dairy products
- Cereals
- Fruits and vegetables
- Pigs and piglets
- Cattle
- Eggs and poultry
- Wine.

All documents are published in the form of monthly reports. They contain relatively detailed

information about the commodity, including lots of tabular data, charts, comparisons, comments and analyses results. Published reports have really high informational value and are surely finding frequent application. That is why they are issued with such regularity and quality. The only downside is the fact that all published documents are in PDF format, so the machine readability is very low. This unfortunately devaluates all published data significantly. If the fund began to publish these as open data, it would mean a lot of opportunities for their further use. Given that these data can be used in both commercial and personal sectors in wide range of applications, the public would certainly welcome opening up this data.

Results and discussion

The following table provides a clear representation of the results of the analysis of availability of open data and information in the agrarian sector.

Table 4 shows that the development regarding open data in the agrarian sector is not at very high level and is considerably worse than in other sectors. Most institutions do not publish open data at all, and if so, it is not an open data with a sufficient degree of openness.

Data which is publicly accessible on the institution portals has generally no restrictions on its subsequent use, so it is possible to consider such data to be at least partially open.

MA has undertaken the biggest step towards open data at the end of last year when it published a substantial GIS part of the LPIS portal that was not publicly available before. Here it is necessary to particularly highlight the fact that the data from the LPIS portal can be exported into open XML format. MA was followed by other institutions such as the SVA or CISTA. Here it should be noted that many other data remain internal. Among them one could find a lot of other data that could be potentially made open. Most of the already published data has great potential in their subsequent use. There are options for potential developers and for the general public. Developers will mainly appreciate access to data in "raw" format. The biggest area opened for specialized farming applications – pest occurrence registers, advisor registers, catalogs of public commissions, etc. On the other hand, the Ministry of Agriculture and other institutions took patronage over of these applications themselves. These applications, which transform the "raw data" to other forms of information, find their use mostly with the general public (Charvat et al., 2014).

However, a problem occurs with institutions that have chosen to disclose only the fully ready information, not "raw data". Many of these

Institution	Publishes data	Data formats	Achieved degrees of openness*	Open information – PDF**	Limits	Information value
MA	yes	XML, XLS	0 - 3	yes	only selected data – mainly from LPIS	high
SAIF	no	-	0 - 1	yes	possibility of fees	medium
SLO	no	-	1	yes	none	low
CZAFIA	no	-	-	yes	none	high
IAEI	no	-	-	yes	possibility of fees	medium
CISTA	yes	XLS, CSV	0 - 2	yes	none	high
SVA	yes	XLS	0 - 2	yes	none	high
CZF	no	-	0 - 1	yes	fees	medium
CZACH	no	-	-	no – only activity reports	none	low
FFDICZ	no	-	0 - 1	yes	none	high
CZSO	yes	XLS	1 - 2	yes	restrictions defined by CZSO apply	high

Note: * Based on the five-star rating, individually requested data not included
**Law no. 106/1999 Coll., and other documents not further processed
Source: own processing

Table 4: Overview of published data and information.

"national" applications are indeed good, but lack a space for developers who could bring new ideas through their own applications, and possibly further enrich such data (Jarolimek et al., 2014) (Reznik et al., 2015). But it can not be said that a state institution always equals the best solution. The above-mentioned applications will surely have their use in the future. For example, the web application "Food at the stake", which was formed under the leadership CZAFIA and already won numerous evaluations. Another application with great future potential is "Find your own producer" by FFDICZ, but it is still in the early stages of development and integration. Another high-quality concept is a SAIF portal "Regional food," which offers consumers high quality and comprehensive information regarding this brand and how it is being awarded.

Regarding the situation with open data in the agrarian sector, CZSO can be considered as the largest distributor of "raw data". Data published CZSO are clear, electronically readable, properly described and should be an example for all other institutions. It is possible to say that its potential for further use in the agrarian sector is really more than sufficient. But it is also necessary to mention that when using open data it is still a requirement to refer to the original source. The openness of data lies in the possibility of unlimited use anywhere, by anyone and for any purpose. All data published by CZSO is in machine-readable formats have a high degree of standardization.

Final evaluation is as follows: data is published only by 3 out of 11 surveyed institutions, one of which (CZSO) does not directly belong to the agrarian sector. These results can be assessed as slightly less than average. Highest quality data is published by the Ministry of Agriculture itself, since valuable exports from the portal LPIS are available in an open XML format that allows unlimited other usage, which is confirmed by the authorization of the free disposal of available data directly on eAGRI portal. Quality of other published data falls into the category of two stars, where its subsequent use is predetermined by owning specialized (often commercial) applications. Regarding the data publishing itself, the situation has somewhat improved. Information released thanks to the Act no. 106/1999 Coll. is provided by almost all institutions with the exception of CZF. The problem may be the possibility of charging for this service, which of course raises numerous discussions regarding the freedom of access to information. Some institutions also publish other free information on their own portals, usually about their activities. This information is in most cases available in PDF. This format does not allow further processing of information, which can greatly reduce the information value of the data. An example of good practice is the Market Information System portal by SAIF, which provides a very carefully crafted data that could be used and processed in other fields such as econometrics and forecasting.

Data standardization

One of the functions of open data should be the possibility of linking with other datasets. This feature can greatly increase the informational value of the final dataset (Sieber and Johnson, 2015). However, none of the examined data supports this. Although most of the formats are readable and usable for a wide range of users, it is still mainly XLS formats. To fully utilize the data in this format, one must have a commercial software MS Excel. These facts unfortunately do not correspond with open data policies in the true sense of the word, but at least some effort has been made towards openness.

A bigger problem occurs with the standardization of thes datasets. According to the results of analysis in the Czech agrarian sector we can not talk about any standardization whatsoever. Data is diverse, often unsorted and in various formats. The problem may also be in the use of graphic elements, for example coloring of cells, usage of variety of fonts etc. This problem stems from the fact that the datasets are compiled by different people from different institutions or external companies. The greatest degree of standardization dataset exists within the CZSO, but without additional export to other formats this still does not allow for linking to other datasets (therefore a five-star rating is currently infeasable).

The data published is also lacking consistency (Figure 2). As an example, a list of subsidy recipients from the SAIF portal was compared to register of subsidy recipients from eAGRI portal. This should be an absolutely identical lists of individuals and legal entities. Both institutions are also interconnected. Their connection is (in terms of subsidy administration) of the utmost importance with respect to other institutions under the Ministry of Agriculture. Both lists are, however, upon closer inspection quite different. They evaluate exactly the same subsidy programs, but the final values are considerably different. This fact is mainly

SEZNAM PŘÍJEMCŮ DOTACÍ

ROSTĚNICE,A.S.

Rostěnice-Zvonovice, okres Vyškov

ROK	FOND/TYP PODPORY	OPATŘENÍ	ZDROJE ČR	ZDROJE EU	CELKEM CZK
2014	EZFRV	I.1.3.1.c-Přidávání hodnoty zemědělským a potravinářským produktům území mimo hlavního města Prahy	64 500,00	193 500,00	258 000,00
2014	EZFRV 14+	Agroenvironmentální opatření 2007-13	8 696,70	26 090,03	34 786,73
2014	EZZF PP	Platba na plochu	0,00	47 522 255,46	47 522 255,46
2014	EZZF PP	Oddělená platba za cukr	0,00	13 632 977,85	13 632 977,85

Základní evidované údaje o hospodaření

Subjekt: ROSTĚNICE,a.s.
SZR-ID: 1000183822
IČO: 63481821
Datum platnosti: 15. 3. 2016
Výměra v LPIS: 8 312,96 ha
Čerpáno celkem: 773 083 198,99 Kč

Rok	Fin. program	Fin. podprogram	Čerpáno z ČR	Čerpáno z EU	Útvar	Číslo jednací
2013	SAPS - jednotná platba na plochu		0,00 Kč	24 379 669,05 Kč	SZIF	13F1D556017950-S
2013	AEO EAFRD - Žádost o dotaci	Biopásy	8 696,70 Kč	26 090,03 Kč	SZIF	13F1D556017950-A21
2013	Přidávání hodnoty zemědělským a potravinářským produktům	Přidávání hodnoty zem. a potr. produktů	64 500,00 Kč	193 500,00 Kč	SZIF	13/019/1131c/564/001060
2014	SAPS - jednotná platba na plochu		0,00 Kč	24 310 467,50 Kč	SZIF	14F1D556030119-S
2014	SAPS - jednotná platba na plochu		0,00 Kč	24 959 811,60 Kč	SZIF	14F1D556030119-S
2014	Přechodná vnitrostátní podpora	Platba na zemědělskou půdu	1 540 398,73 Kč	0,00 Kč	SZIF	14F1D556030119-T
2014	AEO EAFRD - Žádost o dotaci	Biopásy	8 650,62 Kč	25 951,81 Kč	SZIF	14F1D556030119-A21
2014	Oddělená platba za cukr SSP		0,00 Kč	15 388 559,31 Kč	SZIF	14F1D556030119-C

Source: List of subsidy recipients, Czech Ministry of Agriculture

Figure 2: Example of data inconsistencies between SAIF and MA.

due to absence of many records at eAGRI portal. The list compiled by SAIF can be therefore considered as more credible source of information. With such a large degree of mutual integration of both institutions this situation cannot be described as anything but very irregular.

Problems of this kind are not only between institutions, but also within a single institution, for example, the Ministry of Agriculture. The problem is especially noticeable when you export data from different applications, where the resulting structure of the exported file often differs. This example shows that the level of data standardization of this institution is very low.

Conclusion

The analysis showed that the current situation with open data in the agrarian sector is not optimal. Data formats that allow further processing are published by only two out of ten analyzed departmental organizations. A similar situation prevails in the National Catalog of Open Data where no data is coming from the agricultural sector.

The overall amount of content in the National Catalog is still very low. Data in further processable format are only published by MA and SVA on their portals. Ministry of Agriculture contributed towards the disclosure of data in December last year by publishing of significant portion of the geographic LPIS portal from which it is possible to export data to XML. XML format is multiplatform and therefore offers the possibility of further processing. There are also various data available from different registers, which is predominantly in XLS format. The portal, where data are available usually imposes no limitations for working with such data. Hence we can consider this essentially as open data, although not published as such. Another institution that contributes to a significant degree of disclosure of data in the agrarian sector is CZSO. Although this office is not an organization directly from agrarian sector, it publishes high-quality statistical data from the agriculture, food industry and forestry, all of which are significant branches of the agrarian sector. Use of such data is limited by the terms of the statistical office and therefore it is not open data per say. Data from CZSO are very clear, well structured and above all has a high degree of standardization.

That is the biggest problem of all previously released data across institutions in this sector. Standardization is not only an inter-institutional problem but also within the institutions themselves, see also (Juell-Skielse et al., 2014). An example of incorrect standardization is MA itself, where they use different data formats or even different structure. Even before the individual institutions decide to open up the data in RDF format, it is necessary to deal with standardization. The most appropriate format for the initial publication is XML. Until all the data is published in open XML formats with a clear structure it is not possible to even contemplate publication of linked data in RDF format. It offers the possibility to link with other databases, whether on a national or a world scale. The result is enriched data with a high degree of standardization and increased value of information that can be used for further processing or for developing a variety of applications.

Information in various forms is provided by all of the analyzed institutions. They most commonly publish information in PDF format. This format is also frequently associated with the responces to requests for free access to information. Additional information is provided to end consumers through a special web portals or other available documents. The data provided has different levels of information value. In particular, portals dedicated to food, which provide very useful information about food to final consumers, exhibit the highest levels of data quality and information value. However, usefulness of some of this data for further processing is lowered by used data format. This in particular applies to the Market Information System by SAIF, where the monthly reports with high quality data are only available in PDF.

Because the data is published by small number of institutions it is necessary to focus on the correct procedure for its eventual publication. It includes the following steps:

1. Selection of appropriate data
2. Standardization
3. Selection of the place and manner of publication
4. Evaluation of the potential benefit of publications.

The most important step is to standardize, which brings some order to all data published in the agrarian sector. Standardization nowadays also does not impose excessive financial and technical difficulty. When selecting the appropriate data, the farming data sensitivity must be taken into account. The third step depends on the arrangement between individual institutions, whether they prefer a centralized or decentralized manner of publishing and what form of visualization they decide upon - maps, web applications, spreadsheets, etc. (Kubicek et al., 2013; Ojha et al., 2015).

Acknowledgements

The results and knowledge included herein have been obtained owing to support from the Internal grant agency of the Faculty of Economics and Management, Czech University of Life Sciences in Prague, grant no. 20161028, “Assessment of quality, usability and accessibility of electronic services from the perspective of small and middle sized enterprises in the agrarian sector “.

Corresponding author:
Ing. Jan Jarolímek, Ph.D.
Department of Information Technologies, Faculty of Economics and Management Czech University of Life Sciences Prague, Kamýcká 129, Prague 6 - Suchdol, 165 21, Czech Republic
Phone: +420 22438 2293, E-mail: jarolimek@pef.czu.cz

References

[1] Atenas, J., Havemann, L. and Priego, E. (2015) „Open Data as Open Educational Resources: Towards transversal skills and global citizenship", *Open praxis*, Vol. 7, No. 4, pp. 377-389. ISSN 2304-070X. DOI 10.5944/openpraxis.7.4.233.

[2] Bellon-Maurel, V., Peters, G. M., Clermidy, S., Frizarin, G., Sinfort, C., Ojede, H., Roux, P. and Short, M. D. (2015) „Streamlining life cycle inventory data generation in agriculture using traceability data and information and communication technologies-part II: application to viticulture", *Journal of cleaner production*, Vol. 87, pp. 119-129. ISSN 0959-6526.

[3] Czech Republic (1999) Law no. 106/1999 Coll. dated May 11th 1999 on free access to information. Czech Republic legislation, 1999. ISSN 1211-1244.

[4] European Parliament and Council (2013) European Parliament and Council Directive 2013/37/EU, June 26th 2013.

[5] Gymrek, M. and Farjoun, Y. (2016) „Recommendations for open data science", *Gigascience*. Vol. 5. ISSN 2047-217X. DOI 10.1186/s13742-016-0127-4.

[6] Hausenblas, M. (2012) 5-star Open Data. 22 Jan. 2012. [Online]. Available: http://5stardata.info/en/. [Accessed: 10 Oct. 2015].

[7] Holster, H., Fusai, B., Giannerini, G., Horakova, S., Martini, D., Teye, F., and Ipema, B. (2011) „*Current situation on data exchange in agriculture in the EU27 & Switzerland*", EFITA/WCCA '11. pp. 367-381. ISBN 978-80-904830-0-2.

[8] Hossain, M. A., Dwivedi, Y. K. and Rana, N. P. (2016) „State-of-the-art in open data research: Insights from existing literature and a research agenda", *Journal of organizational computing and electronic commerce*, Vol. 26, No. 4, pp. 14-40. ISSN 1091-9392. DOI 10.1080/10919392.2015.1124007.

[9] Charvat, K., Esbri, M., Mayer, W., Campos, A., Palma, R. and Krivanek, Z. (2014) "FOODIE - Open data for agriculture". 2014 IST-Africa Conference Proceedings. [Online]. Available: https://scholar.google.czscholar?q=FOODIE+%E2%80%94+Open+data+for+agriculture&btnG=&hl=cs&as_sdt=0%2C5. [Accessed: 13 Aug. 2016]. ISBN 978-1-905824-44-1. DOI 10.1109/ISTAFRICA.2014.6880647.

[10] Chlapek, D., Kucera, J. and Necasky, M. (2012) „Metodika publikace otevřených dat veřejné správy ČR." (In Czech). [Online]. Available: http://www.korupce.cz/assets/dokumenty/aktuality/Metodika-publikace-otevrenych-dat.pdf. [Accessed: 20 Nov. 2015].

[11] Janssen, M., Charalabidis, Y. and Zuiderwijk, A. (2012) „Benefits, Adoption Barriers and Myths of Open Data and Open Government", *Information systems management*, Vol. 29, No. 4, pp. 258-268. ISSN 1058-0530. DOI 10.1080/10580530.2012.716740.

[12] Jarolimek, J., Vanek, J., Jezek, M., Masner, J. and Stoces, M. (2014) „The telemetric tracking of wild boar as a tool for field crops damage limitation", *Plant, Soil and Environment*, Vol. 60, No. 4, pp. 418-425. ISSN 1214-9368.

[13] Juell-Skielse, G., Hjalmarsson, A., Johannesson, P. and Rudmark, D. (2014) „Is the Public Motivated to Engage in Open Data Innovation?", *Electronic government* (EGOV 2014), Vol. 8653, pp. 277-288. ISSN 0302-9743. DOI 10.1007/978-3-662-44426-9_23.

[14] Kubatova, E. and Faugnerova (2015) INSPIRE. Infrasructure for Spatial Information in Europe. [Accessed: 11 Nov. 2015]. Available: http://inspire.gov.cz/o-inspire.

[15] Kubicek, P., Kozel, J., Stampach and R., Lukas, V. (2013) „Prototyping the visualization of geographic and sensor data for agriculture", *Computers and electronics in agriculture*, Vol. 97, pp. 83-91. ISSN 0168-1699.

[16] Lassinantti, J., Bergvall-Kareborn, B. and Stahlbrost, A. (2014) „Shaping Local Open Data Initiatives: Politics and Implications", *Journal of theoretical and applied electronic commerce research*, Vol. 9, No. 2, pp. 17-33. ISSN 0718-1876. DOI 10.4067/S0718-18762014000200003.

[17] Ministry of Interior (2015) "Školení otevřených dat VS ČR". [Online]. Available: http://opendata.gov.cz/_media/edu:skoleni_open_data_web.pdf. [Accessed: 10 Oct. 2015].

[18] Czech Ministry of Agriculture (2016) "Registry of subsidy recipients". [Online]. Available: http://eagri.cz/public/app/SZR/SubsidyReports#filter--Subjid=&Ico=&SzifId=&LpisId=&Rci=&DatNaroz=&ObchJm=&Jmeno=&Prijmeni=&ObecNaz=&ObecKod=&Ulice=&Okres=&searched=Reload. [Accessed: 20 Feb. 2016].

[19] Ojha, S. R., Jovanovic, M. and Giunchiglia, F. (2015) „Entity-Centric Visualization of Open Data", *Human-Computer interaction* – Interact 2015, PT III, Vol. 9298, pp. 149-166. ISSN 0302-9743. DOI 10.1007/978-3-319-22698-9_11.

[20] Open Knowledge (2015) "Global Open Data Index". [Online]. Available: http://index.okfn.org/place/czech-republic/2014/. [Accessed: 29 Nov 2015].

[21] Reznik, T., Charvat, K. Jr., Charvat, K., Horakova, S., Lukas, V. and Kepka, M. (2015) „Open Data Model for (Precision) Agriculture Applications and Agricultural Pollution Monitoring", *Proceeding of envroinfo and ict for sustainability 2015*, Vol. 22, pp. 97-107. ISSN 2352-538X. DOI 10.2991/ict4s-env-15.2015.12.

[22] Sieber, R. E., Johnson, P. A. (2015) „Civic open data at a crossroads: Dominant models and current challenges", *Government information quarterly*, Vol. 32, No. 3, pp. 308-315. ISSN 0740-624X.

[23] State Agricultural Intervention Fund (2015) "O nás". [Online]. Available: https://www.szif.cz/cs/o-nas. [Accessed: 20 Dec. 2015].

[24] List of subsidy recipients (2016). [Online] Available: https://www.szif.cz/cs/seznam-prijemcu-dotaci. [Accessed: 10 Feb. 2016].

[25] Regionální potravina. [Online]. Available: http://www.regionalnipotravina.cz/. [Accessed: 10 Feb. 2016].

[26] Stočes, M., Benda, P. and Ulman, M. (2015) „Open data and rural development. In: *Agrarian Perspectives XXIV. – Global Agribusiness and Rural Economy*, 16.09.2015, Prague. Czech University of Life Sciences Prague, pp. 399-406. ISBN 978-80-213-2581-4, E-ISSN 2464-4781, ISSN 1213-7960.

[27] Market Information System (2016). [Online]. Available: https://www.szif.cz/cs/trzni-informacni-system. [Accessed: 24 Feb. 2016].

[28] Thorp, K. R., Bronson, K. F. (2013) „A model-independent open-source geospatial tool for managing point-based environmental model simulations at multiple spatial locations", *Environmental modelling & software*, Vol. 50, pp. 25-36. ISSN 1364-8152.

[29] Vanek, J., Kanska, E., Jarolimek, J. and Simek, P. (2010) „State and evaluation of information and communication technologies development in agricultural enterprises in Czech Republic", *Plant, Soil and Environment*, Vol. 56, No. 3, pp. 144-147. ISSN 1214-1178.

[30] Zuiderwijk, A., Janssen, M. and Dwivedi, Y. K. (2015) „Acceptance and use predictors of open data technologies: Drawing upon the unified theory of acceptance and use of technology", *Government information quarterly*, Vol. 32, No. 4, pp. 429-440. ISSN 0740-624X.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Identification of Business Informatics Specifics in Agricultural Enterprises

K. Kubata, P. Šimek

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

Abstract

Presented paper deals with analysis and identification of business informatics specifics in agricultural enterprises in the Czech Republic farming at land of size up to 500 hectares. The study is based on thorough review of literature about latest issues in agriculture business informatics. There is a follow up to certain results of previous research on business informatics in agriculture that was conducted by authors in 2013. The analysis has brought findings that business informatics has several peculiarities that must be regarded in informatics implementation and innovation. Those are common economic and organisational effects and further aspects typical for the agriculture such as climate, local conditions and seasonal nature of production.

Keywords

Business informatics, information, information systems, agriculture, farm.

Kubata, K. and Šimek, P. (2016) "Identification of Business Informatics Specifics in Agricultural Enterprises", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 69 - 76. ISSN 1804-1930, DOI 10.7160/aol.2016.080307.

Introduction

Business Informatics (BInf) in an agriculture enterprise should be clearly beneficial for competitiveness of the company (Kubata et al., 2014), which is to a large extent depending on a suitable implementation and use of BInf. However, this is not a common practice. The application of business informatics varies between enterprises and is confronted with limitations within organisations (Voříšek et al., 2015).

Without doubts, business informatics has its role in Czech agriculture and it is necessary to invest in it as in other branches of national economy. The presented paper brings a critical review of the use of BInf in agricultural enterprises. The need for BInf differs in relation to size and production type of a company, which is another issue that needs to be taken into account. Utilization of BInf in a quality way is, and will be, of a growing importance in the future because the digitisation of business processes in any kind of company, including agricultural companies, is a current trend (D'souza et al., 2015; Tien, 2013). But, there are several setbacks such as data security, high investments and Internet connectivity speed that could be addressed by BInf used in an appropriate way and quality.

Business Informatics in agriculture improvements and risks of use

The informatics in agriculture is specific with changing climate and local conditions, seasonality and not easily predictable length of production. The use of information technologies also depends on the size and type of agricultural company starting from small farmers managing everything by themselves or with help of agricultural advisory (Sarangi, 2016) and using accounting software only, through middle sized farms where several specialized programs are used according to the type of production such as plant or animal production or precision agriculture (Durmus et al., 2015; Malik et al., 2011), up to large capital ventures that deploy all enterprise information systems (Kubata et al., 2014) and special technologies (Pang, 2015; Steinberg et al., 2016). Based on these facts, it is necessary to make an overview of the current state of the art of business informatics (Buchalcevova and Pour, 2015).

Pour and Novotný (2010) has revealed that around 65 % of Czech company representatives perceive

that using informatics has a significant impact on reaching strategic goals of company and that the information strategy is in line with the company strategy. The company strategy could be also realized by company management concepts and focus and not only by a formalized set of documents, as one can often observe in current practice. More than 50 % of respondents replied that informatics plays a supportive role, which does not need to be an opposite to the above stated results, hence both strategic and supportive functions can complement each other effectively. Further 30 % of respondents perceived informatics as a plain technological solution, which is also a positive answer. However, the least positive result was that only 30 % of companies used some sort of indicators to measure benefits of informatics in the organization. There are two obvious reasons, firstly, a relatively high complexity and objectivity of measurement, secondly, a work-intensive detection of relevant figures for informatics analysis (Voříšek et al., 2015). In contrast, among agricultural enterprises, 59 % of respondents claimed that "informatics is perceived as a necessary technological solution to realize business goals", 16 % thought that "informatics has a substantial influence on realization of business goals" and only 12 % had opinion that "informatics has no influence on realization of business goals." (Kubata et al., 2014). Those aspects also influence production control and reflect digital divide in rural and agricultural areas (Herdon et al., 2015).

There is no single optimal way of business informatics management, which is given by a number of objective and subjective influencing factors. Instead, ICT management shall strive for an optimal combination of factors (Voříšek, 2009).

Business informatics is a very up to date topic in agriculture because transformational and processional ties are often missing in companies.

There is a need to set out quality and performance requirements for business informatics and expected effects. A qualified estimation of business informatics level in an organisation, definition of problems, and proposal suggestion have to be done as well (Pour, 2006). Therefore, real data flows must adhere to exact production processes in the company, e.g. like in harvesting of special crops (Ampatzidis, 2016). Moreover, business informatics shapes enterprise information system (Gála et al., 2009).

Compatibility and compactness of enterprise information system bring expected effects (Buchalcevova, 2016). The level of employees digital skills is another important fact impacting the success of business informatics (Agrocenzus, 2010). User trainings, security guidelines for information system use and security policy are foundations of trouble-free operation of business informatics. The Internet is a significant source of data and business opportunities for agricultural enterprises, but also raises issues with privacy protection, data transmission and time investment.

The main source of informatics effects is in applicaitons such as enterprise applications, e-business, e-commerce, etc. However, the level of application use is strongly dependent on ability and motivation of users that can be hardly managed by informatics itself (Pour, 2010). The aforementioned facts expose the issue of digital literacy of users in agricultural enterprises.

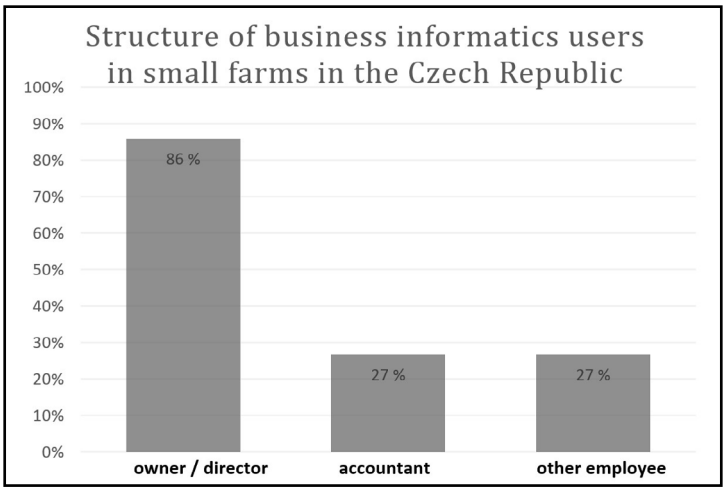
Further and probably the most important fact is that if company management lacks will to change, no innovation of business informatics in agriculture will happen. Making a substantial financial investment in implementation of business informatics in an agricultural enterprise is a closely tied step. There are also non-economic effects that are very important and often may bring a competitive advantage for a company (Pour, 2010).

In small agricultural enterprises, the decision maker is the farm owner or director that have direct motivation to benefit from the improvement of the level of business informatics in their company (see Figure 1).

A development plan for business informatics should be prepared to improve competitiveness of the enterprise (Buchalcevova, 2016).

Questions and issues related to business informatics management should be addressed by a dedicated person that is incorporated in the organisational structure of a company (Buchalcevova and Pour, 2015). However, the organisation structure is often shaped according to the farm's previous development, personnel, and the fact whether or not the farm owner keeps control over informatics in the company (Šilerová and Havlíček, 2007).

Among further problems belong lack of interest of users, limited information availability and lack of professional training in digital skills. Having internal regulations for operation, security, management and use of business informatics is essential for implementation or innovation of information system in the company



Source: Adapted from Kubata et al (2014)

Figure 1: Structure of business informatics users in small farms in the Czech Republic in 2013.

(Buchalcevova and Pour, 2015), which is also applicable in agricultural enterprises.

Based on previous research of Kubata et al. (2014), the utilization of computer hardware is not a limiting factor to BInf development. The hardware capability is important for availability of up to date information about climate, seasonal character of production and further information needs supplied with the Internet. Internet based services for agriculture are growing with fast pace (Rysová et al., 2013).

Lastly, security rules must be followed while working online. According to Doucek (2008), security and security standards are number one and must be kept. There are so-called security requirements for information system that reflect the nature of the system, system requirements and number of standards, norms, laws and regulations. There should also be a standard implementation support comprising technical and methodological help, training of implementation team and end user training. The security policy consists of principles and rules to protect organization's assets. The policy should be regularly updated with ongoing changes of surrounding environment (Gála et al., 2009).

Hoffmann et al. (2013) observes the lack of knowledge about mobile business and low number of mobile applications in agriculture. There is some potential in mobile documentation according to Costopoulou and Molhanec (2014). While broadband Internet connection is usually available in urban areas, the availability in rural areas still poses a problem (Vanek et al., 2010). In addition, the costs of building network infrastructure outside the city or village is on average by 80 % higher than in the city or village (Schneir and Xiong, 2016). Hilbert (2016) claims that number of Internet subscriptions is not the main indicator of divide, but also the bandwidth distribution among countries which is undergoing a significant change. Considering the Internet as a key online medium for conducting business even in agriculture, relevant information sources will be examined in further text. The most used sources among farmers are such as commodity prices, subsidies, weather forecast (Edwards-Murphy et al., 2016), etc.

The objective of the paper is to identify specifics of business informatics (BInf) in the way that enables to address further development of BInf in agricultural enterprises. Agricultural business informatics should be a compact element increasing strategic advantages of agricultural companies.

Materials and methods

The main research focus of the paper is put on business informatics. The current state of agricultural business informatics is analysed by means of exploratory analysis. Secondary resources such as scientific papers and official statistics are analysed and synthesized and based on deduction main specifics of business informatics in agriculture are formulated.

Besides the specifics, optimal conditions for deployment are outlined and areas for improvement are identified.

Results and discussion

Risky areas and framework of business informatics in agriculture were described in the chapter Introduction. Description of specifics of business informatics in agriculture identified by synthesis and deduction is introduced in the following text:

Production specific issues

Company specific issues are comparable across other areas of national economy (Pour and Novotný, 2010). In agriculture, climate and local conditions, seasonality of production and hardly predictable progress of production must be considered. Transformation and processional links are often missing in agricultural enterprises which disturbs execution and management within companies. Further, farmers are conservative towards BInf in many cases. When communication processes are interrupted or missing, there are very limited choices to deploy advanced software for decision making. As Tyrychtr et al. (2015) observed that the rate of use of advanced software tools such as business intelligence, expert and analytical systems is low among Czech farmers and is not related to the type of production, the size of farmed land, the number of employees or the amount of financial subsidies.

Incompatibility of software

Plenty of software in agriculture area was created and launched spontaneously and with limited capabilities. There is a frequent incompatibility between programs and data are not portable which decreases its usability (Tyrychtr et al., 2015). There is also a lack of harmonised support of the use of software which hampers the productivity of the software within agricultural enterprises (Gála et al., 2009). Vendor lock-in or the use of proprietary hardware or software are other limiting factors.

Managing agricultural production concentrates to systems integrating inputs coming from near surroundings such as environmental impacts, public organisations, quality approval and vegetation conditions. A series of norms ISO 11783 (ISOBUS) "Tractors and machinery for agriculture and forestry - Serial control and communications data network" has been introduced due to ICT advancements and overwhelming lack of interoperability between agricultural machinery and computers (Fountas et al., 2015).

Lower digital literacy of employees in agriculture, need for additional training and support

Digital literacy of people working in agriculture has been issue since past (Agrocenzus, 2010). If the farm management is concerned about good operation of BInf in the company, they need to create good condition and provide training and user support to employees from IS suppliers or software vendors (Pour and Novotný, 2010; Cruz-Jesus et al, 2016). The need for high skilled information workers in agricultural enterprises is growing because the production is based on complex process where information processing and knowledge are needed (Ulman et al, 2015).

Conditions for operation and improvement of business informatics in agriculture

Support of company management and sufficient budget

Company management support and sufficient budget have direct impact on quality operation and development of business informatics in agricultural enterprises. Decision must be done after thorough needs analysis of the company management (Gála et al., 2009).

Organisational compliance

Organisational compliance of business informatics in agricultural enterprise must be set and controlled in line with hierarchy, development plan, user motivation, deadlines (Šilerová and Havlíček, 2007; Doucek, 2008).

Internal regulations and documentation

This issue is significant for business process optimization to facilitate equal access of all users within the company (Buchalcevova, 2016).

Sufficient hardware availability

This aspect is not limiting in regards to undergoing ICT development and profitability of agricultural enterprises that can allow to invest money in new equipment (Kubata et al., 2014). More than 25 % of Czech farmers invested in purchasing new hardware for business purposes since 2013. Smartphones and tablets were dominating these investments (Ulman et al., 2015).

Online sources integration

Every farmer needs information both from inside and outside of his or her company. If those sources are integrated it could help to provide better operation of BInf in the company (Rysová et al., 2013). However, the outer sources of data and information are vast and heterogeneous as could be seen in Table 1 (see below).

Institution	Web address
State Agricultural Intervention Fund	www.szif.cz
Ministry of Agriculture	www.eagri.cz
Commodity Exchange in Brno	www.pbb.cz
Czech and Moravia Society of Cattle Breeders	www.cmsch.cz
State Veterinary Administration	www.svscr.cz
Central Institute for Supervising and Testing in Agriculture	www.ukzuz.cz
Czech Hydrometeorological Institute	www.chmu.cz
Institute of Agricultural Economics and Information	www.uzei.cz
Czech Agrarian Chamber	www.agrocr.cz
State Land Administration	www.pfcr.cz
Czech Office for Surveying, Mapping and Cadastre	http://nahlizenidokn.cuzk.cz/
Agrarian portal	www.agromanual.cz
Agrarian portal	www.agroweb.cz
Agrarian portal	www.agris.cz

Source: self-authored

Table 1: Overview of agricultural information resources at the Internet.

Mobile computing

Nowadays, all farmers have necessary equipment to use mobile hardware and software (Kubata et al., 2014; Hoffmann et al, 2013). However, the group of farmers with under 500 hectares of farmed land experienced certain obstacles in leveraging latest technologies due to limited personnel, time constraints and need to focus only on profitable activities such as production. These limitations are observed namely at farms where only the farm owner executes most of tasks related to production (see Figure 1).

Conclusion

Variability of production is an important fact influencing the state of the art and quality of business informatics in agriculture. Besides common economic factors, other aspects typical for agriculture such as climate and local conditions and seasonal character of production must be considered. Despite large conservatism of agricultural entrepreneurs, it can be assumed that an effective and quality implementation of business informatics may lead to strategical advantages of the company.

Deficiencies of business informatics that were identified within the paper are not extremely far from standards of business informatics in other sectors. Business informatics in agriculture is perceived as marginal by farmers for reaching their production goals.

A detailed overview of specifics and drawbacks of business informatics in agriculture has been presented in the paper. Among risk factors that must be identified and addressed in agricultural enterprises belong production specific issues, incompatibility of software, lower digital literacy of employees, need of training and user support, need for skilled knowledge workers and difficulties with planning the production due to climate and local conditions and seasonality. For operation and improvement of business informatics within agricultural enterprises, support of company management, organisational compliance, development plan, user motivation and following time tables are required. Keeping sufficient budget for investments, internal documentation, hardware availability, online sources and mobile computing integration are other necessary parts of business informatics deployment.

Above given aspect may represent limiting factors for increase in operation and compactness of business informatics and for gaining strategical competitive advantage of agricultural enterprises. Provided list of BInf specifics may serve as additional input for decision-makers in agricultural companies.

Based on the presented results, we can claim that there are substantial opportunities to conduct more research on quality and efficiency of business informatics in agricultural enterprises.

Acknowledgements

The results and knowledge included herein have been obtained owing to support from the Internal grant agency of the Faculty of Economics

and Management, Czech University of Life Sciences in Prague, grant no. 20161018, "SW licence a ekonomické dopady ve firmě" (Software licences and economic impacts in the company).

Corresponding author:
Ing. Karel Kubata
Department of Information Technologies, Faculty of Economics and Management Czech University of Life Sciences Prague, Kamýcká 129, Prague 6 - Suchdol, 165 21, Czech Republic
Phone: +420 22438 2861 , E-mail: kubata@pef.czu.cz

References

[1] Agrocenzus (2010) „*Strukturální šetření v zemědělství a metody zemědělské výroby – 2010*". Czech Statistical Office, 2010. [Online]. Available: https://www.czso.cz/csu/czso/2126-11-n_2011-03 [Accessed: 27. Jan. 2016].

[2] Ampatzidis, Y., Tan, L., Haley, R., and Whiting, M. D. (2016) "Cloud-based harvest management information system for hand-harvested specialty crops", *Computers and Electronics in Agriculture*, Vol. 122, pp. 161-167. ISSN 0168-1699, E-ISSN 1872-7107. DOI 10.1016/j.compag.2016.01.032.

[3] Buchalcevova, A. (2016) „Analysis of the management of business informatics framework from the green ICT viewpoint", *International Journal of Information Technology and Management*, Vol. 15, no. 1, pp. 41-58. ISSN 1741-5179. DOI 10.1504/IJITM.2016.073913.

[4] Buchalcevova, A. and Pour, J. (2015) „Business informatics management model", *Lecture Notes in Electrical Engineering*, Vol. 373, pp. 65-71. ISSN 1876-1100. DOI 10.1007/978-981-10-0281-6_10.

[5] Costopoulou, C. and Molhanec, M. (2014) „Evolution towards mobile government: The Greek and the Czech cases", *Communications in Computer and Information Science*, Vol. 441, pp. 183-191. ISSN 1865-0929. DOI 10.1007/978-3-319-11710-2_17.

[6] Cruz-Jesus, F., Vicente, M. R., Bacao, F., and Oliveira, T. (2016) "The education-related digital divide: An analysis for the EU-28", *Computers in Human Behavior*, Vol. 56, pp. 72-82. ISSN 0747-5632. DOI10.1016/j.chb.2015.11.027.

[7] Doucek, P. (2008) „Bezpečnost informačních systémů–zákony a instituce" (In Czech), *Systémová integrace*, Vol. 3, pp. 30 – 44. ISSN 1804-2716.

[8] Durmuş, H., Güneş, E. O., Kırcı, M., and Üstündağ, B. B. (2015) „The design of general purpose autonomous agricultural mobile-robot: "AGROBOT". In: *Agro-Geoinformatics* (Agro-geoinformatics), 2015 Fourth International Conference on. IEEE, pp. 49-53. ISBN 978-1-4673-8088-1. ISSN 2334-3168. DOI 10.1109/Agro-Geoinformatics.2015.7248088.

[9] D'souza, M. J., Barile, B. and Givens, A. F. (2015) „Evolution of a structure-searchable database into a prototype for a high-fidelity SmartPhone app for 62 common pesticides used in Delaware". In: *Industrial Instrumentation and Control (ICIC)*, 2015 International Conference on. IEEE, pp. 71-76. ISBN 978-1-4799-7165-7. DOI 10.1109/IIC.2015.7150714.

[10] Edwards-Murphy, F., Magno, M., Whelan, P. M., O'Halloran, J., and Popovici, E. M. (2016) "b+ WSN: Smart beehive with preliminary decision tree analysis for agriculture and honey bee health monitoring", *Computers and Electronics in Agriculture*, Vol. 124, pp. 211-219. ISSN 0168-1699, eISSN 1872-7107. DOI 10.1016/j.compag.2016.04.008.

[11] Fountas, S., Sorensen, C.G., Tsiropoulos, Z., Cavalaris, C., Liakos, V. and Gemtos, T. (2015) „Farm machinery management information systém", *Computers and Electronics in Agriculture*, Vol. 110, pp. 131-138, ISSN 0168-1699.

[12] Gála, L., Pour, J., and Šedivá, Z. (2009) "*Podniková informatika",* 496 p. ISBN 978-80-247-2615-1.

[13] Herdon, M., Botos, S. and Várallyai, L. (2015) „Decreasing the Digital Divide by Increasing E-Innovation and E-Readiness Abilities in Agriculture and Rural Areas“ *International Journal of Agricultural and Environmental Information Systems (IJAEIS)*, Vol. 6, No. 1, pp. 1-18. ISSN 1947-3192. DOI 10.4018/ijaeis.2015010101.

[14] Hoffmann, C., Grethler, D. and Doluschitz, R. (2013) „Mobile Business: Good Preconditions on Farms“, *Landtechnik*, Vol. 68, No. 1, pp. 18-21. ISSN 0023-8082.

[15] Hilbert, M. (2016) „The bad news is that the digital access divide is here to stay: Domestically installed bandwidths among 172 countries for 1986–2014“, *Telecommunications Policy*, Vol. 40, No. 6, pp. 567-581. ISSN 0308-5961. DOI 10.1016/j.telpol.2016.01.006.

[16] Kubata, K., Tyrychtr, J., Ulman, M. and Vostrovský, V. (2014) „Business Informatics and its Role in Agriculture in the Czech Republic“, *AGRIS on-line Papers in Economics and Informatics*, Vol. 6, No. 2. ISSN 1804-1930.

[17] Malik, K., Georghiou, L. and Grieve, B. (2011) „Developing new technology platforms for new business models: Syngenta's partnership with the university of Manchester“, R*esearch-Technology Management*, Vol. 54, No.1, pp. 24-31. ISSN 0895-6308.

[18] Pang, Z., Chen, Q., Han, W. and Zheng, L. (2015) “Value-centric design of the internet-of-things solution for food supply chain: value creation, sensor portfolio and information fusion”, *Information Systems Frontiers*, Vol. 17, No. 2, pp. 289-319. ISSN 1387-3326, E-ISSN 1572-9419. DOI 10.1007/s10796-012-9374-9.

[19] Pour, J. and Novotný, O. (2010) „K výsledkům průzkumu zaměřeného na kvalitu podnikové informatiky“ (in Czech), *Systémová Integrace,* Vol. 6. ISSN 1804-2716.

[20] Pour, J. (2006) "*Informační systémy a technologie"* (in Czech), 492 p. ISBN 80-86730-03-4.

[21] Rysová, H., Kubata, K., Tyrychtr ,J., Ulman, M., Šmejkalová, M. and Vostrovský, V. (2013) „Evaluation of electronic public services in agriculture in the Czech Republic“, *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 61, No. 2, pp. 473-479. ISSN 1804-1930.

[22] Sarangi, S., Umadikar, J. and Kar, S. (2016) „Automation of Agriculture Support Systems using Wisekar: Case study of a crop-disease advisory service“, *Computers and Electronics in Agriculture*, Vol. 122, pp. 200-210. ISSN 0168-1699, E-ISSN 1872-7107. DOI 10.1016/j.compag.2016.01.009.

[23] Schneir, J. R. and Xiong, Y. (2016) „A cost study of fixed broadband access networks for rural areas“, *Telecommunications Policy*, Vol. 40, No. 8. ISSN 0308-5961. DOI 10.1016/j.telpol.2016.04.002.

[24] Steinberg, M. D., Tkalčec, B. and Steinberg, I. M. (2016) „Towards a passive contactless sensor for monitoring resistivity in porous materials“, *Sensors and Actuators B: Chemical,* Vol. 234, pp. 294-299. ISSN 0925-4005. DOI 10.1016/j.snb.2016.04.169.

[25] Šilerová, E. and Havlíček, Z. (2007) „*Efektivní využívání informací a informačních systémů v rámci zemědělskopotravinárskych systémů*“ (in Czech), Nitra: FEM SPU Nitra, Zborník príspevkov semináru Informačné technológie v riadení a vzdelávaní 2007. ISBN 978 -80-8069-968-0.

[26] Tien, J. M. (2013) „Big data: Unleashing information“, J*ournal of Systems Science and Systems Engineering*, Vol. 22, No.2, pp. 127-151. ISSN 1004-3756. DOI 10.1007/s11518-013-5219-4.

[27] Tyrychtr, J., Ulman, M. and Vostrovský, V. (2015) „Evaluation of the state of the business intelligence among small czech farms“, *Agricultural Economics*, Vol. 61, No. 2, pp. 63-71. ISSN 0139-570X. DOI 10.17221/108/2014-AGRICECON.

[28] Ulman, M., Tyrychtr, J., Vostrovský, V. and Jarolímek, J. (2015) „Information and knowledge engineering in agricultural enterprises in the Czech Republic“. In: *Future Communication, Information and Computer Science: Proceedings of the 2014 International Conference on Future Communication, Information and Computer Science (FCICS 2014)*, May 22-23, 2014, Beijing, China. pp. 139-142.

[29] Vanek, J., Cervenkova, E., Jarolimek, J., and Simek, P. (2010) "State and evaluation of information and communication technologies development in agricultural enterprises in the Czech Republic", *Plant Soil and Environment*, Vol. 56, No. 3, pp. 144-147. ISSN 12141178.

[30] Voříšek, J. (2009) „Faktory ovlivňující řízení podnikové informatiky“ (in Czech), *Systems Integration*, Vol. 196. ISSN 1804-2716.

[31] Voříšek, J., Pour, J. and Buchalcevová, A. (2015) „Management of Business Informatics Model - Principles and Practice“, *E+M Ekonomie a Management*, Vol. 18, No. 3, pp. 160-173 ProQuest Central. ISSN 2336-5604.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Firm Size as a Determinant of Firm Performance: The Case of Swine Raising

M. Kuncová, V. Hedija, R. Fiala

Department of Economic Studies, College of Polytechnics Jihlava, Czech Republic

Abstract

The aim of the paper is to evaluate the effect of firm size to the economic performance of firm belonging to the raising of swine sector (CZ-NACE 01.460). The economic performance is assessed using multiple-criteria evaluation of alternatives methods where the selected coefficients of the profitability ratios, labour productivity and operating ratio are used as the indicator of economic performance. To assess the relationship between firm size and firm performance, the linear regression model is used. The study uses data collected from the database Albertina CZ Gold Edition for the year 2013 that are provided by Bisnode company and from Business Register. The results showed that the larger firms reached higher economic performance compared with smaller ones. These finding indicates that economies of scale are likely to play an important role in sector of raising swine.

Keywords

Economic performance, firm size, linear regression model, operating ratio, profitability ratios, labour productivity, multi-criteria evaluation.

Kuncová, M., Hedija and V., Fiala, R. (2016) “Firm Size as a Determinant of Firm Performance: The Case of Swine Raising", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 77 - 89. ISSN 1804-1930, DOI 10.7160/aol.2016.080308.

Introduction

The sector of raising of swine belongs to the traditional and very important sector of agricultural animal production in the Czech Republic. According to the Czech Statistical Office data, the production of pigs in tonnes of live weight was 302 thousand in 2014 which represented more than 64 percent of total production of livestock for slaughter. The consumption of swine meat is equally important. It was 40.7 kg per capita which represented more than 50 percent of total consumption of meat in 2014 in the Czech Republic. Nevertheless, the self-sufficiency rate in pig meat production reached approximately 58 percent. The domestic production of pig meat dramatically declined from 1989. Pig production of livestock for slaughter decreased more than half from 763 thousand tons of live weight in 1989 to 302 thousand tons. (Czech Statistical Office, 2016; Ministry of Agriculture, 2015)

The problems of this sector are viewed from various aspects. One comprises the international comparison (IAEI, 2013), another ones uses the deeper description of the situation in this sector inside the Czech Republic during several years (Machek, 2011; Špička, 2014) or examines differences of economic outcomes and costs in pig breeding (e.g. Boudný and Špička, 2012 or Štolcová and Homolka, 2012). According to Špička (2014), the financial situation of Czech pig breeders differs significantly and there is big gap between top and bottom pig breeders. There could exist more different factors behind this fact such as another farming activity of the company (not only raising of swine) or different cost connected with the pig breeding (own or purchased feed), nevertheless one of the factor could be firm size (Bojnec and Latruffe, 2011) that might be connected with the economies of scales, competitiveness, market and negotiation power.

The main aim of the paper is to evaluate the effect of firm size to the economic performance of firm belonging to the raising of swine sector (according to CZ-NACE classification) in the Czech Republic.

Review of literature

The performance of the firm and their measurement belong to the very important and discussed issues not only in academic sphere but also at the level

of corporate top management and owners. There are a lot of studies dealing with this issue (for example Hult et al., 2008 or Richard et al., 2009). According to Richard et al. (2009, p. 719) „organizational performance is the ultimate dependent variable of interest for researchers concerned with just about any area of management". March and Sutton (1997) investigated all articles published in three years (1993-1995) in three prestigious journals – the Strategic Management Journal, the Academy of Management Journal and the Administrative Science Quarterly. Performance occurred as variable in 28% of those articles.

The measurement of performance varies in individual studies and many of them not even define this concept (Hult et al., 2008). The clear definition of the performance can be found in the study of Hult et al. (2008). There are divided three types of performance: financial performance, operational performance and overall effectiveness. The financial performance contains overall profitability (ROE, ROA, ROI, ROS), profit margin, earnings per share, stock price, sales growth of foreign sales, Tobin's Q. The operational performance includes product-market outcomes (e.g. market share, efficiency, innovation) and internal process outcomes (e.g. productivity, employee retention and satisfaction). The overall effectiveness contains reputation, survival, perceived overall performance, achievement of aims and perceived overall performance. Žižlavský (2015) divides performance methods into two groups – financial (Balanced Scorecard, budged, cost accounting with or without cost centres, EBITDA, EBIT, economic value added, payback period, revenues from innovation or profitability indicators like ROI, ROE, ROA, ROS) and non-financial tools (cannibalization of existing products by innovation, customer satisfaction indicators, growth of market share, innovativeness, number of new customers, patents or productivity and activity indicators). Fey and Denison (2003) mention that some scholars have criticized subjective indicators of effectiveness. That is one of the reasons why we decided to work only with financial and operational performance measures in this study.

There are a lot of methods which are used to evaluate firm performance. This is usually evaluated using the set of indicators. Yang et al. (2010) made a summary of research techniques for performance measurement including: graphical tools (spider and radar diagrams, Z chart), integrated performance indices (e.g. analytic hierarchy process - AHP or principal components analysis - PCA), statistical methods (e.g. regression analysis) or data envelopment analysis (DEA). Some authors use for measurement of organizational effectiveness multiple-criteria evaluation of alternatives methods as WSA, TOPSIS, ELECTRE or PROMETHEE methods (for example Wang and Hsu, 2004; Yalcin et al., 2012; Kuncová and Štouračová, 2014). There are a lot of studies where only one indicator (most commonly equity ratio, productivity or profitability) is used as a performance measurement (e.g. Coad et al., 2013).

We use multi-criteria evaluation of alternatives method (specifically TOPSIS) to evaluate the economic performance in this study. This method is used in application on the agriculture sector for instance in the studies by Svatoš and Chovancová (2013) or Šišková (2015). Svatoš and Chovancová (2013) investigated the influence of subsidies on the economic performance of farms in the Czech Republic. To evaluate the economic performance they used six proportional indicators of financial analysis (Total Capital Profitability, Operating Profitability of Receipts, Term of Payment of Obligations, Acid Test Ratio, Interest Coverage and Self-Financing Coefficient) and applied WSA and TOPSIS methods. The aim of the paper from Šišková (2015) was to create and to describe application of five type of multi-criterion models for comparison of production options of agricultural biogas plants.

The relationship between firm size and firm performance is a key topic of a lot of scientific studies. These studies usually control other factors that affect the firm performance, mostly age and capital. Most of studies focused on the link between firm size and performance applied linear regression model (for instance Majumdar, 1997; Agiomirgianakis et al., 2006; Liargovas and Skandalis, 2010; Rajčániová and Bielik, 2008) and as explanatory variable were used beside firm size and firm age also selected firm performance indicators.

From the economic theory point of view the relationship between firm size and firm performance is not clear. First view believes in the abilities of large firms to exploit economies of scale and scope and the formalization of procedures or more effective implementation of operations. Thanks to these characteristics larger companies should have better performance than smaller counterparts. Opposite view comes from thesis that firm size is connected with market power and bigger market power creates more x-inefficiencies (Majumdar, 1997).

From a theoretical point of view the relationship between age and firm performance is also ambiguous. Older firms should be more experienced and use the benefits of learning. The older companies can build good network business partners and consumers, and have very good relationship with financial organizations. These facts lead to better firm performance of older firms in comparison with younger ones (Majumdar, 1997; Radipere and Dhliwayo, 2014). Another view suggests that older firms are not so flexible to make rapid adjustments to switching circumstances and this fact speaks in favour of weak performance (Majumdar, 1997; Agiomirgianakis et al., 2006).

The empirical analysis of relationship between firm size, firm age and firm performance is the subject of the study by Majumdar (1997). With the help of a sample of 1020 Indian firms he examined how firm performance is affected by firm size and age. He controls other specific factors as ownership, pro-export orientation, diversity, capital intensity, etc. In this study the firm performance was measured by productivity and profitability. For measuring productivity there was used the ratio of value added to the value of production. Profitability is measured with the help of returns on sales or the margin on sales. The main finding of this study is the fact that larger companies were more productive and less profitable than smaller firms. Older firms were found less profitable and more productive in comparison with younger companies.

Agiomirgianakis et al. (2006) investigated panel of 3094 Greek manufacturing firms for 1995 and 1999 to identify the key indicators of firm profitability and growth. They used return on assets as an indicator for measuring profitability and number of employees as indicator of firm growth. The broad set of explanatory variables was used: firm size, age, location and exports, asset structure, capital structure, reliance on debt, employee productivity and managerial efficiency. The results indicate a statistically positive relationship between firm size and return on assets and only weak statistically significant relationship (at 10% level) between age and profitability.

Liargovas and Skandalis (2010) discovered positive relationship between firm size and financial performance indicator return of equity of 102 listed companies in the Athens Stock Exchange in the period 1997-2004. No significant link was found between firm size and two other indicators – return on assets and return on sales. The authors also investigated if firm performance was affected by firm age. They confirmed significant negative link between firm age and tow financial indicators – return of equity and return on sales. In the case of return of assets this negative link was not statistically significant. In this study they control seven other variables, which might affect firm performance: leverage, liquidity, capitalization ratio, investment, location, export, and management efficiency.

According to Gaur and Gupta (2011), large companies achieve better performance than their smaller counterparts. They focused on the Indian IT industry and tested firm for two different years (2001 and 2008) separately. They worked with Tobin's q as an indicator of firm performance. There was also found a positive link between the age and the firm performance. In this study they control for leverage and group affiliation as other determinant of performance.

Coad et al. (2013) focused on Spanish manufacturing companies over the period 1998 to 2006 and examined the relationship between firm age and firm performance. They used three indicators of firm performance: productivity, profitability and equity ratio. They confirmed that firm age has positive effect on productivity (defined as value added divided by employees) and on the equity ratio and negative effect on profitability (measured as the ratio of profits over sales). They controlled firm size, short term and long term debt ratios. As regards the firm size the link between firm size and firm performance was positive for all three indicators of firm performance.

Radipere and Dhliwayo (2014) used the set of subjective indicators to assess the firm performance. The respondents were asked to state how their enterprise (areas: income, profit, market share, return on investment, number of employees and product line) performed in the past five years. Using the sample of 500 SMEs in retail industry they concluded that there is no statistical significant link between business size and firm performance.

Empirical studies also show that the initial size of company, specifically amount of start-up capital, could be other factor affecting the firm performance, specifically in the case of new companies and capital-intense industries. Cooper et al. (1994) focused on the influence of initial capital on new venture performance. The venture performance was measured with two indicators – survival and growth of venture. The impact of initial resources on subsequent performance was found strong. The similar conclusion is indicated

in the study by Gottschalk and Niefert (2011). They examined the influence of start-up capital on selected performance indicators – sales and return on sales. The effect of start-up capital is positive whereas the impact of start-up capital on return on sales is insignificant.

There are some studies that address the issue of performance of agriculture firms and the determinants of their performance. Rajčániová and Bielik (2008) analysed the determinants of firm-level profitability (measured by return on assets) on a sample of 111 agriculture enterprises from Slovakia. They use linear regression model that contains beside firm size (measured by total assets) also market share (the proportion of firm sales in industry sales), gearing ratio (non-current liabilities plus loans divided by shareholder funds), profit of previous year and liquidity ratio measured by current assets minus stock divided by current liabilities. They found no statistically significant link between the firm size and the profitability. Firm-level profitability was positively influenced by profitability from previous year, gearing ratio and liquidity ratio. Mugera and Langemeier (2011) dealt with a question whether technical efficiency is affected by firm size or specialization using the sample of more than 500 Kansas farms. To estimate the technical efficiency they used the input oriented framework. One of the finding of the study is a fact that smaller farms are less technically efficient than their larger counterparts.

Bojnec and Latruffe (2013) examined the role of agricultural subsidies and farm size on Slovenian farms' performance. As indicators for measuring farm performance they used technical efficiency, allocative efficiency, economic efficiency and profitability. The technical efficiency is calculated with the help of DEA model under the assumption of constant returns to scale. Allocative efficiency indicates whether inputs are used in an optimal combination given their respective prices and whether substitution among inputs is required. Economic efficiency indicates overall efficiency of farms and it is a product of technical and allocative efficiencies. The profitability is measured with the help of cost-revenue ratio which is computed as the total costs from production to total revenue from production. They revealed significant positive link between farm size and technical efficiency and economic efficiency. On the other hand they found negative effect of farm size on profitability.

There was already some research focused on economic results of the Czech pig breeders. For instance Boudný and Špička (2012) examined differences of economic outcomes in pig breeding which is affected by the production efficiency of sows and fattening pigs. They measured the economic performance with the help of profitability of pig farming. Špička (2014) investigated financial results of Czech firms in pig breading area in the period 2007 – 2013. For the evaluation of financial situation he used profitability ratios (ROE, ROA and ROS), capital structure indicators (Debt-Equity ratio, Debt Ratio and Financial Leverage), liquidity ratios (Current Ratio, Acid Test Ratio and Cash Ratio), cash conversion cycle indicators (Days Inventory Outstanding, Days Sales Outstanding and Days Payable Outstanding) and other financial ratios (The Share of Net Working Capital in Total Assets, Labour Productivity and Investment Activity). He found big differences among companies in profitability (measured by ROA, ROE and ROS) because of differences in labour productivity. The best companies had four times higher labour productivity in comparison with the worst quarter.

Materials and methods

As it was mentioned before we compared the economic performance of the companies belonging to the sector CZ-NACE 01.460 – Raising of swine in the year 2013. These companies have raising of swine as a main activity. The used data come from database Albertina CZ Gold Edition that is provided by Bisnode company and from Business Register. According to the database Albertina 45 companies had this type of activity in 2013. Because of the fact that some data for 3 companies were missing we excluded them from the analysis. The final dataset covers the data of 42 companies.

To evaluate the economic performance of companies we use multiple criteria evaluation of alternatives. These methods are usually used in the situations where it is necessary to compare a lot of different alternatives according to the selected criteria in order to find the best alternative, to separate the alternatives into acceptable and non-acceptable or to create the order of alternatives (Yoon and Hwang, 1995). Firstly the aim of the decision-making process must be specified and then the criteria, alternatives and the preferences of the decision maker must be defined. The preferences can be described by aspiration levels (or requirements), criteria order or by the weight of the criteria (Hwang and Yoon, 1981).

The model of multi-criteria evaluation of alternatives contains a list of alternatives $A = \{a_1, a_2, \ldots, a_n\}$, a list of criteria $F = \{f_1, f_2, \ldots, f_k\}$ and an evaluation of the alternatives by each criterion in the criteria matrix with information about the evaluation of each alternative by each criterion (Fiala, 2008). The theory of multi-criteria evaluation of alternatives offers many different methods for this kind of problems. For the analysis we selected TOPSIS method in which the minimization from the ideal alternative principle is included (Laly and Liu, 1994; Fiala, 2008).

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is able to rank the alternatives using the relative index of distance of the alternatives from the ideal and negative ideal (also called basal or nadir) alternative. Higher relative index c_i of distance means better alternative. The user must supply only the information about the weights of criteria (Laly and Liu, 1994). This method can be used not only for the evaluation of companies (like in Yalcin et al., 2012; Wang and Hsu, 2004 or Kuncová and Štouračová, 2014) but also for the evaluation of different products, services or for the ranking of countries according to the selected criteria (Kuncová and Doucek, 2011).

The output provided by TOPSIS is a complete arrangement of possible alternatives with respect to the distance to both the ideal and the basal alternatives incorporating relative weights of criterion importance. The required input information includes decision matrix **Y** with the information about all selected alternatives $a_1, .., a_p$ according to all criteria $f_1, .., f_k$ and weight vector **v** of these criteria. This decision-making approach can be summarized in the following steps (detailed description of steps and notation in Yoon and Hwang, 1995 or Fiala, 2008):

- normalize the decision matrix according to Euclidean metric:

$$r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{p} y_{ij}^2}}, \quad \forall\, i = 1, \ldots, p, \quad j = 1, \ldots, k, \tag{1}$$

  where r_{ij} is the normalized value for each alternative i and criterion j (i.e. the value between 0 and 1) when the real value of the given criterion and alternative is represented by value y_{ij}. In our case study we have 42 companies as alternatives and 5 criteria (Return on assets, Return on equity, Return on sales, Labour productivity and Operating ratio).

- calculate the weighted decision matrix $\mathbf{W} = (w_{ij}) = v_j \cdot r_{ij}$, and from the weighted decision matrix **W** identify vectors of the hypothetical ideal H and basal D alternatives over each criterion

$$H_j = \max_i \left(w_{ij}\right), \text{ for j=1,2,…, } k \tag{2}$$

$$D_j = \min_i \left(w_{ij}\right), \text{ for j=1,2,…, } k \tag{3}$$

- measure the Euclidean distance of every alternative to the ideal and to the basal alternatives over each attribute:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (w_{ij} - H_j)^2} \quad \textit{and}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (w_{ij} - D_j)^2}, \quad \forall\, i = 1, \ldots, p, \tag{4}$$

- for all alternatives determine the relative ratio of its distance to the basal alternative

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-}, \quad \forall\, i = 1, \ldots, p, \tag{5}$$

- rank order alternatives by maximizing ratio c_i that represents the relative distance from the ideal alternative.

TOPSIS method is appropriate to our problem according to its main characteristics: (1) values for each criterion must be given by numbers; (2) the range of the values is not limited (when the negative value appears all values in the given criterion are increased by the absolute value of the most negative one); (3) each criterion is in the first step analysed (normalised) separately with respect to the ranges of best and worst values (the worst value stays the worst after the normalisation procedure but there are different normalised worst values for each criterion according the criterion range – it is different than in for example WSA method where all worst values change into zero after normalisation). For our problem it is very important as the difference between the best and the worst value for our criteria is so big that the WSA principle changing the best value into 1 and the worst value into 0 could influence the results in a negative way. Also methods that use pairwise comparison are not appropriate for our case as they might take any difference as important (ELECTRE methods) or it is necessary to define limits for the importance of the difference (PROMETHEE methods); (4) the results are numbers on the scale 0-1 that can be interpreted not only as the relative distance but also as the coefficient of how successful the company was.

As we stated above the important part in application of multi-criteria evaluation model is the defining the criteria for evaluation. When setting the criteria we use data from the database Albertina. This database consists of only quantitative data from financial statements and there is no information about intangible assets which are the important factor of economic performance of the firms (Šiška, 2013). To evaluate the economic performance of companies we use five financial ratios arranged into three groups:

- Profitability ratio. This group consists of three ratio indicators: Return on equity (ROE) = Earnings after tax (EAT)/Equity; Return on assets (ROA) = Earnings before interest, taxes, depreciation and amortization (EBITDA)/Total assets; and Return on sales (ROS) = Earnings before interest, taxes, depreciation and amortization (EBITDA)/Sales. To calculate ROA and ROS we use EBITDA as the profit. EBITDA is computed as the sum of profit/loss before tax, interest expenses and depreciations of intangible and tangible assets. We prefer EBITDA before earnings before interests and taxes (EBIT) to no penalize firms for their decision to buy new fixed assets. For calculation of ROS the amount of the sales is computed as the sum of revenues from sale of goods and revenues from sales of own products and services. For computing of ROE as EAT is used profit/loss of current accounting period.
- Labour productivity. Labour productivity = Value added/Personnel expenses. Labour productivity is usually calculated using data on the number employees. However, the exact number of employees is not available in our database, so we use this alternative form of indicator.
- Operating ratio. Operating ratio = (Operating expenses - Depreciation)/(Revenues from sold goods + Production). Where production is the sum of revenues from own products and services, changes in inventory of own products and capitalization.

Indicators of profitability ratio are used as the measurement of financial performance. Labour productivity and operating ratio are a measure of operational performance. ROE, ROA, ROS and labour productivity are MAX-indicators which means that the higher value of this indicators implies the higher economic performance. Operating ratio is MIN-indicator. The lower value of this indicator means better economic performance.

Using multi-criteria evaluation method we set the same weight for all three groups of indicators (0.333 for each group and 0.111 for every indicator of profitability ratio). Simultaneously we maximize the value of profitability ratio (the profit per 1 CZK of assets, equity or sales) and labour productivity (value added per 1 CZK of labour costs) and minimalize the value of operating ratio indicator (operating costs per 1 CZK of sales). During the analysis of the firm data we identify two firms having negative equity. These firms report also the lost (negative profit) in examined year. The value of ROE was positive despite the lost. To eliminate the distortion caused by negative equity we assign the worst rating in this criterion to these two firms.

To roughly assess the situation in the industry of raising swine in terms of profitability we compare ROE with opportunity costs of equity. Opportunity cost of equity represents the return on equity which could be achieved if we invest in the same risk investment opportunities. The opportunity cost of equity (re) is the sum of the risk-free rate and the risk margin which consists of risk premiums for entrepreneurial risk, financial structure, financial stability and company size. These risk premiums are firm specific and they depend on the characteristics of company (the ratio of equity and debt, the size of the equity and interest-bearing debt, enterprise liquidity and production strength) (Ministry of industry and trade, 2015).

To assess the relationship between firm size and economic performance of the firm we use linear regression model.

$$c_i = \beta_1.firm\ size_i + \beta_2.firm\ age_i + \beta_3.initial\ capital_i + u_i \quad (6)$$

Where i denotes firm, c_i is economic performance of the i-th firm, $firm\ size_i$ is the size of the i-th firm, $firm\ age_i$ is the age of i-th firm, $initial\ capital_i$ denotes the amount of initial capital of i-th firm and u_i is the disturbance term.

As dependent variable we use the results from multi-criteria evaluation method (TOPSIS) which represent economic performance of the firm. As explanatory variable we use firm size, firm age and initial capital.

- Firm size. We use natural logarithm of sales and total assets (both in thousands of CZK) as the indicator of firm size. Sales, total

assets and number of employees belong to the most frequently used criterion of firm size in empirical studies (Nassar, Almsafir and Al-Mahrouq, 2014). We do not use the number of employees firstly because of the database Albertina (from which we take the data) does not contain the accurate data, number of employees is present in the form of interval. Secondly sales and total assets appear to be better indicators of firm size due to relative rigidity of number of employees. The changes in real output of the company could be reflected in this indicator with a considerable delay (Fiala and Hedija, 2015). As we noted in the part titled Review of literature, from economic theory point of view the relationship between firm performance and a firm size is uncertain. The large firms could realize the economies of scale and scope and reach lower expenses due to formalization of procedures and more effective implementation of operations. They could also benefit from higher competitive power. On the other hand smaller and younger firms could be more flexible and to better adapt to market changes. Boudný and Špička (2012) concluded that in the Czech enterprises specializing in breeding pigs the economies of scale are realized. Due to this fact we can expect that bigger firms would achieve better economic performance as compared with smaller ones in raising of swine sector.

- Firm age. This indicator was being measured as the number of years since the founding of the company until 2013. From the theoretical point of view the age of firm could affect the economic performance of the firm but final effect is not clear. The older firm could benefit from experience, reputation and built business relationships and networks. These factors might be the reason for higher economic performance in comparison with smaller firm. On the other hand the younger firms are more flexible, they suffer less bureaucracy and they are more active in seeking of market opportunities. Due to the characteristics of the raising swine sector and the type of product we expect that reputation, experience and network should play an important role. So we expect mostly positive relationship between firm age and firm performance.
- Initial capital. The initial capital is measured as the natural logarithm of registered capital of the company at the time of its founding (in thousands of CZK). We expected positive effect of initial capital on firm performance. At the stage of establishing a company it is difficult to obtain loans and equity (initial capital) is an important source for firm development and growth.

Descriptive statistics for linear regression are shown in Table 1. We use program Stata to estimate the coefficients of regression model by the Ordinary Least Square (OLS) with heteroskedastic-consistent standard errors (command "regress" and option "robust" in Stata). We detect the multicollinearity using the variance inflation factor ("vif" command in Stata). There is not a problem of multicollinearity in the presented models.

Results and discussion

Firstly we evaluate the economic performance of the firms using TOPSIS. We present the value of all criterions which are used in multi-criteria evaluation model. Table 2 shows the median, average value, the best and the worst values for all three profitability ratios and also for labour productivity and the operating ratio. We remind that profitability ratios and labour productivity are MAX-indicators, the operating ratio is MIN-indicator.

As regards the profitability ratios the average value of ROA is 5.82 percent and 54.8 percent of all firms reach the value above average. 11 from 42 examined firms reached negative ROA and ROS which was

	Sales (in thousands CZK)	Total assets (in thousands CZK)	Age	Start-up capital (in thousands CZK)
Minimum value	424	6724	9	100
Maximum value	1381851	1104142	22	290590
Mean	206662	195945	19	77065
Standard deviation	289440	220551	3	81308

Source: own processing

Table 1.: Descriptive statistics for linear regression.

caused by negative EBITDA. As regards ROE the average value was negative and reached -0.1. The negative value of ROE reported 16 firms which is approximately 38 percent of firms. However, the negative EAT was observed in 18 firms. Two firms report negative equity and negative EAT and ROE were positive in this case.

To assess the situation of companies in the sector we compare ROE with opportunity cost of equity (r_e). Aside from individual factors in any case ROE should be greater than the sum of risk-free rate increased by minimum risk premium for the sector. According to data from Ministry of industry and trade (2015) risk-free rate was (determined as profitability of 10year government bonds) 2.26 percent and minimum penalty for the business risk in agriculture reached 3 percent in 2013. The sum of both rates amounted to 5.26 percent. The ROE of firms from the sector raising of swine should be above this rate in 2013 so that we can assess its situation as satisfactory. Nevertheless, ROE higher than 0.0526 reached only 16 companies that represents only 14 percent of firms in raising of swine industry (excluding two companies that have achieved positive ROE due to the negative EAT and equity). Business in this industry does not appear to be highly profitable.

We used method TOPSIS to assess the economic performance of firms belonging to the raising of swine sector according to selected criteria. The aim is to minimize the distance from the ideal solution. In our case the best values (see Table 2) are taken as the ideal hypothetical company. The results for the best and the worst three companies are presented in Table 3. The values called "Relative distance" describe the closeness to the ideal solution that is why the higher value is the better and in our case it is the indicator of economic performance. The winner company is Agro Vyšehořovice zemědělská a obchodní, a.s that has the minimal distance to ideal solution because of the best ROA (37 percent) and very good values in other criteria. The return on equity is more than 42 percent and return on sales amounts 48 percent. This firm produces almost 3 CZK added value per 1 CZK labour cost and operating costs without depreciation amounts for 85 percent of revenues from sold goods and production. On the other hand the worst company is Velkovýkrmny Zákupy, a.s. that reaches the smallest value of relative distance. This firm had the worst value in three criteria in comparison with other firms (operating ratio, labour productivity and ROE) and surprisingly also the best value of ROS. Very high value of ROS was reached due to very high value of depreciation that cased that EBITDA was positive (despite negative EAT) and high relative to sales. It confirms the fact that ratings firms using only one criterion may be highly misleading.

In second step we examine the relationship between economic performance and firm size using linear regression model (equation 6). As dependent variable the relative distance from TOPSIS is used. Due to higher objectivity we use two variants of firm size indicator: sales and total assets. As other explanatory variables we use initial capital and age of the firm.

The results are shown in Table 4 and Table 5. There are used sales as the measurement of firm size in Table 4 and total assets in Table 5. Firstly we use only firm size as independent variable to find out the explanatory power of these variable respective to economic performance (model (1)). The regression coefficients are positive in both cases that imply the directly proportional relationship between firm size and firm performance. Using

	Profitability ratios			Labour productivity	Operating ratio
	ROA	ROE	ROS		
Best value	0.3713	0.7283	1.0024	3.7458	0.7464
Worst value	-0.1366	-2991 / -4.6204[1]	-0.6673	-2.6723	7.6816
Mean	0.0582	-71.3 / -0.10	0.0827	1.2469	1.2492
Standard deviation	0.0954	455.98 / 0.804	0.2147	1.0553	1.0580
Median	0.0613	0.0254	0.0576	1.1428	1.0179
Number (%) of comp. with negative value	11 (26.2%)	16 (38.1%)	11 (26.2%)	3 (7.1%)	0 (0%)
Number (%) of comp. with values above average	23 (54.8%)	41 / 32 (97.6 / 76.2)	16 (38.1%)	17 (40.5%)	6 (14.3%)

Note: [1)] ROE for 1 company was extremely different (-2991) and so we have calculated first with this value and the second numbers are without this outlier as it influences the average and standard deviation.

Source: own processing

Table 2: Descriptive statistics for selected criterions of firm performance.

Rank		Relative distance	Profitability ratios			Labour productivity	Operating ratio
			ROA	ROE	ROS		
1	Agro Vyšehořovice zemědělská a obchodní, a.s.	0.8696	0.3713	0.4243	0.4824	2.960	0.7464
2	Granero Vlasatice, s.r.o.	0.7859	0.1015	0.0895	0.1701	3.6504	0.8161
3	AG - Horní Rybníky, s.r.o.	0.7717	0.0955	0.0606	0.0749	3.7458	0.9316
40	Vysoká, a.s.	0.4977	-0.0326	-0.2860	-0.0222	-0.1004	1.6868
41	Zemědělsko obchodní společnost Brodek u Prostějova, a.s.	0.4443	-0.1366	-0.1904	-0.6673	0.3652	2.8038
42	Velkovýkrmny Zákupy, a.s.	0.2707	0.0222	-2991[1]	1.0024	-2.6723	7.6816

Note: [1)] Because of negative EAT and negative equity, ROE was positive and reaches 0.5699. In calculation, the worst value from the industry was assigned.

Source: own processing

Table 3: Results and criteria values for the best and worst companies - Multi-criteria evaluation model.

Model	(1)	(2)	(3)
Firm size (β_1)	0.027*	0.043***	0.043***
	(0.015)	(0.009)	(0.009)
Initial capital (β_2)	-	-0.019***	-0.020***
		(0.006)	(0.006)
Firm age (β_3)	-	-	0.002
			(0.005)
Constant	0.320*	0.313***	0.288**
	(0.173)	(0.096)	(0.115)
R^2	0.1527	0.3572	0.3594
F-test	0.0735	0.0001	0.0001
N	42	42	42

Note: ***significant at the 1 percent level, **significant at the 5 percent level, *significant at the 10 percent level, robust standard errors in brackets.

Source: own processing

Table 4: Results - Linear regression model (SALES).

Model	(1)	(2)	(3)
Firm size (β_1)	0.018	0.047**	0.047**
	(0.014)	(0.019)	(0.019)
Initial capital (β_2)	-	-0.020**	-0.022**
		(0.008)	(0.008)
Firm age (β_3)	-	-	0.002
			(0.005)
Constant	-	0.274	0.249
		(0.168)	(0.168)
R^2	0.0481	0.2441	0.2468
F-test	0.1779	0.0407	0.0641
N	42	42	42

Note: ***significant at the 1 percent level, **significant at the 5 percent level, *significant at the 10 percent level, robust standard errors in brackets.

Source: own processing

Table 5: Results - Linear regression model (TOTAL ASSETS).

the sales as the measurement of firm size firm size explained 15 percent of variability in economic performance of firms. In the case of total assets the effect on economic performance was not statistically significant and the firm size explained only 5 percent of variability in economic

performance. These results point to the fact that the relationship between sales and firm performance was tighter than between economic performance and the sum of total assets in the Czech raising swine sector.

The regression coefficients are positive in both cases that imply the directly proportional relationship between firm size and firm performance. Using the sales as the measurement of firm size firm size explained 15 percent of variability in economic performance of firms. In the case of total assets the effect on economic performance was not statistically significant and the firm size explained only 5 percent of variability in economic performance. These results point to the fact that the relationship between sales and firm performance was tighter than between economic performance and the sum of total assets in the Czech raising swine sector.

In models (2) and (3) (Table 4 and Table 5) we added other explanatory variables to the model: initial capital and firm age. The results show that the explanatory power of model increases significantly. As statistically significant factor is proved to be firm size and initial capital. As it could be expected in our case the age is not the significant factor explaining differences in economic performance of firms belonging to the raising swine sector. The significant effect of firm size on performance could be expected in dynamic industry with a large proportion of young firms. In Czech raising of swine sector all companies were active on the market for relative long time. The firms in this sector were on average 19 years old in 2013 and the youngest firm was 9 years old (see Table 1).

The best model explaining the variability in the performance of companies appears to be model (2) for both variant of firm size measurement (sales and total assets). The explanatory variables in this model are statistically significant and it explains almost 36 percent of variability in economic performance using sales and 24 percent using total assets.

Regarding the firm size the regression coefficients are positive for both variant of firm size indicators (sales and total assets). Using sales as the indicator of firm size, the regression coefficient reaches 0.043 and is statistically significant at 1 percent level. The increase of sales by 10 percent causes the growth of economic performance measured by relative distance by 0.0043. In the case of total assets the results are very similar. The regression coefficient amounts 0.047 and is statistically significant at 5 percent level. The increase of total assets by 10 percent causes the growth of economic performance measured by relative distance by 0.0047. This results confirms the hypothesis that larger companies achieve higher economic performance in Czech raising of swine sector. The higher technical efficiency and realization of economies of scales could be the main causes of higher economic performance of bigger firms comparing to their smaller counterparts. The empirical studies devoted to agricultural sector mostly conclude that the bigger farms achieve better technical efficiency than smaller ones (e.g. Mugera and Langemeier, 2011; Bojnec and Latruffe, 2013). We can expect the realization of economies of scales in bigger firms in Czech raising swine sector (Boudný and Špička, 2012).

The effect of initial capital on economic performance is statistically significant and negative. If the initial capital increases by 10 percent, the relative distance decreases by approximately 0.002. Previous empirical studies rather identify the positive relationship between initial capital and firm performance (e.g. Gottschalk and Niefert, 2011). The negative effect of initial capital in Czech raising swine sector could be explained in the history context of development of this sector. Most of the examined companies were formed after the economic reforms in 1992 and 1993 as a successor to the existing agricultural cooperatives (what indicates the amount of initial capital). Companies with higher initial capital (and therefore at the time of establishing larger) can achieve lower economic performance compared with companies with lower initial capital because they have taken over large obsolete areal which maintenance and operation is expensive.

Conclusion

The sector of raising of swine in the Czech Republic has faced various problems, particularly the decline in pork prices on the market in recent years. Our analysis aimed at 42 companies from this sector and the year 2013. The aim of the paper was to examine the relationship between the firm size and the economic performance using linear regression model.

To evaluate the economic performance of the firms we used the multiple-criteria evaluation of alternatives method, specifically TOPSIS. As the measurement of economic performance we used selected indicators of profitability, indicator of productivity and operating ratio. According these selected criteria we estimate the relative distance

of every company from hypothetical optimal solution. The best company was Agro Vyšehořovice zemědělská a obchodní, a.s. It reported the best value of ROA (37 percent) and also very good results in other criteria. The worst company was Velkovýkrmny Zákupy, a.s. that reported the worst value of labour productivity, operating ratio and ROE and on the other hand the best value of ROS.

Then we used linear regression model to examine the relationship between economic performance of the company and its size. As the measurement of economic performance we used relative distance of the firm from ideal solution (results from TOPSIS), as the indicator of firm size, sales and total assets. We added to a model the other two explanatory variables that are closely related to economic performance: initial capital and age of the firm.

We found that the firm size is the statistically significant factor explaining the differences in economic performance among firms in the sector of raising swine in the Czech Republic. The firm size together with the amount of initial capital explained approximately 36 percent of variability in economic performance of the firms. The age of the firm was not statistically significant. The findings were very similar for both indicators of firm size: sales and total assets. The results showed that the larger firms reached higher economic performance compared with smaller ones. These findings indicate that economies of scale are likely to play an important role in this sector.

Corresponding author:
Ing. Veronika Hedija, Ph.D.
College of Polytechnic Jihlava, Tolstého 16, 586 01 Jihlava, Czech Republic
Phone: +420 567 141 204. E-mail: veronika.hedija@vspj.cz

References

[1] Agiomirgianakis, G., Voulgaris, F. and Papadogonas, T. (2006) "Financial factors affecting profitability and employment growth: the case of Greek manufacturing", *International Journal of Financial Services Management*, Vol. 1, No 2/3, pp. 235 – 245. ISSN 1741-8062. DOI 10.1504/IJFSM.2006.009628.

[2] Bojnec, Š. and Latruffe, L. (2013) "Farm size, agricultural subsidies and farm performance in Slovenia", *Land Use Policy*, Vol. 32, pp. 207–217. ISSN 0264-8377.

[3] Boudný, J. and Špička, J. (2012) "The Effect of Production Efficiency on Economic Results in Pig Breeding", *Research in Pig Breeding*, Vol. 6, No. 1, pp. 1 - 8. ISSN 1802-7547.

[4] Coad, A, Segarra, A. and Teruel, M. (2013) "Like milk or wine: Does firm performance improve with age?", *Structural Change and Economic Dynamics*, Vol. 24, No. 1, pp. 173 – 189. ISSN 0954-349X. DOI 10.1016/j.strueco.2012.07.002.

[5] Cooper, A. C., Gimeno-Gascon, F. J. and Woo, C. Y. (1994) "Initial Human and Financial Capital as Predictors of New Venture Performance", *Journal of Business Venturing*, Vol. 9, No. 5, pp. 371 – 395. ISSN 0883-9026. DOI 10.1016/0883-9026(94)90013-2.

[6] Czech Statistical Office. (2016) Statistická ročenka České republiky 2015. [Online]. Available: https://www.czso.cz/csu/czso/statisticka-rocenka-ceske-republiky-2015. [Accessed: 10 March 2016].

[7] Evans, G. W. (1984) "An Overwiev of Techniques for Solving Multiobjective Mathematical Programs", *Management Science*, Vol. 30, No. 11, pp. 1268–1282. ISSN 0025-1909.

[8] Fey, C. F. and Denison, D. R. (2003) "Organizational Culture and Effectiveness: Can American Theory Be Applied in Russia? ", *Organization Science*, Vol. 14, No. 6, pp. 686–706. ISSN 1047-7039. DOI 10.1287/orsc.14.6.686.24868.

[9] Fiala, P. (2008) "*Modely a metody rozhodování*" ("Models and methods of decision making, in Czech") Prague: Oeconomica. ISBN 80-245-0622-x.

[10] Fiala, R. and Hedija, V. (2015) "The Relationship Between Firm Size and Firm Growth: The Case of the Czech Republic", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 63, No. 5, pp. 1639-1644. ISSN 1211-8516. DOI 10.11118/actaun201563051639.

[11] Gaur, J. and Gupta, R. (2011) "Comparing firm performance on the basis of age, size, leverage, and group affiliation in Indian IT industry", *Romanian Journal of Marketing*, Vol. 6, No. 3, pp. 8-13. ISSN 1842-2454.

[12] Gottschalk, S. and Niefert, M. (2011) "Gender Differences in Business Success of German Start-up Firms", Discussion Paper No. 11-019. [Online]. Available: http://ftp.zew.de/pub/zew-docs/dp/dp11019.pdf [Accessed: 10 May 2016].

[13] Hult, G. T. M., Ketchen, D. J., Chabowski, B. R. et al. (2008) "An assessment of the measurement of performance in international business research", *Journal of International Business Studies*, Vol. 39, No. 2008, pp. 1064 –1080. ISSN 0047-2506. DOI 10.1057/palgrave.jibs.8400398.

[14] Hwang, C. L., and Yoon, K. (1981) "*Multiple Attribute Decision Making: Methods and Applications*", New York: Springer-Verlag. ISBN 978-3-540-10558-9.

[15] Institute of Agricultural Economics and Information IAEI. (2013) Bulletin ÚZEI 2013. [Online]. http://www.uzei.cz/data/usr_001_cz_soubory/bu1303.pdf. [Accessed: 8 August 2016].

[16] Kuncová, M., Doucek, P. (2011) "Comparison of the Cluster Analysis and the Methods of the Multi-criteria Evaluation of Alternatives Used to Create a Groups of Countries Similar in the Take up of the Internet Services", In: *Proceedings of the Mathematical Methods in Economics 2011 Conference* [CD-ROM]. Prague: University of Economics in Prague, University of Economics in Bratislava. ISBN 978-80-7431-059-1.

[17] Kuncová, M., Štouračová, I. (2014) "Srovnání výrobců deskových her na českém trhu", *Logos Polytechnikos*, Vol. 5, No. 3, pp. 43-54. ISSN 1804-3682.

[18] Lai,Y., J., and Liu, T., Y. (1994) "TOPSIS for MODM", *European Journal of Operation Research*, Vol. 76, No. 3, pp. 486–500. ISSN 0377-2217. DOI 10.1016/0377-2217(94)90282-8.

[19] Liargovas, P. G. and Skandalis, K. S. (2010) "Factors Affecting Firms' Performance: The Case of Greece", *Global Business and Management Research: An International Journal*, Vol. 2, No. 2 and 3, pp. 184 – 197. ISSN 1947-5667.

[20] Machek, J. (2011) "Chov prasat v ČR po vstupu do EU z pohledu MZe" ("Breeding of pigs in the CR after accession in the EU, in Czech), Conference Chov prasat 2011, [Online]. Available: http://www.vetkom.cz/content/sendFile/name/8865a78cb9168b19e72a35889b1e3dd0. [Accessed: 8 August 2016].

[21] March, J. G. and Sutton, R. I. (1997) "Organizational Performance as a Dependent Variable", *Organization Science*, Vol. 8, No. 6., pp. 698 – 706. ISSN 1047-7039.

[22] Ministry of Agriculture (2015) "Situační a výhledová zpráva: Vepřové maso – 9/2015" (Situation and perspective report: Pig meat - 9/2015, in Czech). [Online]. Available: http://eagri.cz/public/web/file/432953/Veprove_2015_web.pdf [Accessed: 8 August 2016].

[23] Ministry of industry and trade (2015) "Finanční analýza podnikové sféry pro rok 2014" (Financial analysis of business sphere for 2014, in Czech), [Online]. Available: http://www.mpo.cz/dokument157262.html. [Accessed: 26 April 2016].

[24] Mugera, A, W. and Langemeier, M, R. (2011) "Does Farm Size and Specialization Matter for Productive Efficiency? Results from Kansas", *Journal of Agricultural and Applied Economics*, Vol. 43, No. 4, pp. 515–528. ISSN 1074-0708.

[25] Nassar, I. A., Almsafir, M. K. and Al-Mahrouq, M. H. (2014) "The Validity of Gibrat's Law in Developed and Developing Countries (2008-2013): Comparison Based Assessment ", *Procedia - Social and Behavioral Sciences*, Vol. 129, pp. 266-273. ISSN 1877-0428.

[26] Radipere, S. and Dhliwayo, S. (2014) "The role of age and business size on small business performance in the South African small enterprise sector", *Problems and Perspectives in Management*, Vol. 12, No. 4, pp. 7 - 12. ISSN 1810-5467.

[27] Rajčániová, M. and Bielik, P. (2008) "Determinants of variations in firm-level performance", *Acta oeconomica et informatica*, 1/2008, pp. 1–4. ISSN 1336-9261.

[28] Richard, P. J., Devinney, T. M., Yip, G. S. et. al. (2009) "Measuring Organizational Performance: Towards Methodological Best Practice", *Journal of Management*, Vol. 35, No. 3, pp. 718–804. ISSN 0149-2063. DOI 10.1177/0149206308330560.

[29] Svatoš, M. and Chovancová, M. (2013) "The influence of subsidies on the economic performance of Czech farms in the regions", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 61, No. 4, pp. 1137–1144. ISSN 2464-8310.

[30] Šiška, L. (2013) "Intangible Factors of Company´s Performance", In: *21st Interdisciplinary Information Management Talks (IDIMT)*, Prague: Trauner Verlag, pp. 335–342. ISBN 978-3-99033-083-8.

[31] Šišková, J. (2015) "Application of Multi-Criteria Analysis in the Evaluation of Biogas Plants with Respect to the Stability of the Agricultural System", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 63, No. 3, pp. 853–860. ISSN 2464-8310.

[32] Špička, J. (2014) "Financial situation of Czech pig breeders in the period 2007 – 2013", *Research in Pig Breeding*, Vol. 8, No. 2, pp. 20–25. ISSN 1802-7547.

[33] Štolcová, J., Homolka, J. (2012) "Production Costs in the Fattening Period of Pigs and Assessment of the Influence of Selected Factors on the Amount of These Costs", *Agris on-line Papers in Economics and Informatics*, Vol. 4, No.4-Special, pp.107-113. ISSN 1804-1930.

[34] Wang, T.-C. and Hsu, J. C. (2004) "Evaluation of the Business Operation Performance of the Listing Companies by Applying TOPSIS Method". In: *Proceedings of the IEEE International Conference on Systems*, Man & Cybernetics. The Hague: IEEE, pp. 286–1291. ISBN 0-7803-7952-7.

[35] Yalcin, N., Bayrakdaroglu, A. and Kahraman C. (2012) "Application of fuzzy multi-criteria decision making methods for financial performance evaluation of Turkish manufacturing industries", *Expert Systems with Applications*, Vol. 39, No. 1, pp. 350–364. ISBN 0957-4174. DOI 10.1016/j.eswa.2011.07.024.

[36] Yang, H., Yeung, J. F. Y., Chan, A. P. C., et. al. (2010) "A critical review of performance measurement in construction", J*ournal of Facilities Management*, Vol. 8, No. 4, pp. 269–284. ISBN 1472-5967. DOI 10.1108/14725961011078981.

[37] Yoon, K., and Hwang, C. L. (1995) "*Multiple Attribute Decision Making: An Introduction*". Thousand Oaks, California: Sage. ISBN 0-8039-5486-7.

[38] Žižlavský, O. (2015) "Performance Measurement of Innovation Project: Selected Shortcomings", *Littera Scripta*, Vol. 8, No. 2, pp. 178-192. ISSN 1805-9112.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Estimation of Barley (Hordeum Vulgare L.) Crop Water Requirements Using Cropwat Software in Ksar-Chellala Region, Algeria

M. B. Laouisset[1], A. Dellal[2]

[1] Scientific and Technical Research Centre for Arid Areas (CRSTRA), Biskra, Algeria

[2] Laboratory of Agro-Biotechnology and Nutrition in Semi-Arid Regions, Ibn Khaldoun University, Tiaret, Algeria

Abstract

This paper estimates the reference Evapotranspiration (ET0) and Water requirements of barley (Hordeum vulgare L.) in Ksar-Chellala region, Algeria, for one dry year by using CROPWAT software. Determination of Evapotranspiration (*ET*) is important in application such as irrigation design, irrigation scheduling, water resource management, hydrology and cropping systems modeling. Estimation of crop water requirements of barley (CWR_b) respected the methodology adopted by the service of development and management service of FAO, based on the use of software CROPWAT 8.0. The total water requirements for barley depend on a variety of target yields and crops management. The period of climatic data used is 23 years (1990-2012), the average rain in this period is 254 mm. The total rain of the dry year is 190 mm. The results of this study show, during the vegetative cycle of barley which is 6 months, the calculation of ET_0 is 453 mm, the potential water which was used by the crop barley is estimated at 281.4 mm, the efficiency of rainfall is 69 mm and a total water requirements of barley (CWR_b) equals to 211 mm, this amount distributed on three months coincided with important stages of development in barley. The supplementary irrigation in these conditions with optimal contents equals water requirements estimated by CROPWAT software that increases significantly grain yield of barely. Consequently, the gross irrigation water requirements (*GIWR*) of 1250000 ha which project to grow barley in the Algerian steppes regions are estimated at 3.77 billion and this for a dry year and a irrigation efficiency of 70%.

Keywords

Hordeum vulgare, water requirements, CROPWAT, Algerian steppes regions.

Laouisset, M. B. and Dellal, A. (2016) "Estimation of Barley (Hordeum Vulgare L.) Crop Water Requirements Using Cropwat Software in Ksar-Chellala Region, Algeria", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 91 - 102. ISSN 1804-1930, DOI 10.7160/aol.2016.080309.

Introduction

In agriculture, the irrigated areas in Algeria have evolved from 905300 ha in 2007 to 1.64 million ha in 2014. Algeria, an arid to semi-arid country, is characterized by a high population growth rate, making important increase in agricultural productivity to ensure food security. Agricultural development is strongly influenced by irrigation. Agriculture has become highly strategic, because water resources are highly sensitive to climatic conditions, and the soils are weakened by the aggressiveness of natural phenomena, in particular desertification. The country is vulnerable to climate change; it experienced more frequent droughts, increased desertification, greater wind and water erosion in recent years. As well as a decreased rainfall over the past 30 years that has affected dams, groundwater tables and salinization due to aquifer over-exploitation and drought (CEDARE, 2014).

Water resources management has been a challenge in Algeria due to precipitation shortage in recent years. Economically crops production has direct relationship with irrigation. Every plant has specific water supply and needs different amount in different time and in different soil depth (O`Shaughnessy et al., 2012), (Yavuz et al., 2015). However, irrigation scheduling has been based on the predicted crop water requirements (*CWR*). 'Crop water requirements' is defined as the total water needed for evapotranspiration, from planting to harvest for a given crop in a specific climate regime, when adequate soil water is maintained by rainfall and/or irrigation so that it does not limit

plant growth and crop yield (Allen et al., 1998).

As the crop grows and extracts water from the soil to satisfy its evapotranspiration requirements (*ETc*), the stored soil water is gradually depleted. In general, the net irrigation water requirements (*NIWR*) is the amount of water required to refill the root zone soil water content back up to field capacity. This amount, which is the difference between field capacity and current soil water level, corresponds to the soil water deficit (Andales, Chávez, and Bauder, 2015).

Plant responses to water deficit are dependent on the amount of water lost, the rate of loss and the duration of the stressed condition (Bray, 1997).

The objective of a proper irrigation schedule is to supply the right amount of water before harmful stress occurs (optimum quantity and timing). It's very important to define a precise strategy when designing an irrigation system. Knowing the crop water requirements enables to determine the proper irrigation schedule at any given time; irrigation managers need to calculate the best time to irrigate, and how much water to use so that crops are economically productive, and water resources are managed in a sustainable manner. The calculation of seasonal and peak project supply required for a given cropping pattern and intensity includes the (*NIWR*) and other water needs including leaching of salts and efficiency of the distribution system Irrigation requirements are one of the principal parameters for the planning, design and operation of irrigation and water resources systems. Detailed knowledge of the (*NIWR*) and its temporal and spatial variability is essential for assessing the adequacy of water resources, to evaluate the need of storage reservoirs and to determine the capacity of irrigation systems. It is a parameter of prime importance in formulating the policy for optimal allocation of water resources as well as in decision-making in the day-to-day operation and management of irrigation systems (Savva and Frenken, 2002).

The spatial and temporal variation of rainfall in Ksar-Chellala region, resulting from topography and climate, makes that any action of agricultural intensification requires the recourse to the irrigation. According to several hydro geological studies in this area, the water resources mobilization is done in general by the means of drillings and/or wells feeding in the various groundwater systems which conceals a significant potential water resource.

Food and Agriculture Organization (FAO) developed software CROPWAT (Smith, 1992), which can deal with climate and crop information to determine the irrigation water requirements and also the efficiency and deficiency of the irrigation schedule. CROPWAT software includes a simple water balance model that allows the simulation of crop water stress conditions and estimations of yield reductions based on well established methodologies for determination of crop evapotranspiration (Smith, 1992) and yield response to water (Doorenbos and Kassam, 1979).

Simulation models, information systems and decision support systems can be relevant to support farmer's selection of water-use options, including crop patterns and irrigation systems, and to implement appropriate irrigation scheduling (Solinas, 2011). FAO software, such as CROPWAT, ET0 Calculator or AquaCrop, is nowadays widely used to calculate crop water and irrigation requirements and to develop irrigation schedules for different management conditions (Smith, 1992).

Barley is among the most important cereal in the world. It is one of the most ancient crops among the cereals and has played a significant role in the development of agriculture (Ullrich, 2011). Barley ranks fourth among cereals in terms of total world production. In 2009, around 54 million ha of barley were harvested, producing 152 million tons of grain at an average yield of 2.8 tons/ha (FAO, 2011)

Over the last 50 years, the average yield per hectare has increased noticeably (Pasquale, Theodore, Elias and Dirk, 2012).

Water is often the resource that most significantly limits barley yield, depending on severity of the deficiency. Seasonal evapotranspiration (*ETc*) of barley ranges from 100 to 500 mm. Barley is usually grown under rain fed situations. In some cases, however, full or partial irrigation may be applied, especially when barley is grown for malting or where double cropping is practised, with early-maturing barley followed by late-sown maize (or soybean). The seasonal water requirements for barley depend on target yield and crop management. Malt barley requires better water management than food barley to meet the standards set by the industry. During initial growth stages, crop water use ranges from 1 to 3 mm/ day, rising to 5 - 8 mm/day after canopy approaches complete cover (usually at the appearance of flag leaves), and remains high until the beginning

of canopy senescence. Although winter rainfall is sufficient in many climates to supply the full barley water requirements in the early vegetative phase, effective root zone soil moisture should not be depleted beyond 50 percent of total available water from emergence until flag leaf, after which depletions should probably not exceed 60 percent of the total available soil water until the soft dough stage. Normally, with adequate winter rainfall, border or flood irrigation of malt barley will require 2 to 3 irrigations on heavier soils corresponding with the critical growth stages. Light, sandy soils would require more frequent irrigations. Excessive soil moisture during the jointing and boot stage, coupled with high nitrogen fertility, may promote vegetative growth that could result in lodging as the crop develops. Excessive irrigation after the crop is well developed also promotes lodging (Pasquale, Theodore, Elias, Dirk, 2012). In Algeria and at the beginning of the nineteenth century, barley came at the head of cultures by its importance; it was intended for human consumption and was used as fodder complement. At present, barley ranks third in Algeria from the point of view of growing area and production. It represents currently the main animal food of sheep (Rahal-Bouziane, 2015).

However, sheep dominate in Algeria and are essentially concentrated in the steppe territory, employing 15 million head or more than 80% of the national total which is 18 million head and this according to the development office of the steppes (HCDS) in 2006, while livestock food requirements (feed grain) is: in 2005-2006, the year of low cereal prices, 60% of the feed requirements of sheep were provided by barley and 40% steppe rangelands. Cereal yields in the steppe are modest on land suitable for the cultivation of cereals, the yield varies from 03 to 05 qx/ha in poor years and from 08 to 12 qx/ha in a good year, through 05-08 qx/ha on average year. In 50 years the area under cereals (90% of barley) in the steppe has almost tripled from less than 1 million hectares in the sixties at 2.7 million hectares currently. According to HCDS until the end of 2005, 918 floodwater diversion works were rehabilitated or made, and thanks to these works, fodder production of 418 000 ha is possible today. The figures announced by the HCDS within the desertification fight days seminar held in Algiers in 2005, indicate the water engineering work shave involved only 30% of potential land which is favorable to spate irrigation (Bencherif S., 2011). Consequently, we can estimate the total area that can be irrigated, which stands at 1250000 ha in the steppe regions with climatic and soil characteristics are almost similar to those of Ksar-Chellala region.

Finally, the aim of this study is to estimate Water requirements for barley in central steppe areas of Algeria by using CROPWAT software. In addition, to achieve a good yield, it is imperative to provide supplemental irrigation in this area and therefore we can estimate the water requirements of this large area.

Materials and methods

Study area

The agricultural region of Ksar-Chellala belongs to the central steppe areas of Algeria. The geographical coordinates of the weather station of Ksar-Chellala, are: the latitude 35°10, longitude 2°19, Altitude is 800 m above sea level, it is 3 km far from the study area. The precipitations' average during the period of climatic used data (23 years: 1990-2012) is 254 mm, Further series data of precipitation is representative of the last 30 years this is a sample spread.The climate of this region is characterized by subtropical dry semiarid Steppe (BSh): Low-latitude dry. Evaporation exceeds precipitation on average but is less than potential evaporation. Average temperature is more than 18°C (Peel, 2007).

Software used

This study is based on the methodology adopted by the Development and Management Service of FAO. It based on the use of software CROPWAT 8.0.

CROPWAT is a decision support system developed by the Land and Water Development Division of FAO for planning and management of irrigation. Estimation of the crop water requirements are derived from crop evapotranspiration (crop water use) which is the product of the reference evapotranspiration (ET_0) and the crop coefficient (Kc). The reference evapotranspiration (ET_0) is estimated based on the FAO Penman-Monteith method, using climatic data (Allen, 1998).

All calculation procedures used in CROPWAT 8.0 are based on two FAO publications of the Irrigation and Drainage Series, namely, No. 33 titled "Yield response to water" (Doorenbos and Kassam, 1979) and No. 56 "Crop Evapotranspiration - Guidelines for computing crop water requirements" (Allen,

1998). The development of irrigation schedules in CROPWAT 8.0 is based on a daily soil-water balance using various user-defined options for water supply and irrigation management conditions.

In addition, (Smith et al., 1992) reported that CROPWAT is a practical tool (software) used to help agro meteorologists, agronomists and irrigation engineers to carry out standard calculations for evapotranspiration and crop water use studies, and more accurate design and management for irrigation schemes.

In order to run properly, CROPWAT 8.0 needs some data inputs, namely: climatic and rainfall data, crop characteristics and soil features. As a starting point, and only to be used when local data are not available, CROPWAT 8.0 includes standard crop and soil data. When local data are available, these data files can be easily modified or new ones can be created. Likewise, if local climatic data are not available, these can be obtained from the climatic database, CLIMWAT, containing data from more than 5000 stations worldwide. After all inputs have been correctly introduced, the software gives some important outputs, such as reference evapotranspiration, effective rainfall (P_{eff}), *NIWR* and gross irrigation water requirements (*GIWR*). After *CWR* has been calculated, CROPWAT 8.0 can simulate different types of irrigation scheduling, mainly depending on the user desired option: by changing the Irrigation timing (irrigate at critical depletion, irrigate at user defined intervals, irrigate at given yield reduction, etc.) and Irrigation application (fixed application depth, refill soil to field capacity, etc..) the user can find the more suitable irrigation scheduling for the specific situation.

Calculation of reference evapotranspiration ET_0

Evapotranspiration (*ET*, normally expressed in mm/day) is the combination of two separate processes: evaporation (water lost from the soil surface) and transpiration (water lost from the crop). Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. When the crop is small, water is predominately lost by soil evaporation (at sowing, nearly 100% of *ET* comes from evaporation), but once the crop is well developed and completely covers the soil, transpiration becomes the main process (Allen, 1998). Weather parameters, crop characteristics, management and environmental aspects are factors influencing evaporation and transpiration.

The evaporation power of the atmosphere is expressed by the reference evapotranspiration (ET_0). ET_0 (expressed in mm/day) is defined as "the evapotranspiration rate from a reference surface, not short of water; the reference surface is a hypothetical grass reference crop with specific characteristics. It is called the reference crop evapotranspiration and is denoted as ET_0. The reference surface is a hypothetical grass with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s m-1 and an albedo of 0.23. The reference surface closely resembles an extensive surface of green, well-watered grass of uniform height, actively growing and completely shading the ground (Allen R.G., 1998). The principal weather parameters influencing evapotranspiration are radiation, air temperature, humidity and wind speed at 2m above ground level. A large number of empirical or semi-empirical equations have been developed for assessing reference crop evapotranspiration from meteorological data. Numerous researchers have analysed the performance of the various calculation methods for different locations. As a result of an Expert Consultation held in May 1990, the FAO Penman-Monteith method is now recommended as the standard method for the definition and computation of the ET_0 (Allen, 1998). For daily, weekly, ten day or monthly calculations, the FAO Penman-Monteith equation requires:

Site location: altitude above sea level, latitude and longitude;

Air temperature (°C): maximum and minimum temperature or mean temperature;

Air humidity (%): maximum and minimum or mean relative humidity;

Radiation (MJ/m²/day or hours/day): net radiation or actual duration of bright sunshine;

Wind speed (m/s): wind speed at 2m above the ground level.

All meteorological data can be estimated using agro-meteorological stations; these stations are commonly located in cropped areas where instruments are exposed to atmospheric conditions, similar to those for the surrounding fields. In these stations, air temperature and humidity, wind speed and sunshine duration are typically measured at 2 m above ground level an extensive surface of grass or short crop. Where needed and feasible, the cover of the station is irrigated (Allen R.G., 1998).

Calculations of ET_0 are often computerized. Many software packages use the FAO Penman-Monteith equation to assess ET_0: nowadays, FAO ET_0 Calculator and CROPWAT are largely used. The selection of the time step with which ET_0 is calculated depends on the purpose of the calculation, the accuracy required and the time step of the climatic data available. In this work, daily time step has been utilized.

Estimation of the ET_0 was based on a 23 year climatic data (1990-2012). For the sunshine duration, this one is converted to solar radiation by the Ångström formula (Ångström, 1924). Pen-Mon equation was used in ET0 calculations with the following values for Ångström's coefficients: a = 0.25, b = 0.5.

Crop Water Requirements (*CWR*) are defined as the depth of water needed to meet the water loss through evapotranspiration of a crop, being disease-free, growing in large fields under non restricting soil conditions, including soil water and fertility, and achieving full production potential under the given growing environment(Doorenbos and Pruitt, 1984). The water requirements of each crop are calculated taking into consideration the evapotranspiration rate; this depends mainly on climate, but also on growing season and crop development (Doorenbus and Pruitt, 1977). Crop evapotranspiration under standard condition (ET_c) is the sum of transpiration by the crop and evaporation from the soil surface. Prediction methods for *CWR* are used owing to the difficulty of obtaining accurate field measurements. The methods often need to be applied under climatic and agronomic conditions very different from those under which they were originally developed. To estimate ET_c a three-stage procedure is recommended (Doorenbus and Pruitt, 1977):Effect of climate on crop water requirements is given by ET0;Effect of the crop characteristics on *CWR* is given by the crop coefficient (*Kc*) which represents the relationship between reference evapotranspiration (ET_0) and crop evapotranspiration under standard condition (ET_c). Values of *Kc* vary with the crop; the main factors affecting its values are crop characteristics, crop planting or sowing date, rate of crop development and length of growing season; Effect of local conditions and agricultural practices on *CWR* includes the local effect of variations in climate over time, distance and altitude, size of fields, advection, soil water availability, salinity, irrigation and cultivation methods, for which local field data are required.

The (*NIWR*) defined as:the amount of irrigation water that needs to be supplied to the crop to compensate all evapotranspiration losses (Savva and Frenken, 2002), are calculated using the soil water balance, which includes crop evapotranspiration, effective rainfall, groundwater contribution, stored soil water at the beginning of each period and leaching requirements.

Calculation of irrigation water requirements

Crop water requirements (*CWR*) for a given crop, *i*, are given by:

$$CWR_i = \sum_{t=0}^{T}(Kc_{i_t} \times ET_{0_t} - P_{eff_t}) - (Pe + Ge + Wb) + LR \quad (1)$$

$$\Leftrightarrow \quad CWR_i = \sum_{t=0}^{T}(ETc_t - P_{eff_t}) - (Pe + Ge + Wb) + LR$$

Where:

Kc_{i_t} is the crop coefficient of the given crop "*i*" during the growth stage "*t*" and where "*T*" is the final growth stage.

Pe = Effective dependable rainfall (mm);

Ge = Groundwater contribution from water table (mm): the contribution of the groundwater table to the soil water balance varies with the depth of the water table below the root zone, the soil type and the water content in the root zone (Savva and Frenken, 2002);

Wb = Water stored in the soil at the beginning of each period (mm): some water could be left in the soil from the previous irrigation or rainfall event, which can be used for the next crop. This amount can be deducted when determining the seasonal irrigation requirements;

LR = Leaching requirements (mm): an excess amount of water are applied during the irrigation, where necessary, for the purposes of leaching.

Not all dependable rainfall is effective and some may be lost through surface runoff, deep percolation or evaporation. Only a part of the rainfall can be effectively used by the crop, depending on its root zone depth and the soil storage capacity. Different methods exist to estimate the effective rainfall; one of the most commonly used is the USDA Soil Conservation Service Method;

Each crop has its own water requirements ET_c. Net irrigation water requirements (*NIWR*) in a specific

scheme for a given year are thus the sum of individual crop water requirements (CWR_i) calculated for each irrigated crop $_i$. Multiple cropping (several cropping periods per year) is thus automatically taken into account by separately computing crop water requirements for each cropping period. By dividing the area of the scheme (S. in ha), a value for irrigation water requirements are obtained and can be expressed in mm or in m^3/ha (1 mm = 10 m^3/ha).

$$NIWR = \frac{\sum_{i=0}^{n} CWR_i \times S_i}{S} \quad (2)$$

Where S_i is the area cultivated with the crop *i* in ha. Since culture and the growth cycle are known and the area of the scheme is dedicated only for barley:

and If Ge = 0, Wb = 0 and LR = 0,

equation (1) turns:

$$CWR_b = ETc - P_{eff} \quad (3)$$

And equation (2) turns:

$$NIWR = CWR_b \quad (4)$$

Gross irrigation water requirements (GIWR) are the amount of water to be extracted (by diversion, pumping) and applied to the irrigation scheme. It includes NIWR plus water losses:

$$GIWR = \frac{1}{E} NIWR \quad (5)$$

Where *E* is the global efficiency of the irrigation system.

Limited objective information on irrigation efficiency was available and estimations were based on several criteria:

- figures found in literature;
- type of crops irrigated;
- The level of intensification of the irrigation techniques.

If irrigation is the only source of water supply for the plant, the gross irrigation requirements will always be greater than the ET_c to compensate for inefficiencies in the irrigation system. If the crop receives some of its water from other sources (rainfall, water stored in the ground, underground seepage, etc.), then the irrigation requirements can be considerably less than the *CWR* (Savva and Frenken, 2002).

Climate data conversion

In general, climate data by the National Meteorological Service are standardized. Normally some conversions are required in order to adjust the data into the format accepted by CROPWAT 8.0. In our case, the wind is measured at 10 m, we must extrapolate it at 2 m (table 1), and because determining the reference evapotranspiration ET_0 is function of the wind at 2 m above the ground leveland in this case was used the formula of (Paulson,1970) (Equation 4).

$$u_2 = u_z \, 4.87 / ln\,(67.8\, z_m \, 5.42) \quad (6)$$

Where:

u_2 = wind at 2 m,
u_z = wind at 10 m,
z_m = 10 m.

Table 1: Estimate of wind at 2 m

Month	Wind at 10 m (Km/day)	Wind at 2 m (Km/day)
January	276.2	163.9
February	311.0	184.5
March	374.6	222.2
April	365.3	216.7
May	315.5	187.1
June	303.5	180.1
July	268.6	159.3
August	350.4	207.9
September	237.8	141.1
October	235.1	139.5
November	303.0	179.7
December	297.2	176.3
Average	303.2	179.9

Source: own processing

Table 1: Estimate of wind at 2 m

Processing of rainfall data

For programming the irrigation water supply and management of barley crop, rainfall data dry year is used. An estimation of the respective rainfall data can be obtained by computing and plotting probabilities from the rainfall records. The different steps are:

1) Tabulate yearly rainfall totals for a given period;
2) Arrange data in descending order of magnitude;
3) Tabulate plotting position (Equation 7);
4) Plot values in the probability paper.

$$F_a = 100\, m / (N + 1) \quad (7)$$

Where:

N = number of records,

m = rank number,

F_a = plotting position.

To plot values in the probability paper one has to choose the statistic model. Our choice is related to the law of Gumbel, since this model is frequently used in hydrology and climatology, to model the extreme events, in particular the annual rainfall. The function of distribution of the law of Gumbel is available on Equation 8. Thus we calculated the density of probability of the law of Gumbel (Equation 9).

$$F(x) = exp\ (-exp\ (-x-a/b)) \quad (8)$$

$$f\ (x) = 1/b\ exp\ (-exp(-x-a/b))\ exp\ (-x-a/b) \quad (9)$$

Finally we determined monthly values for the dry year according to Equation 10.

$$P_{idry} = Piav \times P_{dry} / P_{av} \quad (10)$$

Where:

P_{iav} = average monthly rainfall for month I,

P_{idry} = monthly rainfall dry year for month I,

P_{av} = average yearly rainfall,

P_{dry} = yearly rainfall at 80% probability of exceedance.

Crop data collection

We have taken the characteristics of the barley of the bulletin of FAO of irrigation and drainage N°46, (Smith, 1992), such as crop factors, rooting depth, critical depletion, yield response, crop height, (Table 2). For the length of the growth cycle and vegetal stage of barley is 170 days (FAO Irrigation and Drainage Paper No. 24)

Table 2: Essential information collected for barley crop

Soil Data Collection

The red sandy Loam characterizes all grounds of this area. The red sandy Loam is a medium ground. According to bulletin FAO N° 46, (Smith, 1992), its total available soil moisture is 1.4 mm/Cm.

Results and discussion

Calculation of reference ET_0

Calculation of ET_0 by CROPWAT 8.0 requires information on the meteorological station together with input climatic data: temperature, humidity, wind speed and sunshine duration (table 3).

Following this table that characterizes this area of study and during the vegetative cycle of barley, the highest average daily evapotranspiration ET_0 values are attained in March (3.14 mm/d) and in April (4.26 mm/d), it is a critical phase with regard to the culture of the barley, if we multiply these values by the number of days of each month, you can have the amount of water that has been evapotranspired, respectively during the month of March (97.3 mm) and April (127.8 mm). Consequently and in the absence of rains during this period must be applied to net irrigation dose during March of 973 m^3/ha and during the month of April 1278 m3/ha.

Determination of normal, wet and dry year rainfall

Processing of rainfall data

An estimation of the respective rainfall data can be obtained by computing and plotting probabilities from the rainfall records. The different steps are:

1) Tabulate yearly rainfall totals for a given period (table 4);

Crop name BARLEY	Planting date: 01/11 Harvest : 19/04				
stage	Intial	Developement	Mi-season	Late season	Total
Stage days	35	50	45	40	170
Kc Values	0.30	-->	1.15	0.25	
Rooting depth (m)	0.30	-->	0.90	0.90	
Critical depletion (fraction)	0.60	-->	0.60	0.90	
Yield response (fraction)	0.20	0.60	0.50	0.40	1.00
Crop height (m)			0.90		

Source: own processing

Table 2: Essential information collected for barley crop.

Month	Min Temp (deg.C)	Max Temp (deg.C)	Humidity (%)	Wind (Km/d)	Sunshine duration (Hours)	Solar Rad (MJ/m²/d)	ET_0 (mm/d)
January	2.8	13	70	163.9	6	10.1	1.42
February	3.5	14.3	64	184.5	7	13.3	2.01
March	6.3	18.3	60	222.2	8.2	17.7	3.14
April	8.6	21.1	51	216.7	9.1	21.6	4.26
May	12.9	26.8	45	187.1	9.9	24.3	5.38
June	18	33.4	34	180.1	9.9	24.7	6.61
July	21.1	37.5	28	159.3	10.8	25.7	7.16
August	21	36.3	32	207.9	10.7	24.3	7.41
September	16.7	30	47	141.1	9.7	20.4	4.86
October	12.5	24.3	56	139.5	8.9	16.2	3.31
November	6.8	16.4	62	179.7	8.2	12.6	2.12
December	4.4	13.2	74	176.3	6.5	9.8	1.32
Averge	11.2	23.7	52	179.9	8.7	18.4	4.08

Source: own processing

Table 3: Calculation of reference evapotranspiration (ET0) for Ksar-Chellala weather Station.

Year	1999	2009	2003	1990	1996	2011	1994	1997	2010	2008	2007
Rain (mm/year)	371	355	335	325	311	310	308	304	297	273	256
Rank No	1	2	3	4	5	6	7	8	9	10	11
Fa %	4.2	8.3	12.5	16.7	20.8	25	29.2	33.3	37.5	41.7	45.8

Year	2004	2006	1992	2012	1993	2005	1991	1998	2001	1995	2000	2002
Rain (mm/year)	251	247	240	235	225	210	198	197	196	163	147	114
Rank No	12	13	14	15	16	17	18	19	20	21	22	23
Fa %	50	54.2	58.3	62.5	66.7	70.8	75	79.2	83.3	87.5	91.7	95.8

Source: own processing

Table 4: Statistical analysis of Ksar-Chellala rainfall.

2) Arrange data in descending order of magnitude;
3) Tabulate plotting position (Equation 3);
4) Plot values in the probability paper.

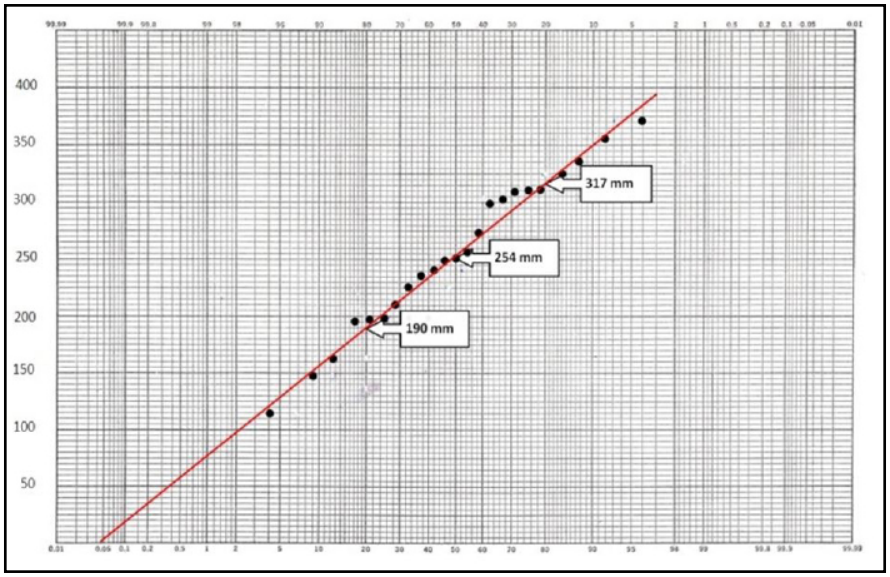
Adjustment by the graphic method

In the case of an adjustment according to the law of Gumbel, the graphic method rests on the use of a probabilistic paper of Gumbel Figure 1. We deferred the data points to be adjusted in a system of axes, in X-coordinate places from there the values possible of the density of probability of the law of Gumbel, in Y-coordinate places from there the total annual rain. Then to plot the straight line which passes best by these points. It is noted that the arithmetic mean 254 mm coincides with the value with 50% of exceedance probability which as of 254 mm. Without passing by the statistical tests, we can confirm graphically that the law of Gumbel adjusts better the series of rain data. Thus we can estimate the exceedance probability which it is advisable to give to each rain value.

Calculate year values at 20, 50 and 80% of exceedance probability: P80 = 190 mm, P50 = 254 mm, and P20 = 317 mm. Similarly values for dry, normal and wet years can be determined. Results are given in the Table 5.

Effective rainfall

To account for the losses due to runoff or percolation, a choice can be made of one of the four methods given in CROPWAT 8.0 (Fixed percentage, Dependable rain, Empirical formula, USDA Soil Conservation Service). In general, the efficiency of rainfall will decrease with increasing rainfall. For most rainfall values below 100 mm/month, the efficiency will be



Source: own processing

Figure 1: Probabilistic paper of Gumbel.

	Jan	Fev	Mar	Avr	Mai	Juin	Juil	Août	Sept	Octo	Nov	Dec	year
Normal year	16.2	19.4	20.7	24.1	28.7	11.2	8.9	11.3	32.2	36.9	23.0	21.6	254.3
Dry year	12.1	14.5	15.5	18.0	21.5	8.4	6.7	8.4	24.1	27.6	17.2	16.2	190.2
Wet year	20.2	24.2	25.9	30.1	35.8	14.0	11.1	14.1	40.2	46.1	28.7	27.0	317.4

Source: own processing

Table 5: Monthly values for the normal, dry and wet year.

	Jan	Fev	Mar	Avr	Mai	Juin	Juil	Août	Sept	Octo	Nov	Dec	year
Rain dry year	12.1	14.5	15.5	18.0	21.5	8.4	6.7	8.4	24.1	27.6	17.2	16.2	190.2
Effrain	9.7	11.6	12.4	14.4	17.2	6.7	5.3	6.8	19.3	22.1	13.8	12.9	152.2

Source: own processing

Table 6: Effective rain is 80 % of actual rain.

approximately 80%. In our case we chose the fixed percentage (80%) (Table 6).

Crop water requirements of barley CWR_b calculations

The calculation of the CWR_b was based on the climatic data and the information of crop and soil. The CWRb (Table 7) are the difference between the crop evapotranspiration ET_c and the effective rainfall of dry year. The table 7 is illustrated by figure 2.

The total water requirements of barley CWRb are equal to 211 mm. The highest CWR_b was attained in the month of March (81.8 mm) and which represents 39 % of total CWR_b it represents there productive stage, which is a critical phase with regard to the culture of the barley. While the lowest CWR_b was attained in the month of December (8.4 mm), which represents a vegetative phase of dormancy.

If we assured a supplementary irrigation during February, March and the beginning of April and by respecting the doses of irrigation, we can increase significantly grain yield of barely in this region.

So following these results the Gross irrigation water requirements *GIWR* of 1250000 ha which are projecting to grow barley can be estimated in the Algerian steppe regions and this for a dry year. If we fix the irrigation system efficiency to 70%, these needs are estimated at:

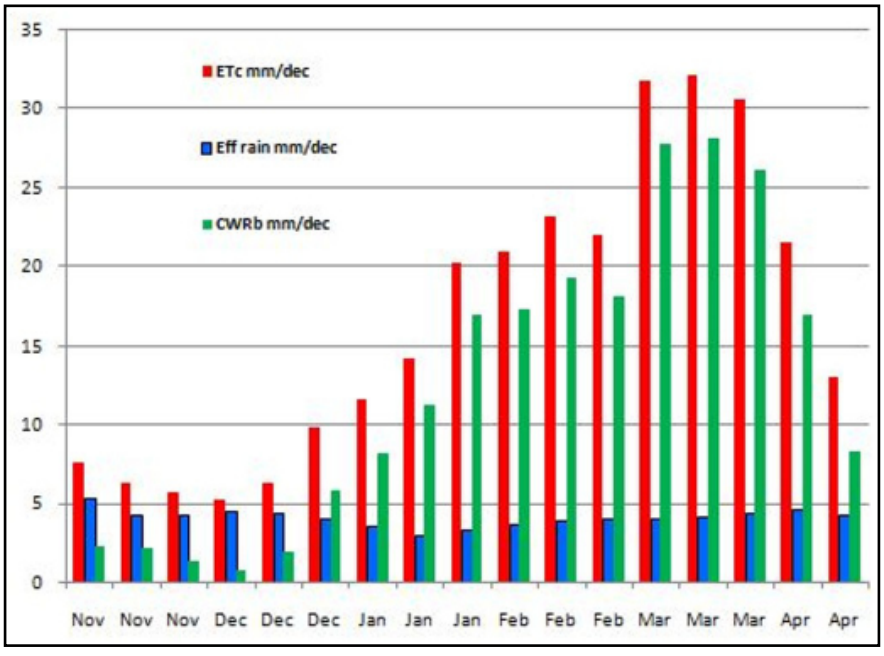
$NIWR = CWR_b = 211$ mm/m² = 2110 m³/ha

$$GIWR = \frac{2110}{0.70} \times 1250000 = 3\,767\,857\,143\ m^3$$

Month	Decade	Stage	Kc coeff	ET_c mm/day	ET_c mm/dec	Effrain mm/dec	CWR_b mm/dec
Nov	1	Init	0.3	0.75	7.5	5.3	2.2
Nov	2	Init	0.3	0.63	6.3	4.3	2.1
Nov	3	Init	0.3	0.56	5.6	4.3	1.3
Dec	1	Deve	0.33	0.52	5.2	4.5	0.7
Dec	2	Deve	0.48	0.63	6.3	4.4	1.9
Dec	3	Deve	0.66	0.89	9.8	4	5.8
Jan	1	Deve	0.83	1.16	11.6	3.5	8.1
Jan	2	Deve	1	1.42	14.2	3	11.2
Jan	3	Mid	1.14	1.84	20.2	3.3	16.9
Feb	1	Mid	1.15	2.08	20.8	3.7	17.2
Feb	2	Mid	1.15	2.31	23.1	3.9	19.2
Feb	3	Mid	1.15	2.74	21.9	4	18
Mar	1	Mid	1.15	3.17	31.7	4	27.7
Mar	2	Late	1.02	3.21	32.1	4.1	28
Mar	3	Late	0.79	2.77	30.5	4.4	26.1
Apr	1	Late	0.55	2.15	21.5	4.6	16.9
Apr	2	Late	0.34	1.45	13	4.3	8.2
				Total	281.4	69.5	211.4

Source: own processing

Table 7: Crop water requirements of barley.



Source: own processing

Figure 2: Crop water requirements of barley CWR_b in Ksar-Chellala region.

Conclusion

The Sustainable Water Management helps ensure a more stable production. Improving irrigation efficiency is very important for farmers to have a more correct use of water and for this reason, before thinking of irrigation as a water source, they must establish whether irrigation is really necessary or not in their specific environmental conditions. For this purpose, a preliminary analysis is very useful.

The planning stage of an irrigation project design actually implies a survey of all factors which could influence *CWR* (climate, soil and crop itself).

Then *CWR* need to be compared with available water coming from the rain (effective rainfall) and from the soil (initial soil water available). In case of a water deficit, the technician can evaluate the possibility of introducing irrigation, assessing if the water source will be able to cope with all aspects of demand. This survey is of paramount importance in order to establish if irrigation is effectively needed or not.

The first three parameters that must be taken into account in an investigation so described are: climate, soil and crops. If effective rainfall during the period is insufficient to cover the entire crop cycle, taking into account the infiltration rate of the soil and its permeability, the construction of the irrigation system is imperative. This kind of situation is quite normal in the case of an arid climate with a light soil; relative humidity and rainfall are low.

Following this study, the determination of the CWR_b requires several stages in particular the collection of the climatic data and their processing by the prescribed methods, in particular the method adopted by the FAO. Further to this approach, we were able to estimate the CWR_b in the region of Ksar-Chellala for dry year.

The total of the $CWR_b$is 211.4 mm, CWR_b of February, March and April equal 161.3 mm which represents 76% of the total CWR_b, and also represents stages of flowering, beginning of grain-filling period and physiological maturity. If we assure a supplementary irrigation during February, March and the beginning of April and by respecting the doses of irrigation, we can increase significantly grain yield of barely in this region.

Finally, the underground water potentials of steppe regions are limited and cannot meet the needs of this large area which amounts to 1250000 ha, whose gross irrigation water requirements (*GIWR*) are estimated at 3.77 billion and this for a dry year and a irrigation efficiency of 70%. So the steppe regions (30 million ha) receive an average amount of effective rainfall for a dry year 152 mm equivalent to 40.56 billion m^3/yr. So if one gets only 10 % of this volume falling from the sky we can meet the needs of this area without affecting the underground water potentials. So it is imperative to be based on the technical spate.

Corresponding author:
Ms. Laouisset Mhamed Bensalah
Scientific and Technical Research Centre for Arid Areas (CRSTRA)
BP 1682 RP, 07000, Biskra, Algeria
Phone: +213 29 16 32 65, Fax: +213 29 16 32 68, Cell-phone: +213 661 377 896; +213 774 066 888
E-mail: laouissetbensalah@gmail.com

References

[1] Andales, A. A., Chávez, J. L., Bauder, T. A. (2015) "Irrigation Scheduling: The Water Balance Approach", Fact Sheet No. 4.707, Crop Series Irrigation, Colorado State University Extension, 11/93. Revised 1/15. [Online] Available: http:// www.ext.colostate.edu. [Accessed 30 April 2016].

[2] Ångström, A. (1924) "Solar and terrestrial radiation. Report to the international commission for solar research on actinometric investigations of solar and atmospheric radiation". *Quarterly Journal of the Royal Meteorological Society*, Vol. 50, No. 210, pp. 121-126. E-ISSN 1477-870X. ISSN 0035-9009.

[3] Bencherif, S. (2011) "L'élevage pastoral et la céréaliculture dans la steppe algérienne", thèse de doctorat, Agro Paris Tech, Institut des Sciences et Industrie du Vivant et de l'Environnement (AgroParisTech), p. 269, pastel-00586977, version 1 - 19, Apr 2011 [Online] Available: http://pastel.archivesouvertes.fr/docs/00/58/69/77/PDF/These_bencherif.pdf. [Accessed: Mai 25, 2016].

[4] CEDARE (2014) North Africa Regional Water Sector M&E Rapid Assessment Report, Monitoring & Evaluation for Water in North Africa (MEWINA) Project, Water Resources Management Program.

[5] Bray, E. A. (1997) "Plant responses to water deficit", *Trends in Plant Science*, Vol. 2, No 2, pp. 48-54, ISSN 1360-1385. DOI: http://dx.doi.org/10.1016/S1360-1385(97)82562-9.

[6] Doorenbus, J. and Pruitt, W. O. (1977) "Guidelines for predicting Crop water requirements, Irrigation and Drainage", FAO, Paper No. 24.

[7] Doorenbos, J. and Kassam, A. H. (1979) "Yield Response to Water, Irrigation and Drainage", FAO, Paper No. 33.

[8] O'Shaughnessy, S., A., Evett, S. R., Colaizzi, P. D. and Howell, T. A. (2012) "A crop water stress index and time threshold for automatic irrigation scheduling of grain sorghum", *Agricultural Water Management*, May 2012, Vol. 107, pp. 122-132. ISSN 0378-3774. DOI: 10.1016/j.agwat.2012.01.018.

[9] Pasquale, S.,Theodore, C. H., Elias, F. and Dirk, R. (2012) "Crop yield response to water", FAO, Paper No. 66, pp. 134-141. ISBN 978-92-5-107274-5.

[10] Paulson, C. A. (1970) "The Mathematical Representation of Wind Speed and Temperature Profiles in the Unstable Atmospheric Surface Layer", *Journal of Applied Meteorology*, No. 9, pp. 857–861. DOI 10.1175/1520-0450(1970)009<0857:TMROWS>2.0.CO;2

[11] Peel, M. C., Finlayson, B. L. and McMahon, T. A. (2007) "Updated world map of the Köppen-Geiger climate classification", Hydrology and Earth System Sciences, No 11, pp. 1633-1644. [Online] Available: http://www.hydrol-earth-syst-sci.net/11/1633/2007/. [Accessed 20 Oct 2015]. DOI 10.5194/hess-11-1633-2007.

[12] Rahal-Bouziane, H. (2015) "Genetic diversity of traditional genotypes of barley (Hordeum vulgare L.) in Algeria by pheno-morphological and agronomic traits", *African journal of agricultural research*, Vol. 10, No. 31, pp. 3041-3048. ISSN 1991-637X. DOI 10.5897/AJAR2015.9513.

[13] Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. (1998) "Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements", FAO, Irrigation and drainage paper No. 56. ISBN 92-5-104219-5.

[14] Solinas I. (2011) "Information Technology in Irrigation and Drainage Course, Power-Point presentations". Florence, Italy.

[15] Savva, A. P. and Frenken, K. (2002) "Crop Water Requirements and Irrigation Scheduling. Irrigation Manual Module 4", Water Resources Development and Management Officers, FAO, Sub-Regional Office for East and Southern Africa, 2002, Harare, Zimbabwe.

[16] Smith, M. (1992) "A computer program for irrigation planning and management. Irrigation and Drainage", FAO, Paper No. 46.

[17] Ullrich, S. E. (2011) "Significance adaptation production and trade of barley", In: B*arley Production, Improvement and Uses*, Ed. Ullrich John Wiley & Sons Inc., Ames, IA, USA. pp. 3-13.

[18] Yavuz, D., Seymen, M., Yavuz, N., and Türkmen, O. (2015) "Effects of irrigation interval and quantity on the yield and quality of confectionary pumpkin grown under field conditions", *Agricultural Water Management*. September 2015, Vol. 159, pp. 290-298. ISSN 0378-3774. DOI 10.1016/j.agwat.2015.06.025.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Economic Valuation of Mountain Landscapes and Ecosystems: A Meta-Analysis of Case Studies

Z. Žáková Kroupová, M. Havlíková, P. Hálová, M. Malý

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

Abstract

The paper is focused on the value of the European mountain landscape/ecosystem and evaluates the impact of agriculture and agricultural policy on the value of this public good. Based on the meta-analysis of 22 landscape/ecosystem valuation studies, it was found that the average value of the European mountain landscape/ecosystem is 3,068 EUR per hectare per year, and 3.91 EUR per person per day. However, there are regions with a significantly higher value – Tatra in Poland and Alpujarran in Spain. The value is influenced by the position of agriculture in the national economy. Higher values of the mountain landscape/ecosystem were achieved in countries where the contribution of agriculture to the gross value added is above average. On the other hand, there is no significant relationship between the proportion of farming in the LFA and the value of the mountain landscape/ecosystem. Public support was found to be insufficient to cover the cost of landscape services performed by farmers.

Keywords

Mountain, landscape, ecosystem, value, agriculture, LFA, Europe, meta-analysis.

Žáková Kroupová, Z., Havlíková, M., Hálová, P., M. Malý (2016) "Economic Valuation of Mountain Landscapes and Ecosystems: A Meta-Analysis of Case Studies", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 3, pp. 103 - 112. ISSN 1804-1930, DOI 10.7160/aol.2016.080310.

Introduction

Mountains constitute the ecological backbone of Europe, providing essential ecosystem services (Bernués et al., 2014). These ecosystem services include a provisioning function (agricultural production, production of timber, game, berries, mushrooms, fresh water, etc.), a regulating function (carbon sequestration, hydrological protection, etc.), and a cultural function (recreation, aesthetics, spiritual benefits) (Považan et al., 2014; Häyhä et al., 2015; Bernués et al., 2014). Palleto et al. (2015) add a habitat function, reclassifying the supporting services function (plant production, animal production, gene pool protection, nutrition cycling).

Farming activities are a key factor in shaping the mountain landscape (Lefebvre et al., 2012). Society benefits from agricultural landscapes in many ways. The benefits of landscape can be seen as having three components: landscape value (scenic), recreational value, and nostalgic value (Gioi et al., 2007). Notaro and Paletto (2011) point out that the natural environment in mountain areas predominantly consists of forests and meadows, which provide an important resource for the socioeconomic development of mountain areas.

The environmental assets of mountain landscapes generated through agricultural land management have the characteristic of agro-environmental public goods – non-rival, non-excludable goods, demanded by society, whose supply can be increased by farming activity (Burrell, 2011). Ciaiac and Gomez y Poloma (2011) also noted that landscape is one of the key public goods produced by agriculture. Due to their specific characteristics, a market for these goods does not exist and policy measures are needed to ensure delivery. Notable policy measures which contribute to the provision of valuable landscapes and their associated assets include environmental and Less-Favoured Areas (LFA) payments. However, these supports often do not reflect the value of such an environment. This is supported by Bernués et al. (2014), who found that the total economic value of the mountain agro-ecosystem is three times higher than the current level of support for agro-environmental policies.

Valuation of mountain landscapes and ecosystems

Environmental services and landscape goods are rarely incorporated into the economic valuation of natural resources, even though they form a large portion of the total economic value (Molina et al., 2016). Bernués et al. (2014) add that economic valuation is highly controversial. A non-material good is considered by many to be incommensurable, and therefore economic valuation is assumed to be a driver for the commodification of nature and very difficult to apply to certain ecosystems. Tagliafierro et al. (2013) stress that determining monetary value is not easy due to individual preferences regarding landscapes. Knudsen et al. (1995) add that a landscape cannot be the same for two individuals, because each of them has a different interaction with the landscape and their knowledge of the landscape differs. Soliva and Hunzinker (2009) explain landscape preferences using psychological, biological and aesthetic approaches. Rodriguez-Ortega et al. (2014) found that the willingness to pay for mountain ecosystems differs from 88 EUR to 334 EUR, according to psychographic profile, demonstrating individual preferences and valuations of landscapes and ecosystems.

A literature survey proves that studies valuating ecosystems or landscapes use both market and non-market valuation methods. Market valuation is normally used for assessing the provisioning services of ecosystems and includes, for example, the market price of timber or livestock (Paletto et al., 2015; Hÿahä et al.; 2015; Považan et al., 2014). The regulating services of ecosystems are usually valued through non-market methods. Paletto et al. (2015) use the replacing cost method and voluntary price; Hÿahä et al. (2015) use carbon price and the cost of bioengineering technologies to assess hydrological and carbon protection as a part of protection services. The cultural services of ecosystem are predominantly valuated through non-market methods, namely stated preferences methods. Similarly, landscape is evaluated mainly by non-market, especially stated preferences, methods, including willingness to pay (further WTP) and choice experiment (CE). Exceptions include the travel cost approach (Melichar, 2007; Gluck and Kuen, 1997) and hedonic pricing (Lutting, 2000; Van Huylenbroeck et al., 2006). Studies using stated preferences methods usually apply WTP (Sayadi et al., 2009; Kubickova, 2004; Bastien et al., 2015, Notaro and Palleto, 2011; Antouskova, 2012) or choice experiment (Campbell et al., 2015; Bernués et al., 2014; Molina et al., 2016).

Addressing this issue, the paper aims to evaluate the contribution of agriculture to the value of European mountain landscapes and ecosystems, and to explain the differences in the values. The paper should answer the following research questions: What is the average value of mountain landscapes/ecosystems in Europe? How is this value covered by environmental and LFA subsidies? Does this value differ based on the position of agriculture in the national economy of the analysed countries? Are the differences connected with the share of agricultural land in less-favoured areas and with the share of LFA payments in the total subsidy payment? How is this value determined by the valuation technique? Are there differences in this value for visitors and residents?

The rest of the paper is organized as follows. First, we introduce the methods and data we used. We then present the main characteristics of the analysed studies and the results of our analysis. Finally, we discuss the results and provide concluding remarks.

Materials and methods

The aims of the paper are reached through meta-analysis, which uses empirical estimates of some indicators from several studies and attempts to explain the variation in these estimates, based on differences across studies, as explanatory variables in a regression model (Thiam et al., 2001).

We focus on 22 studies that evaluated the value of mountain landscape/ecosystem in European countries. Empirical studies focusing on mountain landscapes and ecosystems were retrieved from the Scopus, ISI Web of Science, and ScienceDirect databases. Keywords for searching were: mountain and landscape (or ecosystem), and valuation (or value, evaluation or appreciation). In addition, a snowball method was used to find the required studies. Subsequently, the found studies were selected according to the area studied, and only those dealing with European mountains were analysed.

First we described these studies, and then compared the estimated values of the mountain landscapes/ecosystems, measured in EUR per hectare, to the amount of environmental and LFA payments drawn by the average farm in less-favoured mountain areas per hectare, according to the Farm Accountancy Data Network (FADN).

Secondly, we formulated a regression model based on the studies and measured the value in EUR per person. The basic hypothesis of this research was that the variation in mountain landscape/ecosystem value reported in these studies can be explained by attributes of the studies such as evaluation technique, respondent specification (visitor/resident), position of agriculture in the national economy, and the localization of agriculture in mountain LFA (Alvarez-Farizo et. al., 1999; Maragon and Visintin, 2007; Ciaian and Gomez y Paloma, 2011). We also supposed that the differences in the value of mountain landscapes/ecosystems result from agricultural policy (Moon and Griffith, 2010), namely from the significance of LFA payments in the total subsidy scheme of farms. That is, the following model was estimated:

$$value = f(AS, LFAMS, LFAPS, DVIS, DTC, DCE) \quad (1)$$

where value is a landscape/ecosystem value measured in EUR per person (visitor or resident) per day, AS is the share of agriculture in total gross value added (GVA) retrieved from the Eurostat database, DVIS is a dummy variable for the value for visitors, LFAMS is the share of less-favoured mountain areas in the total utilized agricultural area, retrieved from the Eurostat database, LFAPS is the share of LFA subsidies in total subsidies, excluding subsidies on investments gained by an average farm located in a mountain area according to FADN, DTC is a dummy for the travel cost method, and DCE is a dummy for choice experiment.

Most analysed studies present a range of mountain landscape/ecosystem values. We used averages of this range as the value of the dependent variable.

The model was estimated in linear form by the ordinary least square procedure using the econometric software LIMDEP version 9.0. Homoscedasticity was tested by the Breusch-Pagan test, and heteroscedasticity was solved by White's heteroscedasticity-consistent standard errors estimator (Green, 2008).

Results and discussion

The main characteristics of the analysed studies are presented in a Table 1.

Out of 22 studies focused on the value of mountain landscapes/ecosystems, 17 studies measured the value per person and six studies analysed the value per hectare. These six studies were removed from the base of the regression model and described separately. Of these six studies, two were focused on the Alps in Italy, namely Trentino and Fiemme, Fassa, one on the Alps in Austria (Leiblachtal), one on the Alps in Switzerland (Davos), one on Velká Fatra in Slovakia, and one on Tatra in Poland. All of these studies used the market approach, contingent valuation method and replacement costs. The value of the mountain landscape/ecosystem ranged from 5 EUR per hectare per year to 22,596 EUR per hectare per year. The maximum value was achieved in the Polish part of Tatra. The minimum occurred in the Italian Alps (Fiemme, Fassa) as the price for cultural services. The average value was 3,068 EUR per hectare per year. However, the mountain landscape/ecosystem value was lower in the Alps in Italy and Austria than in the mountains of Slovakia and Poland. That is, the value is higher in countries with lower GDP.

Measurement of the value in EUR per hectare enables a comparison of the landscape/ecosystem value and the policy support for farming in these areas. This is presented in Table 2.

It is obvious that the agricultural policy support (namely environmental (ES) and LFA subsidies) for farming in mountain areas covered less than 30% of the landscape/ecosystem value. Taking into account that the value was determined by the replacement cost method, we can conclude that public support is insufficient to cover the costs for landscape services performed by farmers. Bernués et al. (2014) also present similar results. On the other hand, Ciaian and Paloma y Gomez (2011) took into account total CAP supports and, on the basis of meta-analysis of agricultural landscape valuation studies, found that the value of agricultural landscapes (142 EUR per hectare) is smaller than the CAP support level (270 EUR per hectare).

The remaining 17 studies represent the basis of the meta-analysis. These studies can be characterized by a dominant focus on the value for residents (11 studies), determined by willingness to pay. Three studies also used choice experiment, and two studies preferred the travel cost technique. The majority of the studies were focused on Central European countries – seven studies. Southern European countries were represented by six studies, and there was also one case of a Western European country. Seven studies were focused on the landscape/ecosystem in countries where GDP per capita was higher than the EU average – 28.

Study	Country	Mountain	Method	Value
Bastian et al. (2015)	Germany	Ore Mountains (Sachsische Sweiz-Ostrzbiege)	WTP for natural conservation and landscape management	0.75-1.36 €/guest/night by tourist service provider
				1.06-2.73 €/day by visitors
				5.03-18.91 €/residents/year
Bernués et al. (2014)	Spain	Mediterranean mountains (Sierra y Canones de Guara)	WTP/CE	198.8 €/person/year for general public
			Annual tax	121.2 €/person/year for locals
Molina et al. (2016)	Spain	Sierra Morena massif (Huelva)	WTP/CE	9.25 €/person as entrance fee
				landscape - type 5 - 4.21-25.84 €
Kubickova (2004)	Czech Republic	Bile Karpaty	WTP for provisioning agricultural-landscape cultivation services	261.21 CZK/person/year
Campbell et al. (2005)	Ireland		CE	45.18-92.63 €/person/year
Tempesta and Thiene (2004)	Italy	Cortina D'Ampeyyo	WTP for conservation of mountain meadows	3.25 €/year/person
Getzner (2000)	Austria	Alps (Hohe Tauern National Park (NP))	WTP	7 €/visitor /visit
Gluck and Kuen (1977)	Austria	Alps (Grosser Ahornboden)	TC	5 €/visitor/visit
Hackl and Pruckener (1997)	Austria	Alps (Kalkalpen NP)	WTP	10-30 €/resident/year; 8-13/visitor/year
Gios et al. (2006)	Italy	Alps (Campogrosso)	WTP	5 €/resident/visit
Lowenstain (1995)	Germany	Alps (Hinterstein)	WTP	48 €/resident
Notaro and Paletto (2011)	Italy	Alps (Premena)	WTP donation for maintaining LS	94 €/year
Antouskova (2012)	Czech Republic	Sumava mountains	WTP	100 CZK/visitor/visit
Sayadi et al. (2009)	Spain	Alpujarran	WTP for a day of lodging to enjoy different views presented in photographs	27.07 €/day is the average price to enjoy view of the landscape
Füzyová et al. (2009)	Slovakia	Tatra NP	WTP for environment	Visitors: Mean for entrance fee 54.12 SKK
				For better environment 329.71 SKK
				Residents for environment: 645.40 SKK
				Entrepreneurs for environment: 1,043.75 SKK
Melichar (2007)	Czech Republic	Jizerske mountains	TC	Consumer surplus: 18 USD Poisson model, 17 USD truncated Poisson, 56 USD truncated negative Binomial
Gret-Regamey et al. (2008)	Switzerland	Alps (Davos)	Gret-Regamey et al. (2007)	Scenic beauty, 24,000 €
				per ha per year; habitat, 2 €/ha/year; carbon sequestration: 3,100 €/ha/year;
				avalanche protection: 64,700 €/ha/year
Goio et al. (2008)	Italy	Alps (Trentino)	Market approach (MA), CVM, replacement costs (RC)	392.08 €/ha
Paletto et al. (2015)	Austria	Alps (Leiblachtal)	MA, CVM, RC	200-1,400 € /ha/year (provisioning services)
				10-760 €/ha/year (regulating services)
				5-60 € /ha/year (cultural services)
Häyhä et al. (2015)	Italy	Alps (Fiemme, Fassa)	MA, CVM, RC	820 €/ha/year
				(provisioning services 40%, regulating services 49%, cultural services 11%)
Považan et al. (2014)	Slovakia	Velká Fatra	MA, CVM, RC	4,437 € /ha/year
Getzner(2010)	Poland	Tatra NP	MA, CVM, RC	22,596 €/ha/year

Source: Own calculations

Table 1: Analysed studies.

Country	Value [EUR/ha]	Environmental subsidies [EUR/ha]	ES/Value [%]	LFA payment [EUR/ha]	LFA/Value [%]
Italy	606	29.25	4.83	25.76	4.25
Austria	1,218	198.22	16.27	135.32	11.11
Poland	22,596	70.96	0.31	48.25	0.21
Slovakia	4,437	131.03	2.95	79.41	1.79

Source: FADN, Own calculations

Table 2: Comparison of landscape/ecosystem value and subsidies.

The average value of mountain landscape/ecosystem ranged from 0.01 to 27.07 EUR per person per day. The highest value was achieved in Alpujarran in Spain by WTP, and represented the price to enjoy a view of the landscape. On the other hand, the lowest value occurred in Cortina D´Ampezzo in Italy by WTP, as the price for conservation of mountain meadows. The mean value was 3.91 EUR per person per day. However, the standard deviation (6.81) shows that the differences between the values presented in the analysed studies are huge. These differences are presented in Table 3 according to the specific characteristics of the studies.

Category	Mean value [EUR / day]	Standard deviation
Share of agriculture in GVA under EU average	2.02	2.86
Share of agriculture in GVA above EU average	4.92	8.13
Share of UAA in LFA-mountain under EU average	3.1	5.74
Share of UAA in LFA-mountain above EU average	4.34	7.51
Share of LFA payment in total subsidies under EU average	5.33	9.38
Share of LFA payment in total subsidies above EU average	2.95	4.65
Resident	4.07	8.56
Visitor	3.65	3.24
Willingness to Pay	3.36	7.59
Choice Experiment	2.58	4.45
Travel Cost	10.37	7.59
Country in Central Europe	2.95	4.65
Country in Southern Europe	6.07	9.89
Country in Western Europe	0.19	NA
GDP under EU average	4.37	8.07
GDP above EU average	3.34	5.3

Note: GVA means total gross value added, UAA means utilized agricultural land, LFA means less-favoured area,
NA means not-available due to the sample having only one case.

Source: Own calculations

Table 3: Basic characteristics of mountain landscape/ecosystem value in different categories.

Table 3 shows that higher values of mountain landscape/ecosystem were achieved in countries where the contribution of agriculture to the total gross value added is above average. We can also observe that the mountain landscape/ecosystem value is higher on average in countries where agricultural land is more often located in a less-favoured area. However, it seems that this higher value is not a consequence of LFA subsidies, because the mountain landscape/ecosystem value is lower in countries where LFA payments represent a more significant part of the total subsidy structure for a typical farm. A majority of the analysed studies distinguished between the value for visitors and the value for residents. The descriptive statistics show that residents were willing to pay a slightly higher price than visitors for a more attractive landscape and a higher quality of ecosystems. When focused on the method of valuation, it is obvious that a significantly higher value was obtained when the travel cost technique was employed.

The figures in Table 3 suggest that a higher mean value for mountain landscape/ecosystem was achieved in countries with lower wealth, measured by GDP per capita, than in countries where GDP was higher that the EU average of 28. That negates the assumption that people in wealthier countries are willing to pay a higher price for an attractive landscape, which was based on the findings of Ciaian and Gomez y Paloma (2011). The value of mountain landscape/ecosystem was also assessed higher in countries located in Southern Europe and on the basis of the travel cost technique. A connection can be seen between the position of tourism in the economies of European states. People in countries with a higher share of tourism in GDP appreciate landscape/ecosystem more than people in strongly industrial or financial countries.

A detailed analysis of the main determinant of mountain landscape/ecosystem value in connection with agriculture and the Common Agriculture Policy is based on a regression model, described in equation (1). Table 4 shows that the majority of parameters in this model are statistically significant, at least at the 10% level of significance. Because the model used dummy

Variable	Coefficient	Standard error	Prob. |t|>T*
Constant	4.7671	3.3947	0.1837
DVIS	3.2557**	1.5069	0.05
DTC	8.8047**	3.1763	0.0159
DCE	-12.3178*	6.9364	0.0992
AS	0.0478**	0.0214	0.0436
LFAMS	-0.0561	0.0473	0.2571
LFAPS	-0.5254*	0.2864	0.0895
R-square	0.447		
Breusch-Pagan	21.13		0.0017

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively
Source: Own calculations

Table 4: Model estimates.

variables, the intercept represents the mean value of mountain landscape/ecosystem for residents based on the willingness-to-pay method. When we employ a dummy variable for visitors, we can conclude that the value for visitors is higher on average by 3.26 EUR, ceteris paribus. The parameter of the travel cost technique shows that this method leads to a higher value that WTP, specifically by 8.81 EUR on average in the case of resident value, ceteris paribus. On the other hand, choice experiment yields a lower value, specifically by 12.32 EUR on average in the case of value for residents, ceteris paribus. That is, the WTP seems to be a more appropriate evaluation technique, as it leads to a value in the middle of the extremes achieved using other techniques.

Considering the role of agriculture, it is obvious that a stronger position of agriculture in the national economy, measured by the share of agriculture in gross value added, leads to a higher value of the landscape/ecosystem. Because the share of agriculture in GVA is employed in the model in percentage form, we can conclude that an increase in this share of one percentage point is connected with an increase in the value by 0.05 EUR per person per day. That is, the landscape/ecosystem has a higher value in countries where land is a more important resource for the economy. Based on this result, we can conclude that the landscape/ecosystem value will be higher in countries such as Bulgaria, Romania, Hungary, Croatia, Greece, Estonia, Lithuania and Latvia, where the share of agriculture in gross value added is more than 3.3%. On the other hand, the landscape/ecosystem in countries whose share of agriculture in gross value added is under 1% will be assessed a lower price. Belgium, Luxembourg and the United Kingdom are examples of such countries.

The parameter of proportion of farming in less-favoured mountain areas in national agriculture is not statistically significant. Table 5 shows this proportion, measured by the share of agricultural land in mountain and other LFA in the total utilized agricultural area (UAA) of the analysed countries. It is obvious that there is no unequivocal relationship between the share of LFA and the value of mountain landscape/ecosystem. This could help explain the non-significant result.

Table 5 also presents the share of LFA payments in the sum of subsidies (excluding subsidies on investments) gained by the average farm operating in mountain LFA in the analysed countries. However, no unequivocal relationship could be seen between this share and the value of mountain landscape/ecosystem; the parameter that measures the influence of LFA subsidies is statistically significant at the 10% level and proves that the one-percent increase in the share of LFA payments in the total sum of subsidies of a typical farm is connected with a decrease in the landscape/ecosystem value by 0.53 EUR, ceteris paribus. That is, a higher value is supposed in countries such as Bulgaria, Spain and Romania, where the share is under 10%. On the other hand, we can suppose that the mountain landscape/ecosystem value will be assessed lower in France, Portugal, Finland and Slovenia, where the share of LFA subsidy is higher than 20%.

Arriaza et al. (2004) explained this negative effect of LFA payments – maintenance in the production of land of poor agricultural quality, as an alternative to natural vegetation, decreases the perception of wilderness in the landscape, and thus its beauty. On the other hand, Lefebvre et al. (2012) mentioned

Country	Mountain LFA [%]	Other LFA [%]	LFA subsidy share [%]	Landscape/Ecosystem Value [EUR/day]
Czech Republic	17.8	36.06	23.9	6.49
Germany	1.84	53.52	18.73	0.69
Ireland	0	74.14	0	0.19
Spain	29.71	58.32	4.66	9.3
Italy	33.75	23.33	8.76	1.76
Austria	54.71	18.89	22.21	3.02
Slovakia	34.32	41.37	32.8	0.92

Source: Own calculations

Table 5: Proportion of mountain and other LFA, shares of LFA subsidies in total subsidies and mean value of mountain landscape/ecosystem in the analysed countries.

that abandoning production in marginal areas can have a negative influence on landscape because of the homogenisation effect.

Conclusion

Agricultural land management strongly shapes mountain landscape, which is considered a public good, per se (for its aesthetic, recreational and cultural value), but also provides the ecological infrastructure necessary for the existence of other public goods such as biodiversity, water and soil quality. The importance of delivering such public goods has been recognized by the public policy of European countries. Environmental and LFA payments are the most significant examples of Common Agriculture Policy measures which target the support of this delivery of public goods. However, there are studies which have declared that these supports do not reflect the value of such environments (e.g. Bernués et al., 2014). To set the right level of subsidies, it is important to find out the value of the landscape/ecosystem and evaluate the factors which led to differences in this value.

According to the meta-analysis of 22 mountain landscape or ecosystem valuation studies, we can conclude that the average value of a European mountain landscape/ecosystem is 3.91 EUR per person per day. However, there are regions with significantly higher values – Alpujarran in Spain. The research questions were especially focused on the differences in the mountain landscape/ecosystem value due to farming and agricultural policy, and we can conclude that the mountain landscape/ecosystem is assessed higher in countries where agriculture has a stronger position in the national economy and where the land is a more important resource for the economy. Bulgaria, Romania, Hungary, Croatia, Greece, Estonia, Lithuania, Latvia and Slovakia are examples of these countries in Europe.

Because mountain areas are usually characterized as less-favoured areas, our research also tried to find out whether the differences in landscape/ecosystem value are connected with the share of agricultural land in less-favoured areas in total agricultural area, and with the share of LFA payments in total subsidies. From this point of view, we can conclude that no unequivocal relationship was demonstrated between the share of land in LFA and the value of mountain landscape/ecosystem. On the other hand, the regression analysis brought a significant result, namely that the higher share of LFA subsidies in the total sum of subsidies (excluding subsidies in investments) of the average farm located in less-favoured mountain areas is connected with the lower value of mountain landscape/ecosystem. France, Portugal, Finland and Slovenia are examples of countries where LFA subsidies are an important part of the income of the average farm drawn from agricultural policy. Furthermore, we can conclude that the public support represented by LFA and environmental payments is insufficient to cover the cost of landscape services provided by farmers.

We also analysed the effect of the valuation technique on landscape/ecosystem value and the differences in this value for visitors and residents. Our conclusion is that the WTP is the most appropriate evaluation technique, as it leads to a value in the middle of the extremes acquired using other techniques. Moreover, the regression model showed that visitors are willing to pay a higher price for mountain landscapes and the quality of mountain ecosystems than residents.

Acknowledgements

Pieces of knowledge introduced in this paper resulted from the solution of the research project QJ1530286 “Optimization of the subsidy system for agricultural producers with regard to the production of public goods” financed by NAZV within the research program: Complex sustainable systems in agriculture 2012 -2018 "KUS".

Corresponding author:
Ing. Michaela Havlíková, Ph.D.
Department of Economics, Faculty of Economics and Management,
Czech University of Life Sciences Prague, Kamýcká 129, Prague 6, 165 21, Czech Republic
Phone: +420 224382338, E-mail: havlikovam@pef.czu.cz

References

[1] Alvarez-Farizo, B., N. Hanley, R.E. Wright and D. Macmillan (1999) “Estimationg the Benefits of Agri-environmental Policy: Econometric Issue in Open-ended Contingent Valuation Studies”, *Journal of Environmental Planning and Management*, Vol. 42, No. 1, pp. 23-43. ISSN 0964-0568. DOI 10.1080/09640569911280.

[2] Antoušková, M. (2012) “Economic value of recreation – Determinants influencing the willingness to pay in natural region with low-intensity agriculture”, *Agris on-line Papers in Economics and Informatics*, Vol. 4, No. 4, pp. 3 – 9. ISSN 1804-1930.

[3] Arriaza, M., J. F. Cañas-Ortega, et al. (2004) ”Assessing the visual quality of rural landscapes”, *Landscape and Urban Planning*, Vol. 69, pp. 115–125. ISSN 0169-2046. DOI 10.1016/j.landurbplan.2003.10.029.

[4] Bastian, O., Ch. Stein, G. Lupp, J. Behrens, Ch. Renner, and K. Grunewal (2015) “The appreciation of nature and landscape by tourism service provides and visitors in the Ore Mountains (Germany)”, *Landscape online*, Vol. 41, pp. 1 – 23. ISSN 1865-1542. DOI 10.3097/LO.201541.

[5] Bernués, A., Rodriguez-Ortega, T., Ripoll-Bosh, R. and Alfnes, F. (2014) “Socio-cultural economic valuation of ecosystem services provided by Mediterranean mountain agroecosystem“, *PLoS ONE*, Vol. 9, No. 7, pp. e102479. ISSN 1932-6203. DOI: 10.1371/journal.pone.0102479.

[6] Burrel, A. (2011) „Evaluating Policies for Delivering Agri-environmental Public Goods“, paper presented on OECD Workshop on the Evaluation of Agri-environmental Policies, Braunschweig, 20-22.6.2011.

[7] Campbell, D., Hutchinson, G. and Scarpa, R. (2005) “Using choice experiment to value farm landscape improvements: Implications of inconsistent preferences”, Applied Environmental Economics Conference. [Online]. Available: https://www.researchgate.net/publication/237522629_USING_CHOICE_EXPERIMENTS_TO_VALUE_FARM_LANDSCAPE_IMPROVEMENTS_IMPLICATIONS_OF_INCONSISTENT_PREFERENCES. [Accessed: 15 Jun. 2016].

[8] Ciaian, P., Gomez y Paloma, S. (2011) „The Value of EU Agricultural Landscape“, Paper presented at the Agricultural & Applied Economics Association’s 2011 AAEA & NAREA Joint Annual Meeting, Pittsburg, Pensylvania, July 24-26, 2011. DOI 10.2791/60382

[9] Füzyová, L., Lániková, D. and Novorlský, M. (2009) “Economic Valuation of Tatras National Park and Regional Environmental Policy”, Polish Journal of Environmental Studies, Vol 18, No. 5, pp. 811 – 818. ISSN 1230-1485.

[10] Getzner M. (2000) “Hypothetical and real economic commitments, and social status in valuing a species protection program”, *Journal of Environmental Planning and Management*, Vol. 43, No. 3, pp. 541 – 559. ISSN 1360-0559. DOI 10.1080/713676576.

[11] Getzner, M. (2010) “Ecosystem services, financing, and the regional economy: A case study from Tatra national Park, Poland”, *Biodiversity*, Vol. 11, No. 1-2, pp. 55 – 61. ISSN 2160-0651. DOI 10.1080/14888386.2010.9712648

[12] Gios G., Goio I., Notaro S. and Raffaelli R. (2006) "The value of natural resources for tourism: A case study of the Italian Alps", *International Journal of Tourism Research*, Vol. 8, No. 2, pp. 77 – 85. ISSN 1522-1970. DOI 10.1002/jtr.552.

[13] Glück P. and Kuen H. (1977) "Der Erholungswert des Grossen Ahornbodens" [in German]. *Allgemeine Forstzeitung*, Vol. 88, pp.7 – 11. ISSN 0002-5879.

[14] Goio I., Gios, G. and Pollini C. (2008) "The development of forest accounting in the province of Trento (Italy)", *Journal of Forest Economics*, Vol. 14, No. 3, pp. 177 – 196. ISSN 1104-6899. DOI 10.1016/j.jfe.2007.09.002.

[15] Green, W. H. (2008) "*Econometric Analysis*", Sixth edition. Upper Saddle River, New Jersey: Pearson Education. 1178 p. ISBN 978-0-13-513740-6.

[16] Grêt-Regamey A, Bebi P, Bishop I. D, Schmid W. (2008) "Linking GIS-based models to value ecosystem services in an Alpine region", *Journal of Environmental Management*, Vol. 89, No. 3, pp. 197-208. ISSN 0301-4797. DOI 10.1016/j.jenvman.2007.05.019.

[17] Häyhä, T., Franzese, P. P., Palleto, A. and Fath, B. D. (2015) "Assessing, valuing and mapping ecosystem services in Alpine forest", *Ecosystem Services*, Vol. 14, pp. 12 – 23. ISSN 2212-0416. DOI 10.1016/j.ecoser.2015.03.001.

[18] Hackl, F. and Pruckner G. J. (1997) "*Contingent Valuation als Instrument zur ökonomischen Bewertung der Landschaft* [in German]." Frankfurt am Main, Germany: Lang. ISBN 978-3631305379.

[19] Knudsen D. C., Metro-Roland, M. M., Soper, A. K. and Greer Ch. E. (1995) "*Landscape, tourism, and meaning*". Ashgate Publishing Ltd., Hampshire. ISBN 978-0-7546-49-3.

[20] Kubíčková, S. (2004) "Non-market evaluation of landscape function of agriculture in the PLA White Carpathians", *Agricultural Economics*, Vol. 50, No. 9, pp. 399 – 393. ISSN 1805-9295.

[21] Lefebvre, M., Espiroza, M., Gomez y Poloma, S. (2012) "*The influence of the Common Agricultural Policy on agricultural landscapes*", Luxembourg: Publications Office of the European Union, 2012. ISBN 978-92-79-25828-2.

[22] Löwenstein W. (1995) "Die monetäre Bewertung der Schutzfunktion des Waldes vor Lawinen und Rutschungen in Hinterstein (Allgäu) [in German]" , In: Bergen V, Löwenstein W, Pfister G. Studien zur monetären Bewertung von externen Effekten der Forst- und Holzwirtschaft. Schriften zur Forstökonomie 2. 2nd edition. Frankfurt am Main, Germany: Sauerländer, pp 117–178.

[23] Lutting, J. (2000) "The value of trees, water and open space as reflected by house price in Netherlands", *Landscape and Urban Planning*, Vol. 48, No. 3-4, pp. 161 – 167. ISSN 0169-2046. DOI 10.1016/S0169-2046(00)00039-6.

[24] Marangon, F. and F. Visintin (2007) "Rural landscape valuation in a cross-border region", *Cahiers d'économie et sociologie rurales*, Vol. 84, pp. 113-132. ISSN 0755-9208.

[25] Melichar, J. (2007) "Economic valuation of forest quality change in Jizerské Hory mountains: The evidence from contingent behavior study", Paper presented at the Ninth Annoual Bioecon Conference, Kings College Cambridge. [Online]. Available: http://www.bioecon-network.org/pages/9th_2007/Melichar.pdf. [Accessed: 15 Jun. 2016].

[26] Molina, J. R., Silva, F. R. and Herrera, M. A. (2016) "Integrating economic landscape valuation into Mediterranean territorial planning", Environmental Science & Policy, Vol. 56, pp. 120 – 128. ISSN 1462-9011. DOI: 10.1016/j.envsci.2015.11.010

[27] Moon, W. and W. Griffith (2010) „Assessing public preferences and holistic economic value for multifunctional agriculture in the U.S." Paper presented et 2010 Annual Meeting, Orlando, Florida. [Online]. Available: http://ageconsearch.umn.edu/bitstream/56010/2/Wanki_Moon_manuscript_SouthernAgEconMeeting_Dec24_2009.pdf. [Accessed: 15 Jun. 2016].

[28] Notaro, S. and Paletto, A. (2011) "Links between Mountain Communities and Environmental Services in the Italian Alps", *Sociologia Ruralis*, Vol. 51, No. 2, pp. 137 – 156. ISSN 1467-9523. DOI 10.1111/j.1467-9523.2011.00532.x.

[29] Palleto A., Geitner, C., Grilli, G., Hastik, R., Pastorella, F. and Rodrigez Garcia, L. (2015) "Mapping the value of ecosystem services: A case study from the Austrian Alps", *Annals of Forest Research*, Vol. 58, No. 1, pp. 157 – 175. ISSN 1610-7403. DOI 10.15287/afr.2015.335

[30] Považan, R., Getzner, M. and Švajda, J. (2014) "Value of ecosystem services in mountain national parks. Case study of Veľká Fatra National park (Slovakia)", *Polish Journal of Environmental Studies*, Vol 23, No. 5, pp. 1699 – 1710. ISSN 1230-1485.

[31] Rodriguez-Ortega, T., Bernués, A. and Alnes, F. (2016) "Psychographic profile affects willingness to pay for ecosystem services provided by Mediterranean high nature value farmland", *Ecological Economic*, Vol. 128, pp. 232 – 245. ISSN 0921-8009. DOI 10.1016/j.ecolecon.2016.05.002.

[32] Sayadi, S., González-Roa C. M. and Calatrava-Raquena, J. (2009) "Public preferences for landscape features: The case of agricultural landscape in mountainous Mediterranean areas", *Land Use Policy*, Vol. 26, No. 2, pp. 334 – 344. ISSN 0264-8377. DOI 10.1016/j.landusepol.2008.04.003.

[33] Soliva, R. and Hunziker, M. (2009) "How do biodiversity and conservation values relates to landscape preferences? A case study from the Swiss Alps", *Biodiversity and Conservation*, Vol. 18, No. 9, pp. 2483 – 2507. ISSN 1572-9710.

[34] Tagliafierro, C., Longo, A., Eetvelde, V., Antrop, M. and Hutchinson, W. G. (2013) "Landscape economic valuation by integrating landscape ecology into landscape economics", *Environmental Science & Policy*, Vol. 32, pp. 26 – 36. ISSN 1462-9011.

[35] Tempesta, T. and Thiene, M. (2004) "The willingness to pay for conservation of mountain landscape in Cortina d´Ampezzo", Proceeding of the 90th EAAE Seminar, Multifunctional Agriculture, Rennes, France. [Online]. Available: https://www.researchgate.net/publication/237115492_The_willingness_to_pay_for_the_conservation_of_mountain_landscape_in_Cortina_D'Ampezzo_Italy. [Accessed: 15 Jun. 2016].

[36] Thiam, A., Bravo-Ureta, B. E., Rivas, T. E. (2001) "Technical Efficiency in Developing Countries Agriculture: A Meta-Analysis", *Agricultural Economics*, Vol. 25, pp. 235– 243. ISSN 1805-9295. DOI 10.1111/j.1574-0862.2001.tb00204.x.

[37] Van Huylenbroeck, G., Vanslembrouck, I., Calus, M and Van De Vaide, L. (2006) "The influence of planned-change context on the evaluation of natural landscape", *Landscape and Urban Planning*, Vol. 43, No. 1-3, pp. 14 – 21. ISSN 0169-2046.

[38] Welch, B. L. (1947) "The generalization of "Student's" problem when several different population variances are involved", *Biometrika*, Vol. 34, No. 1–2, pp. 28 – 35. ISSN 1464-3510.

Agris on-line Papers in Economics and Informatics

Volume VIII Number 3, 2016

Editorial board

Agris on-line Papers in Economics and Informatics

The international reviewed scientific journal issued by the Faculty of Economics and Management of the Czech University of Life Sciences Prague.

http://online.agris.cz

ISSN 1804-1930