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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

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A Comparative Analysis of Organic and Conventional Farming Profitability

I. Brožová, M. Beranová

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

Abstract

The objective of this article is to determine the economic performance of organic farms compared with conventional farms. The analysis included a set of farms the concentration of which is in natural and climatic conditions typical for this type of farming high. The outputs may be therefore considered representative and generalised.

In order to determine the performance of these farms, their production basis was first assessed by using the indicators of available assets and assets coverage resources. Consequently, their efficiency was assessed based on the profit. For the purposes of comparison, the profit was (in various forms) converted to a hectare of agricultural land. The economic results were also compared with the average level achieved in the EU. The final part of the research focused on the evaluation of the economic and financial standing of the farms using selected return, liquidity, debt, and activity related ratio indicators. The established results show that the situation of organic farms on the national level tends to be economically more favourable. This is demonstrated by the higher share of profit-making farms and more favourable values of certain ratio indicators, i.e. those concerning profitability, liquidity, and interest coverage. The comparison with the average values achieved in the EU revealed a significantly more favourable situation in the Czech Republic.

Keywords

Conventional farms, farms as legal entities, financial analysis, ratio indicators, loss-making farms, organic farms, profitable farms.

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Introduction

In connection with the increasing competitiveness and global openness of the markets, the economic performance of any sector has been the topic of ever more frequent discussions. It is the objective of any business in any entrepreneurial field to be successful, develop for the future, and consolidate its position on the market.

The position of agriculture among other sectors of the economy is rather specific because its importance is irreplaceable in terms of nourishing the population and protecting all the components of the environment. Because of the specifics of this sector (regarding both the production process and the market operation process), economic performance is more difficult to achieve than in other economic sectors.

This also applies to organic farming, which, unlike conventional farming, also includes additional characteristics (such as higher production costs, stricter rules applicable to the production process, more complex sales of bio products, etc.) that can hinder the achievement of the performance requirements. However, support for organic farming and for ensuring its efficiency appears desirable because the demand for, and public interest in, high-quality and safe foodstuffs as well as in animal welfare and in the preservation of natural resources has been rising in recent years.

In these difficult times, with the ending era of cheap natural resources and with each farm striving to use all resources as efficiently and effectively as possible, it is necessary to learn how to use such resources sustainably so as to reduce the environmental impact. The space for the development of organic farming and its stable support are advisable.

In the scientific literature, the issue of economic performance is one of the key topics and receives

the attention of many authors. Farrell (1957) was the first one to introduce this concept: "A firm is technically efficient if it cannot produce the same volume of goods using a lower quantity of one factor of production without increasing the volume of another factor of production." According to Samuelson and Nordhaus (2001), efficiency is: "the use of economic resources that produces the maximum level of satisfaction possible with the given inputs and technology" At the level of an undertaking, efficiency is defined by Hindls et al. (2003): "At the most general level, economic efficiency is the ability of a business to create value out of the resources invested in the enterprise" or, for example, by Petrackova (1995) "… the efficiency of the resources input in the production, evaluated from the perspective of their results."

A number of international and Czech authors have observed the performance of agricultural undertakings. Research focused on conventional farms prevails significantly. Businesses following the principles of organic farming have received less attention.

The issue of performance is mostly observed by the authors in connection with the transition from conventional to organic farming. However, the outcomes do not provide clear conclusions to confirm success or failure.

Each study follows its own methodology (the selected farms came from different climatic and production conditions, different evaluation methods and procedures), which complicates any comparison and clouds the clarity of the findings.

Certain research studies conducted among conventional farmers, e.g. in Belgium, show the lack of knowledge and the underestimation of the economic potential of organic farming and the prevailing opinion that the additional limitations associated with organic farming will unavoidably lead to reduced income. According to De Cock (2005), this negative perception is the predominant cause for the low willingness of Belgian farmers to convert. The model proposed by Kerselaers (2007) is also based on the example of Belgian farming, utilising specific accounting data of organic and conventional farms to show the potential income changes resulting from the conversion to organic farming. According to this model, the economic performance is not clearly positive for all the farms and it is dependent on the type and nature of the farm.

The observations made by Madau (2007) also confirm the lower performance of organic farms in comparison with conventional farms.

The above-mentioned studies are rather sceptical about the transition to organic farming and do not consider economic profit very realistic.

On the contrary, however, there are studies (e.g. that by Offermann and Nieberg, 2000) that have demonstrated the economic success of farms. Nevertheless, we need to remember to accept these assertions with caution because the analysed samples may (and the studies did indeed) also include companies whose profitability was lower than that of the conventional farms they were compared to.

While Lund et al. (2002) or Nowak (1987) consider economic performance an important factor limiting the existence of organic farming (without mentioning other factors), other authors (e.g. Köhne and Köhn (1998), Lampkin and Padel (1994)) also mention other motivations that should be considered when converting to organic farming. They hold that economic motivation is less important than other (non-economic) motives such as environmental concerns, animal welfare, psychosocial characteristics, etc. These aspects must be considered when evaluating economic data regarding organic farms. The evaluation cannot be one-sided even though the economic aspects are, without doubt, important.

The research on the efficiency of conventional and organic farming in the Czech Republic also provides rather varied outputs.

Some authors focus on economic performance at the general level – e.g. Sarapatka and Urban (2006) or Kopta and Kourilova (2008).

Using their own samples of entities (organic versus conventional farms), they go on to examine the efficiency of selected plant and livestock farming products (most commonly involving dairy farms and farms keeping cows without the market production of milk; in terms of plant production, wheat, potato and oats growing is represented most commonly), e.g. Zivelova et al. (2003), Jansky et al. (2006) or Hrabalova and Zander (2006).

Governmental institutions also pay attention to the actual economic situation of farms. Under authorisation from the Czech Ministry of Agriculture, the Institute of Agricultural Economics and Information (IAEI, the FADN liaison agency) uses the so-called Farm Accountancy Data Network (FADN CZ) to monitor the results and economic situation of selected farms. It is

a selected sample of legal entities, representing both conventional and organic farms (with conventional farms prevailing at the ratio of 89:11). As a novelty, the performance of purely organic farms is presented separately (since 2013) but it is only done in the form of the FADN EU standard output (at the level of items such as Gross Farm Income, Farm net value added, Family Farm Income, i.e. items used for the purposes of comparing farms among all EU Member States), while the items required for determining the profit/loss (in the same structure as that in the overall FADN database) according to Czech financial statements is missing.

The IAEI also collects data from organic farms in regular yearly intervals (through supervisory authorities). The exercise is commissioned by the Czech Ministry of Agriculture and the data, defined by Eurostat, is used for the purposes of comparison among the EU Member States (Sejnohova et al., 2015). Within the framework of the basic statistical data, the development of the share of profitable farms (by production focus) is also monitored to assess the economic performance. However, more detailed economic categories (selected profit/loss items, selected assets/liabilities items) which are monitored at the level of the FADN sample as a standard and could be used to establish the economic profit of the organic farming sector as a whole (through the application of selected economic methods) are missing.

It was therefore the objective of this research to respond to this fact and use the economic analysis of organic farms to assess their economic performance in greater detail (and compare it to the performance of conventional farms), and thus to contribute to addressing the persisting need for information about whether or not such entities are viable in our conditions and whether or not they may contribute to meeting the requirements for environmentally friendly and sustainable farming. The results of the analysis should be used to propose measures aimed at improving the awareness of the performance of the entire organic farming sector. This is a must for the government agencies, which should be interested in feedback, mainly based on the fact that they financially support this sector. They should be therefore interested in whether these resources are spent effectively.

The above-mentioned main objective is divided in the following partial objectives:

- Map and evaluate the production basis of the organic farm as the prerequisite for the subsequent establishment of the efficiency of these undertakings. Evaluate the production basis on the basis of the indicators of assets availability and resources covering these assets. For higher-quality output, make a comparison with conventional farms and with farms from the FADN CZ sample;
- Evaluate the efficiency of organic farms in comparison with the same groups of samples as in the previous point as follows:
  1. according to profit (in absolute terms; in relative terms per hectare of agricultural land);
  2. through selected financial ratio indicators;
- Propose measures to improve awareness of the economic profit of this sector for the needs of the public administration as well as of farmers.

While one of the authors has conducted research in the field for some time (Brozova, 2011a, 2011b), there is definitely space for further evaluations, in particular of the economic nature. The author now seeks to follow up on her previous research, in which she worked with other authors (e.g. Vanek et al., 2011) to create a map portal in the region of South Bohemia, and go on to focus on the economic aspects of the issue. She intends to continue researching the region both because of its continued dominant position among the regions of the Czech Republic and in connection with the previous outputs, allowing for the comparison of the outcomes.

Organic farming is mainly centred in the less favourable mountain and sub-mountain areas in the Czech Republic and the region of South Bohemia offers suitable conditions for this type of farming. That is why it has the largest area of organically farmed land in the country (15.2% of the total area of organically farmed land in the Czech Republic – as of 31 December 2015) and the region has also dominated in the long run in terms of the number of farms (13.7% of the total number of eco farms in the Czech Republic – as of 31 December 2015 (MoA, 2016). For these reasons, the authors consider the region suitable for the presentation of conclusions regarding the economic profit of the organic farming sector.

Materials and methods

For evaluating the efficiency of organic farms in comparison with conventional farms, primary data from three main sources were used:

- Amadeus database. It provides financial and economic information about the companies based on processing their financial statements. The data taken into consideration was that which can be accessed – i.e. data concerning legal entities, which have the legal obligation to publish their financial statements. 31 final accounts of organic farms and 99 final accounts of conventional farm were analysed. Farms were selected based on an identification number. These farms were located in the South Bohemia Region which is typical for its organic farming. The highest number of organic farms and largest area farmed organically is located in the region. The largest portion of the total agricultural land fund area is permanent grassland (almost 86%), the rest is arable land (about 9%) and orchards and vineyards (only 0.4%). Livestock production of these farms specialises mainly in cattle breeding without the market production of milk, either exclusively or in combination with another livestock category (sheep, goats, horses). The production orientation of plant and livestock production is also reflected in the average size of organic farms in the region, which is 141 ha (slightly above the national average – 127 ha). The structure of the agricultural land fund and orientation of livestock production is not significantly different from the national average, they just confirm that farms are concentrated in areas at higher altitudes and unfavourable natural conditions. For this reason, it is possible to consider the farm selection to be representative and generalise the result on the national level.
- Farm Accountancy Data Network (FADN). It is based on the methodology of the annual economic result statement of enterprises with double-entry bookkeeping. The database provides the results of a sample survey organised from different perspectives, allowing a comparison of economic results of agriculture enterprises in different natural conditions for companies of various legal forms, sizes, and types of farming. The results are presented in the form of a weighting system.
- IAEI database. It is created by representatives of monitoring organisations directly on farms throughout the year. The data is collected by inspectors when conducting a proper review. The collection was made using a questionnaire annually updated according to the European Commission requirements. Since 2007, the output is the annual "Statistical Survey of Organic Farming". In addition to ordinary statistical data relating to the evaluation of production base, it includes data on sales and use of organic farms production, and data on the economic result of the enterprise.

The data of 31 organic farms (sample 1 in the presented results) and 99 conventional farms (sample 2) were taken from the Amadeus database. Sample 3 included data from the FADN CZ database, while the number of enterprises ranged from 233 to 529 farms monitored in 2008 – 2013. The number of organic farms included in the IAEI database ranged from 1849–3926.

In addition to the above mentioned main sources, the documents were supplemented and confronted with databases and information sources accessible to the public (e.g. REP - Register of Organic Entrepreneurs, LPIS - Land Parcel Identification System, FADN EU).

In the first part of the research, the evaluation of economic performance of agricultural enterprises focused only on the evaluation of their production base. For this, ratios of assets availability (total assets per hectare of agricultural land, fixed assets per hectare of agricultural land and current assets per hectare of agricultural land) and of assets coverage resources (equity per hectare of agricultural land, external resources per hectare of agricultural land) were selected. The comparison was made between the individual types of enterprises (cooperatives, corporations, and total legal entities), between farming systems (organic and conventional farming), and with the companies included in the FADN database.

The second part of the research focused on the performance evaluation based on the profit. At first, the profit was monitored in absolute terms (the share of profitable and loss-making farms in samples 1, 2 and IAEI sample was monitored) and then the profit was converted to a hectare of agricultural land for the purposes of comparison with sample 3. Three methodologically different profit categories were selected - Operating profit 1

(= added value - personal expenses - depreciation), operating profit 2 (same as operating profit, taken from line 30 P&L statement) and accounting profit (identical to the result for the accounting period, taken from line 60 P&L statement).

To be able to compare the profitability of farms in the Czech Republic and EU, the cash flow category was also selected. For comparison were chosen category of cash flow. It is reported in two ways calculations. CF1 represents the holding's capacity for saving and self-financing = Receipts - Expenditure for the accounting year, not taking into account operations on capital and on debts and loans. This indicator is close to that used by EUROSTAT on the basis of Macro-economic accounts = Net Receipts of Agricultural activity and Other Receipts + Balance farm subsidies and taxes + Balance subsidies and taxes on investments = Sales of products + Other Receipts + Sales of livestock - All costs paid - Purchases of livestock + Farm subsidies - Farm Taxes + VAT balance + Subsidies on investments - Taxes on investments. CF2 represents the holding's capacity for saving and self-financing = Receipts - Expenditure for the accounting year = Net receipts of agricultural activity and other receipts + Balance farm subsidies and taxes + Balance subsidies and taxes on investments + Balance of operations on capital + Balance of operations on debts and loans = Sales of products + Other receipts + Sales of livestock - All costs paid - Purchases of livestock + Farm subsidies - Farm taxes + VAT balance + Subsidies on investments - Taxes on investments + Sales of capital – Investments + Closing valuation of debts - Opening valuation of debts.

In the final part of the research, financial analysis ratio indicators were selected out of elementary methods of technical analysis. These included selected indicators of profitability, liquidity, indebtedness, and economic activities of the company - Return on Assets, Return on equity, Liquidity, Gearing, Interest coverage, Net assets turnover. In the design of indicators authors patterns based primarily on publications Mrkvicka and Kolar (2006), or the construction of some indicators adjusted (due to the absence of items of financial statements of companies).

Other scientific methods, such as analysis, synthesis, induction, deduction, comparison and questioning, were used in the processing of the article. The data was processed using MS Excel.

Results and discussion

In order to comprehensively evaluate the performance of farms, it is first necessary to assess the production basis of these entities and only then to proceed by evaluating their economic profit through profit. That is why the focus of the first part of the research was on evaluating the production basis of the organic farms (operated by legal entities) in the region of South Bohemia using the assets available indicator (total assets per hectare of agricultural land, fixed assets per hectare of agricultural land, and current assets per hectare of agricultural land) and the indicator of the resources of assets coverage (equity per hectare of agricultural land, liabilities per hectare of agricultural land). In order to enable comparison among the individual types of legal entities (cooperatives, corporations, and total legal entities), between farming systems (organic versus conventional farming), and with the companies included in the FADN CZ database, the indicators were calculated per hectare of agricultural land.

The average values of these indicators achieved by the specified groups of legal entities (cooperatives, corporation) and by legal entities in total in organic farming (sample 1), in conventional farming (sample 2) and in the FADN CZ sample (sample 3) is shown in tables 1a, 1b, and 1c for the period 2008 - 2013.

The tables 1a, 1b and 1c indicate that *the availability of assets per hectare of agricultural land* is significantly higher in conventionally operated farms. In addition, the differences between cooperatives and corporations are not as striking for conventional farming as they are between cooperatives and corporations for organic farming. Agricultural cooperatives posted significantly lower results than corporations. The values for cooperatives from the FADN sample were between the borderline values of sample 1 and sample 2 (except for the year 2013).

In terms of the structure of assets, fixed assets prevail in the total assets over current assets in all the samples (in the interval of 53% to 68%).

As for *the capital structure*:

- Among farms operating as legal entities, there is a prevailing share of own funds over external funding in all the samples (in the interval of 54% to 67%).
- There are more significant differences between agricultural cooperatives and corporations mainly in the organic farm

Ratios CZK .ha^{-1}	sample	Cooperatives					
		2008	2009	2010	2011	2012	2013
Total assets	1	23,625	23,434	22,750	25,234	31,493	31,393
	2	75,752	73,319	72,810	77,342	81,827	81,461
	3	66,556	66,471	67,523	72,875	79,975	84,938
Fixed assets	1	11,089	12,440	13,031	13,618	19,165	19,638
	2	45,854	45,751	45,559	47,084	51,418	52,998
	3	38,799	40,340	41,581	44,478	50,436	53,291
Current assets	1	12,537	10,994	9,718	11,616	12,328	11,755
	2	29,898	27,568	27,251	30,258	30,409	28,463
	3	27,128	25,744	25,545	27,982	29,146	31,197
Equity	1	9,889	7,062	6,121	8,191	9,885	10,734
	2	41,585	40,627	40,838	44,853	47,531	47,740
	3	36,291	36,468	38,651	42,043	45,585	49,195
Liabilities	1	13,737	16,372	16,629	17,044	21,608	20,659
	2	34,167	32,686	31,977	32,521	34,314	33,694
	3	30,031	29,908	28,790	30,705	34,233	35,624

Source: authors, based on the Amadeus database (2016), Farm Accountancy Data Network (FADN CZ) (2016)

Table 1a: Production basis of agricultural cooperatives farming in the region of South Bohemia in 2008 – 2013.

Ratios CZK .ha^{-1}	sample	Corporations					
		2008	2009	2010	2011	2012	2013
Total assets	1	46,439	47,278	46,122	48,232	46,447	52,076
	2	61,829	62,576	70,019	73,449	77,617	78,378
	3	59,833	62,347	64,540	71,020	75,161	80,255
Fixed assets	1	31,415	31,364	30,343	30,455	29,081	32,377
	2	36,102	37,804	43,091	45,968	49,334	48,695
	3	33,878	36,824	38,885	42,418	45,895	49,505
Current assets	1	15,024	15,914	15,779	17,777	17,365	19,699
	2	25,726	24,773	26,928	27,482	28,283	29,683
	3	25,291	25,061	25,298	27,996	28,772	30,281
Equity	1	31,103	31,707	30,341	31,572	31,133	33,235
	2	34,124	35,110	36,434	39,651	42,826	44,038
	3	36,333	39,508	41,023	45,340	46,780	51,390
Liabilities	1	15,336	15,571	15,782	16,661	15,314	18,841
	2	65,669	26,959	65,215	33,360	65,854	34,339
	3	23,313	22,660	23,356	25,453	28,149	28,622

Source: authors, based on the Amadeus database (2016), Farm Accountancy Data Network (FADN CZ) (2016)

Table 1b: Production basis of corporations farming in the region of South Bohemia in 2008 – 2013.

sample. There is a substantially lower share of equity in the total capital in agricultural cooperatives (in the reporting period it was between 27% and 42%) than in corporations (between 62% and 67% in the reporting period).

It can be said overall that there are differences in the available assets of the farms and in the structure of their capital both among the sample groups observed (the organic farm sample, conventional farm sample, and the FADN CZ sample) and within these samples. There are a number of factors underlying this situation. This is, for example, due to: the manner in which the entity was created and the initial resources invested in the enterprise (tangible, financial as well as information resources); the attitude of the owner(s) to securing an assets base, investment activities, acquiring external sources of financing, etc.

Ratios CZK .ha^{-1}	sample	Legal entities total					
		2008	2009	2010	2011	2012	2013
Total assets	1	42,837	43,513	42,432	44,601	44,086	48,810
	2	69,719	68,664	71,600	75,655	80,003	80,125
	3	62,200	64,122	65,536	71,518	76,953	81,858
Fixed assets	1	28,206	28,376	27,609	27,797	27,515	30,366
	2	41,628	42,307	44,490	46,600	50,515	51,133
	3	35,728	38,415	39,933	43,186	47,769	50,930
Current assets	1	14,631	15,137	14,822	16,805	16,570	18,445
	2	28,090	26,357	27,111	29,055	29,488	28,992
	3	25,826	25,278	25,227	27,809	28,739	30,471
Equity	1	27,754	27,816	26,516	27,880	27,778	29,682
	2	38,352	38,236	38,930	42,599	45,492	46,136
	3	35,889	38,003	39,725	43,622	45,990	50,132
Liabilities	1	15,083	15,697	15,915	16,721	16,307	19,128
	2	31,164	30,243	32,624	33,075	34,520	33,974
	3	26,108	25,981	25,686	27,716	30,769	31,537

Source: authors, based on the Amadeus database (2016), Farm Accountancy Data Network (FADN CZ) (2016)

Table 1c: Production basis of total legal entities farming in the region of South Bohemia in 2008 – 2013.

The second part of the research focused on evaluating the performance of organic farms in comparison with conventional farms and with those included in the FADN CZ (all in the same region) and FADN EU.

Profit is the indicator that is most commonly used to evaluate the success of the economic activities of a company. That is why this category:

- was first observed in absolute terms, i.e. to determine the share of profitable and loss-making farms in samples 1 and 2.
- For the purposes of comparison with sample 3, the profit was then recalculated per hectare of agricultural land used. Three different categories of profit were selected: *operating profit 1, operating profit 2, and book profit (profit/loss for the accounting period).* As stated by Svobodova et al. (2011), "the efficiency of operations is mainly reflected in the creation of added value, thus in operating profit 1 (op. P_1[1]). However, it does not take into considerations other operating items such as income from the sale of fixed assets, from the creation and clearing of provisions, from the difference between other income and expenditure, where subsidies represent an important revenue item." However, operating subsidies represent a significant part of the revenues in all farms, especially in organic farms. That is why both of these categories (op. P_1 and op. P_2[2]) were examined.
- It was also used for the construction of the efficiency (profitability) indicators - ROA and ROE.
- Finally, the category of profit and compared with those achieved in the EU. With regard to a number of methodological differences and the presentation of outputs at the level of EU FADN was chosen categories cash flow (CF1, CF2).

The following table (Table 2) shows the share of profitable and loss-making farms in samples 1 and 2 in the region of South Bohemia. For comparison purposes, the results of the annual statistical surveys by the IAEI Brno are also presented (e.g. Sejnohova et al. 2015).

The table suggests that, except in the last two years, the share of profitable farms was significantly higher in organic farming than in conventional farming. However, this concerned the category of profit (book P_1, i.e. profit/loss for the accounting period posted in row 60 of the P&L statement), the calculation of which already included subsidies (operating subsidies[3]). If they were not included

[1] op. P_1 = added value – personnel expenses – depreciation of fixed assets

[2] op. P_2 = operating profit/loss – see row 30 of the P&L statement

[3] Subsidies of an operating nature include, for example, SAPS, TOP UP support; for organic farms, they also include support for organic agriculture under agri-environmental measures (AEMs) as well as support under other AEM schemes, LFA payments, etc.

year	farms	sample 1		sample 2		IAEI survey
		book P1	book P2	book P1	book P2	book P1
2008	**profitable**	82.2	13.1	78.2	20.7	75.5
	loss-making	17.8	86.9	21.8	79.3	19.0
2009	**profitable**	78.8	11.3	56.6	21.8	82.8
	loss-making	21.2	88.7	43.4	78.2	6.7
2010	**profitable**	89.6	15.7	82.1	30.2	90.7
	loss-making	10.4	84.3	17.9	69.8	9.1
2011	**profitable**	92.6	17.1	89.3	34.5	92.0
	loss-making	7.4	82.9	10.7	65.5	5.5
2012	**profitable**	81.5	12.8	94.9	41.7	91.0
	loss-making	18.5	87.2	5.1	58.3	6.0
2013	**profitable**	85.2	14.2	89.3	36.8	95.7
	loss-making	14.8	85.8	10.7	63.2	3.4

Source: authors, based on the Amadeus database (2016), Sejnohova et al. (2015)

Table 2: Profitable and loss-making farms in organic and conventional farming in South Bohemia and in organic farming in the Czech Republic (%).

(book P_2 – the authors' own calculation), most farms (both organic and conventional) would post a loss. The importance of subsidies for operating profit can also be demonstrated using the results of the survey by the IAEI Brno (which also reported on the operating profit/loss the calculation of which included subsidies) – for details see Table 2.

The importance of subsidies is also suggested by Table 3, in which the profit/loss is expressed in relative terms per hectare of agricultural land. The presented results show that operating profit/loss (in case of operating profit 1) is not efficient (in samples 1 and 2; FADN CZ does not follow this category). The average values of the farms in both samples were negative in all the periods in question. However, after subsidies were included (operating profit 2), only cooperatives were not efficient - and only in a single year (but in all the samples in question, i.e. in sample 1, sample 2 and in the FADN CZ sample).

As far as the category of book profit was concerned, the situation in South Bohemia was almost identical with operating profit 2.

A high degree of dependence of farms on subsidies, in particular, as regards farms operating in mountain LFAs, is mentioned by Lososova and Zdenek (2014) as well as by Sarapatka and Urban (2006), according to whom certain types of farms could not otherwise exist (subsidies account for 15-20% of their revenue).

In terms of the achieved amount of profit per hectare of agricultural land, the legal entities operating in organic farming mostly reported lower values than the legal entities involved in conventional farming. A more detailed look at the individual types of companies (cooperatives, corporations) and farming systems (organic farming, conventional farming) suggests differences between the farms, to a greater or smaller extent. Such differences are not exceptional and their general causes are difficult to find. We need to remember a number of variations resulting from the different farming systems. As Kourilova (2006) suggests, they could contribute to the lower production efficiency in organic farming because of the higher risks involved (based on the limits set by the strict standards, a more limited number of processing parties, the marketability of the commodities, objective risks, etc.). On the other hand, the higher subsidies (coming from a broader range of support schemes), higher selling price of bio products and foodstuffs, and diversification of activities should contribute to increased performance.

However, in addition to these economic factors, there are other, non-economic, ones that play a major part in affecting performance. They include, for example, the natural and climatic conditions in the area, the production focus of the farm, market access, management skills, as well as the availability of information, available information and communication technologies, etc.

Another reason for lower profit per hectare of agricultural land in certain farms could be the larger areas typically farmed by organic farms in comparison with conventional farms (the average area of an organic farm in the Czech Republic is 123 hectares, while that of a conventional farm is

	year	Indicators								
		op. P_1 (CZK.ha^{-1})			**op. P_2 (CZK.ha^{-1})**			**book profit (CZK.ha^{-1})**		
		sample			sample			sample		
		1	2	3	1	2	3	1	2	3
Co-op	2008	-4,156	-7,018	-	1,313	1,736	1,005	876	1,323	633
	2009	-12,284	-11,835	-	-2,087	-1,486	-1,599	-2,401	-1,987	-1,870
	2010	-9,427	-6,530	-	111	2,114	1,608	-265	1,615	1,216
	2011	-2,335	-5,482	-	2,898	4,177	3,989	2,420	3,369	3,248
	2012	-3,056	-5,730	-	3,047	4,047	3,329	2,391	3,175	2,598
	2013	-5,018	-6,022	-	1,235	3,836	3,606	770	2,759	2,637
Corporations	2008	-10,535	-7,422	-	2,652	1,676	2,489	1,742	840	1,725
	2009	-8,485	-6,339	-	2,694	2,295	332	2,143	1,536	-159
	2010	-12,356	-6,415	-	1,907	2,654	2,434	1,438	1,592	1,666
	2011	-11,850	-4,935	-	1,956	4,807	4,564	1,447	2,905	3,152
	2012	-11,025	-3,812	-	1,138	5,288	4,736	587	3,640	3,217
	2013	-12,164	-4,050	-	1,790	4,592	4,427	878	2,826	2,967
Legal ent. total	2008	-8,145	-7,321	-	2,413	1,113	1,550	1,605	1,710	1,036
	2009	-11,314	-9,547	-	1,888	-460	-859	1,425	152	-1,213
	2010	-11,891	-6,754	-	1,561	1,605	1,897	1,169	2,348	1,373
	2011	-15,185	-5,714	-	2,048	3,168	4,189	1,601	4,450	3,215
	2012	-15,082	-4,894	-	1,396	3,377	3,741	872	4,585	2,779
	2013	-9,191	-5,712	-	1,651	2,788	3,873	861	4,164	2,744

Source: authors, based on the Amadeus database (2016)

Table 3: Economic results I of farms (operating as legal entities) in South Bohemia in 2008 – 2013.

75 hectares). With 133 hectares, the average area of an organic farm in South Bohemia exceeds the national average; in addition, the region ranks first, with a great margin, nationally in terms of permanent grassland and the farms' orientation on cattle farming.

The final part of the research focused on evaluating the economic and financial situation of the farms (both organic and conventional) in South Bohemia. Ratio indicators from the following areas were selected for that purpose: return, liquidity, indebtedness and activity. Their choice was limited by the items available from the financial statements of the farms (provided by Amadeus) – they did not all have the detailed structure required for the construction of certain indicators.

No comparison of the indicators with the FADN database was possible because of the absence of data in certain years in the period or question and because of the different methodology applied in the calculation of the relevant indicators.

The *ROA (Return on Assets)* is the main measure of a company's ability to use the assets input in the entrepreneurial activity. There may be various modifications of the profit that is entered as the numerator. If EBIT (Earnings before Interest and Taxes) is entered, it suppresses the impact of the financial structure and taxation and the focus is only on the operating activities of the farm.

Operating profit/loss according to the Czech methodology represents a reliable assessment of the company's operating performance and is an acceptable substitution for EBIT (Mrkvicka and Kolar, 2006).

The other (and probably the more suitable) option is to enter profit/loss before tax in the numerator. However, it was not known for most companies in the examined samples, for which reason the profit/loss after tax, i.e. the profit/loss for the accounting period – row 60 of the P&L statement – was used.

Therefore, both of these categories of profit/loss were used for the calculation of the ROA – i.e. EBIT for the calculation of ROA_1 and profit/loss for the accounting period for the calculation of ROA_2.

As the values contained in Table 4 show, the values of ROA_1 and ROA_2 were significantly higher in organic farming compared to those in conventional farming both in terms of the average value for legal entities in total

Ratios	sample	Cooperatives						Corporations						Legal entities total					
		2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
ROA_1 (%)	1	3.12	-7.54	0.46	11.08	6.76	5.01	8.45	9.32	5.82	5.86	5.46	3.70	7.97	7.72	5.26	6.33	5.58	3.82
	2	1.91	-3.50	1.57	5.02	4.19	4.04	2.69	3.55	2.72	4.90	6.90	3.62	2.26	-0.38	2.10	4.96	5.44	3.84
ROA_2 (%)	1	2.18	-7.51	0.52	10.00	5.86	4.25	5.96	7.75	4.86	5.11	4.28	3.06	5.61	6.20	4.41	5.55	4.43	3.17
	2	1.79	-3.05	1.50	4.32	3.70	3.42	2.13	3.31	2.87	3.98	5.68	2.71	1.94	-0.24	2.13	4.16	4.61	3.09
ROE (%)	1	3.90	-24.94	3.18	31.09	18.49	11.26	11.25	12.70	9.71	16.70	5.50	6.03	10.59	9.12	8.98	18.07	1.83	6.56
	2	3.13	-7.35	6.32	9.96	8.57	7.90	-5.56	7.63	8.46	14.83	23.20	12.08	-0.66	-0.75	7.27	12.08	15.20	9.79
Total liquidity (x)	1	4.52	2.56	3.35	1.86	2.42	1.88	3.31	3.87	2.87	2.68	4.26	4.20	3.42	3.75	2.92	2.60	4.09	3.97
	2	2.17	2.01	2.26	2.20	2.16	2.20	1.85	1.80	1.64	1.66	2.36	2.77	2.03	1.92	1.97	1.95	2.26	2.46
Gearing (%)	1	201.41	259.11	283.77	190.66	185.97	167.32	54.89	74.96	60.11	47.94	34.68	90.73	68.85	92.50	84.96	68.85	49.81	98.39
	2	115.04	108.06	95.78	85.48	87.71	91.51	108.30	107.15	98.11	113.77	93.61	103.38	112.18	107.67	96.79	62.96	90.36	96.80
Interest coverage (x)	1	6.54	-14.39	6.42	23.47	9.35	17.55	18.59	35.20	25.48	42.54	58.32	39.05	17.83	30.24	23.36	40.72	53.66	37.00
	2	4.90	-4.30	9.57	19.93	25.55	12.03	8.73	14.53	8.09	15.62	12.03	11.44	6.58	4.00	8.90	17.94	19.59	11.76
Net assets turnover (x)	1	0.81	0.75	0.84	0.95	0.94	0.77	1.76	1.39	4.52	1.27	2.96	1.35	1.48	1.32	4.02	1.06	2.59	1.10
	2	0.79	0.68	0.96	0.87	1.02	1.18	1.62	1.60	1.64	1.26	3.77	2.49	1.16	1.08	1.27	1.05	2.25	1.77

Source: authors, based on the Amadeus database (2016)

Table 4: Economic results II of farms (legal entities) operating in the region of South Bohemia in 2008 – 2013.

and for corporations and cooperatives. Even though these findings do not correspond to the results of profit per hectare, they confirm the higher efficiency of organic farmers, despite the higher level of risk involved. The reasons for this are apparent and have been commented on above.

ROE (Return on Equity) is another profitability indicator and a crucial criterion for owners in evaluating the success of the company. This indicator shows the net yield from the resources invested in the company. The numerator in the fraction uses profit/loss after tax. The values achieved in this case are not unambiguous, either, but they again tend to favour organic farming.

Total liquidity is another indicator and it is used to assess the liquidity of a company. It shows the ability of the company to use cover (using short-term financial assets, short-term receivables and inventory) its short-term debt (short-term payables, short-term loans and short-term borrowings). The corporations operating in organic farming reported clearly higher values; the values for cooperatives were also higher but not in all the years.

On the one hand, the higher values can be seen as a positive – the farm can meet its obligations. On the other hand, however, the resources involved in inventory or in receivables do not bring a profit to the company and thus reduce its returns. An individual approach must be taken to address this situation and a specific strategy must be adopted depending on the attitude of the farm's management to risk and depending on the required returns.

The *indicator of gearing - an indicator showing the level of indebtedness* - was selected for evaluating the level of coverage of the company's assets with external resources. This indicator was constructed as the ratio of external and internal sources of financing. As is the case of the values of equity per hectare of agricultural land, the values of indicators calculated for legal entities in total mostly show a higher share of the farm's own sources compared to external sources (mainly in the sample of organic farms). A more detailed view of the individual types of companies and of the individual samples shows rather large differences between the calculated values. While external capital prevails in organic farms operating as cooperatives and the farms' own capital prevails in organic farms operating as corporations, the situation is exactly the opposite in conventional farming.

A certain level of debt is healthy for the company as it increases the capital yield. On the other hand, a very high share of external sources may suggest lower financial stability and higher business risks.

No clear conclusions can be drawn because of the varying results. The specific values of the indicators would have to be examined to a greater detail (considering also the structure of external financing). While this could be done at the level of a single entity, it cannot be done to interpret the results for an entire sample of farms.

In this case, we have to do with only stating the value of the indicator. Higher values may be viewed as an opportunity to increase capital efficiency; lower values may be seen as the less

risky choice of strategy by those farms that prefer a lower financial risk.

The ability of the farms to cover the costs involved in using external sources of financing was assessed using the *Interest coverage* indicator. It was designed as the ratio of EBIT and interest expenses. The higher the indicator value the better. The generally accepted rule is that the value should be at least 3, ideally greater than 7. The table clearly shows the differences between the groups of organic farms in terms of the in the values achieved as corporations achieved significantly higher values of the indicator. In comparison with conventional farms, the values in organic farming were usually much better (even though the value for cooperatives in 2009 represents the so-called "uncovered debt"). The ideal value was exceeded or at least nearly met in organic farming in most of the reporting years.

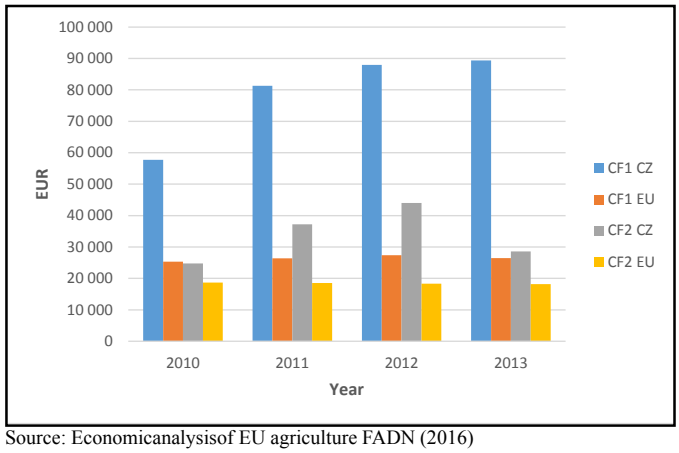
The *net assets turnover* (the ratio of revenue to the total assets) was the last indicator observed with a view to evaluating the efficiency of assets use. It is the indicator of entrepreneurial activity and of the efficiency of creating value out of fixed and current assets in the farm's production activities. While the availability of assets per hectare was significantly higher in conventional farming than in organic farming, the differences were not as striking between these two systems (organic versus conventional) in terms of the efficiency of the use of these assets. Significant disproportions were observed only between cooperatives and corporations. The higher values reported by corporations suggest a higher ratio of yield to the value of the assets, i.e. a higher efficiency in using the assets.

At the conclusion, the profit of farms in the Czech Republic compared with the average achieved in the EU.

The graph shows values significantly higher profit in the Czech Republic than the EU average. Among individual states, there are wide differences. Significantly higher than the national average achieved eg. in Luxembourg, the Netherlands and Belgium, while lower values eg. in Romania, Bulgaria or Poland.

Conclusion

The results provided above rather diverse outcomes. Nevertheless, they tend to show a more favourable situation of organic farms, which is consistent with the findings of the author's previous research conducted in this region (Brozova, 2011b). Note, however, that those are average results. As the samples may include entities whose results greatly deviate from this average, these findings need to be accepted with caution. Nevertheless, the authors still believe that these outputs may be considered sufficiently representative and they are convinced that organic farms significantly participate in meeting the requirements for environmentally friendly and sustainable farming. It is also necessary to take into consideration the vacuum of the data base (which is still insufficient despite certain improvements in recent years). For this reason, there is a persisting need for a high-quality data base including the basic economic characteristics in order to determine the economic profit of the entire organic farming sector in the Czech Republic.



Source: Economicanalysisof EU agriculture FADN (2016)

Graph I: Profit of farms in the Czech Republic and the EU (the average farm in EUR).

The solutions may include:

- extending the FADN CZ sample to include a representative sample of organic farms with the same structure as is applied in the general FADN database, i.e. to monitor selected profit/loss items, including detailed cost and revenue items and selected items of assets and liabilities (for agricultural cooperatives, corporations and legal entities in total) in accordance with the financial statements of the Czech Republic, broken down by region;
- extending the existing database of the IAEI Brno (which monitors nearly all the organic farms in the Czech Republic) to include a more detailed structure of cost and revenue items for the purposes of determining economic performance.

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Corresponding author:
Ing. Ivana Brožová, Ph.D.
Department of Economy, Faculty of Economics and Management,
Czech University of Life Sciences Prague, Kamýcká 129, Praha 6 – Suchdol, 16521, Czech Republic
Phone: +420 224 382 083, E-mail: brozovai@pef.czu.cz

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Do Sunspots Matter for Cycles in Agricultural Lending: a VEC Approach to Russian Wheat Market

D. Burakov

Department of Financial Markets & Banks, Financial University under the Government of Russian Federation

Abstract

In this article, we test a hypothesis about the influence of sunspot cycles on cycles of agricultural lending on example of wheat market. Analyzing data on Russian wheat market for period from 1990 to 2015 we test a hypothesis of solar activity's impact on cycles in agricultural lending in the short and long run. Using a vector error correction approach to the sample, we obtain the following results: in the long run, sunspots, wheat yield, world wheat prices, and non-performing loans (NPL) for wheat market are related. In the short run, level of non-performing wheat loans depends only on wheat yields. However, results of Granger causality test confirm that wheat yield dynamics and sunspots Granger cause non-performing bank loans in Russia, which confirms our hypothesis of solar activity importance for agricultural lending activity.

Keywords

Solar activity, wheat market, agricultural lending, crop yield, vector error correction, Granger causality test, credit cycle.

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Introduction

World agricultural market: current challenges

Contemporary global economic system is characterized by high turbulence and increased amplitude of cyclic fluctuations in many markets for goods and services. The formation of a new era of economic instability has led to necessity of revision of many, seemingly immutable, pillars of economic science. Empirical deviations from classical elegant models has brought the business community and public authorities in different countries to increase their emphasis in ensuring stability of economic development. No exception present market theories for goods and services and, in particular, agro-industrial sector. In the context of acute problem of food security in many countries of the world, in the context of declining budget surplus and the need for rationing funds to support a variety of industries due to increasing tensions in global economic infrastructure, in context of increased probability of tail risks (black swans) occurrence increasing, there is a strong need to modify risk management and methods of their estimation, not to mention forecasting tools.

In case of the agricultural sector, one of the main directions of development of scientific thought as a reaction to increased uncertainty, is a rising interest in strengthening the predictive and forecasting power of models that evaluate the potential damage and benefits from changes in cosmic and terrestrial climate patterns in order to determine the impact on the agricultural sector, particularly on crops yield, exploring areas of risk farming, influence of regional and seasonal deviations of climatic and physical sense (for example, geomagnetic fields) on the stability of yield of different crops. A thorough theoretical review of methods and models of crop yield forecasting is presented in paper by Basso et al. (2013)

Thus, it can be assumed that forecasting and risk assessment in the agricultural sector becomes one of main directions in conventional economic science.

It seems logical to assume that assessment of potential risks and forecasting deviations of agricultural sector has an applied character. Firstly, an ability to predict changes in exposure to physical and climatic factors of crop yields may contribute to optimization of public financial support to agricultural sectors on the one hand. In case of expected high crop – additional support.

In case of expected low yield – redistribution of financial resources to other sectors, or partial supporting for providing food security. In case of financial markets of developing countries, agricultural sector and its lending is seen by many banks as the most marginally profitable, and in some cases unprofitable directions. (Salin et al., 2007; Sadanandan, 2014) However, importance of agriculture leads to implementing tools in form of interest rate subsidies as well as restructuring of current debt burden. For example, in case of Russia, the share of non-performing bank loans (NPL) to agricultural sector accounts for over 20% of the total outstanding debt. For wheat market, the figure varies between 1990 and 2015 from 4.6% to 39.4%. Such deviations in dynamics of bad debts are a consequence of the credit risk realization, even given standard support of agricultural sector. (Bank of Russia Statistical Bulletin, 1990-2015).

The specifics of credit risk in agriculture usually refers to exogenous factors (temperature, deviation from average values of rainfall, climatic shocks, etc.), so in most cases, the process of assessing credit risk when issuing loans is conditional and heavily sponsored by government or lending to agricultural sector being concentrated in state "controlled" banks, which leads to growing financial losses and a rising need for continued support.

However, strengthening of risk management process by private banks and bodies of state financial support should be based on a solid evidence base. In particular, lenders must have confidence in tools and techniques to assess risks on the one hand, on the other – to have evidence of significance of factors included in models. Otherwise, borrowers may face credit rationing in form of underlending of agricultural sector.

In the Russian scientific field there are only a few studies (discussed below) on the impact of climate change on individual agricultural zones and regions. Moreover, no studies, arguing for inclusion of climatic and physical factors in bank models for assessing risks of agricultural lending aimed to ensure financial stability during cycles of agricultural lending is present.

In other words, the main objective of this paper is to empirically test a hypothesis, stating that there exists a causal relationship between solar cycles and cycles in agricultural lending on example of Russian wheat market, thereby stressing importance of accounting climatic factors when forecasting yield and evaluating associated credit risk.

In this regard, we refer to an overview of main studies on the issue of relationship between natural factors, dynamics of economic variables, and in particular, crop yields.

Literature review

The question of relationship between solar activity, climate change and dynamics of economic variables has attracted attention of researchers many centuries ago, yet still being actual.

The first theories of economic cycles were associated with exogenous events or exogenous shocks. For example, one of the now-canonized works in this field is the study of Herschel (1801), which revealed the presence of a correlation between sunspots, as a manifestation of solar activity and wheat prices for the period from 1779 to 1818. He identified a 22-year cycle of solar activity, which based his hypothesis: solar activity significantly influenced the price of wheat.

The next step in developing Herschel's hypothesis was sunspot cycles hypothesis of W. S. Jevons (1879), which identified 11-year solar cycles and based on Herschel's hypothesis allocated a transmission mechanism of solar activity. The omission by Herschel of 11-year cycles is because the observations came during the Dalton Minimum – a period of low solar activity. In case of Jevons' observations, the essence of the hypothesis was reduced to transmission of sunspots effect: the initial shock in low (high) solar activity leads to a decrease (growth) of crop yields and a decline (increase) of yield (secondary shock) leads to reduction (expansion) of business activity in the economy. Around the same time, a colleague of Jevons – John Mills (1875) puts forward the first theory of the Credit cycle, also stemming from Jevons hypothesis. Unlike Jevons, Mills at the heart of economic fluctuations has placed not so much a change in the rate of return on the markets, but rather expectations of its changes, creating one of the first behavioral theories of business cycles.

Before continuing to review the evolution of this approach up to the present day (conventionally it can be called Herschel-Jevons approach), it is necessary to note one important fact. We in any case, like all researchers studying the impact of natural processes on economic activity, do not claim that dynamics of natural phenomena and them only are sufficient and enough to explain changes in economic processes. At the same time, denying presence and importance of certain natural processes

in economic dynamics seems to us inappropriate in connection with the presence of significant argumentation base.

The development of Herschel-Jevons approach in the twentieth century was varying. In other words, stemming from simple relationship between solar activity and economic process, several main directions of development exist to this day.

The first area of research is maintaining a classic narrow nature of the hypotheses of Herschel and Jevons, and is mainly aimed at finding the relationship (transmission) between solar activity, climate change and the functioning of agriculture, environment across countries and regions. In this area there are two blocks.

The first block of studies is devoted to the direct transmission of solar activity in the form of sunspots, solar radiation on crop yields. Most of research in this area is based on the study of influence of amplitude and duration of solar activity on vegetation processes of plants and crops. One of the brilliant research conducted by Harrison (1976) showed that there is significant positive correlation between solar activity and the yield of different crops in the United States. To similar conclusions come researchers who conducted similar studies in Canada, UK, India, Europe and Africa for various time periods, sometimes exceeding hundreds of years (a short description of the results is presented in Table 1). One of the important research studies that adds to significance of this hypothesis is a paper of Pustil'nik and Yom Din (2004, 2013), which is based on the analysis of agricultural markets in countries of Europe and their relationship with cycles of solar activity, between which there also was discovered a significant connection.

The second line of studies is devoted to the question of indirect solar activity's influence on the yield of agricultural crops. The basis of the transmission includes effects of solar activity on the Earth's geomagnetic field, climate changes, degree of cloudiness, deviations in rainfall, which also has a significant potential impact on crop yields. One of the most significant works in this area is the study by Marsh and Svensmark (2000), which, being based on the analysis of worldwide data, presents a map of dependence of level of cloud cover the earth and temperature from solar radiation (cosmic rays). The detection of the correlation was an important step for the development of scientific research in the field of the relationship between solar activity and climate. For example, Hiremath (2006) proved the existence of a connection between solar cycles and deviations in rainfall. To similar conclusions about dependence of the global temperature changes from solar radiation comes and Gupta (2015).

It is important to note that at the global level in some cases and countries, the dependence is statistically insignificant as in case of relationship between solar radiation and crop yields, so in case of dependence of cloud cover from cosmic ray radiation. This fact is reflected in several papers (e.g. Dewey (1968), Marsh and Svensmark (2000), Lockwood (2012), Love (2013), Pustil'nik and Yom Din (2013), Savin and Leo (2016)). The explanation for this peculiarity is due to physical processes. So, for example, Pustil'nik and Yom Din (2013) studying dependence of agricultural crops' yield from changes in solar activity, recommend to take into account sensitivity of local weather (cloud cover, atmospheric circulation) and atmospheric and climate anomalies in the areas of agriculture. However, most of papers confirm the presence of indirect impact of solar activity on crop yields.

The second direction (mainly in behavioral and experimental economics) in contrast to the first, aims to explore direct and indirect linkages between solar cycles and their derivatives (climate change, weather conditions, magnetic fields) on behavior of economic agents and macroeconomic variables. Because for us this direction is not of a substantial nature, we confine ourselves to a brief review of main papers in this field.

As can be seen from a summary presented in Table 1, many authors come to conclusion that there is a statistically significant and positive relationship between solar activity and dynamics of social and macroeconomic variables – employment, mortality rates, output rates, trading, etc. However, it is important to note that the influence of natural factors should be regarded as the accelerator – a factor, influencing economic activity, rather than the source.

Concluding, it can be noted that provided review of research on relationship between solar activity (sunspot cycles) and economic processes, allows to assume that between them there is a certain relationship on the one hand. On the other hand, we assume that sunspots have the potential to impact (both direct and indirect) the yield of agricultural crops. The latter, in turn, should influence cycles of agricultural lending (in our sample - the wheat market).

Unfortunately, in contemporary literature a question

Author	Sample	Method	Sunspots-Socio-Economic Fluctuations
Walsh (1993)	Earth's geomagnetic field-business cycles (1870-1960)/USA	Time series, correlation analysis	Significant, positive, partial correlation
Saunders (1993)	Stock Prices Fluctuations-Local Weather (New York)	Correlation, regression analysis	Significant, positive
Hirshleifer and Shumway (2003)	Sunshine index – Stock returns/ USA	Correlation, regression analysis	Significant, positive. Rain(snow) falls – insignificant. Support for solar activity hypothesis
Kamstra et al. (2003)	Stock returns-Amount of daylight/Worldwide	Regression analysis (VAR model)	Seasonal affective disorder (winter depression) effect confirmed. Support for solar effect on sentiment
Otsu et al. (2006)	Sunspots-Unemployment/ Mortality (1971-2001)/Japan	Correlation, regression analysis	Significant, positive for males, negative for females
Gorbanev (2012)	Sunspot Cycles-Recessions/ Unemployment (Worldwide)	Time series, correlation analysis	Significant, positive
Novvy-Marx (2014)	Solar, Climate Fluctuations – Market Anomalies/USA	Regression analysis (Panel VAR model)	Significant, positive
Author	**Sample**	**Method**	**Solar Activity/Climate Change-Crop Yield**
Herschel (1801)	Sunspot-Wheat Price/England	Time series analysis	Positive
Jevons (1879)	Sunspots-Crop Prices (Corn)/ England	Time series analysis	Positive
Dewey (1968)	Double sunspot cycle (22y) – Cycles in financial, manufacturing, agricultural sectors/USA	Time series, correlation analysis	Ambiguous, partial correlation revealed
Monteith (1972)	Solar radiation -crop vegetation/ Kenya, Congo, Nigeria	Predictive regression model	Significant, positive
Harrison (1976)	Sunspot Cycles/Crop Yields/USA (1866-1873)	Regression analysis	Significant, positive: high sunspot numbers lead to high crop yield
Marsh and Svensmark (2000)	Solar activity (cosmic rays) – Global cloud cover/Worldwide	Correlation analysis	Significant correlation: high solar activity leading to low cloud cover and high top temperature in low clouds, vice versa
Pustil'nik and Yom Din (2004)	Wheat Prices-Solar Cycles/ Medieval England (1249-1703)	Correlation, regression analysis	Significant, positive
Hiremath and Mandi (2004)	Solar Activity-Indian Monsoon Rainfall Occurrence (1871-2000)	Correlation analysis	Significant positive correlation
Garnett et al. (2006)	Sunspot Activity-Crop Yield/ Canada (1950-2004)	Correlation analysis	Significant, positive: high sunspot numbers leading to low summerfall, fall in crops yield
Hiremath (2006)	Solar Activity-Rainfall Occurrence (1871-2000)/India	Correlation analysis	Significant, positive: high(low) sunspot numbers lead to low (high) rainfall occurrence
Lockwood (2012)	Solar activity-Climate change (temperature)/Eurasia	Regression analysis	Significant, positive in case of seasonal analysis
Pustil'nik and Yom Din (2013)	Solar Activity-Prices for agricultural commodities/ European agricultural markets (1650-1715)	Correlation, regression analysis	Depends on sensitivity of local weather; sensitivity of crops to weather anomalies; degree of market's isolation
Love (2013)	Sunspots-Wheat Prices (1868-2012)	Regression analysis	Statistically insignificant. Sunspot numbers fail to predict future wheat prices in retrospective

Source: author's compilation

Table 1: Summary of relevant literature.

Author	Sample	Method	Solar Activity/Climate Change-Crop Yield
Huhtamaa et al. (2015)	Temperature fluctuations-Crop yield (rye, barley)/Finland (1861-1913)	Correlation, regression analysis	Significant, positive
Gupta et al. (2015)	Sunspot Numbers-Global temperature (1880-2013)	Granger causality test, frequency domain test	Sunspots cause global temperature fluctuations (frequency domain test)
Savin and Leo (2016)	Wheat Yield-Solar caused fluctuations in Earth's magnetic field /Worldwide	Correlation analysis	Significant, positive and negative for sample, depends on meteorological conditions

Source: author's compilation

Table 1: Summary of relevant literature (continuation).

of relation between solar activity and cycles of agricultural lending as a manifestation of economic fluctuations has not been studied thoroughly. Thus, our study, devoted to search for causality between cycles in agricultural lending and solar cycles, is designed to provide scientific argumentation base for developing and strengthening methods of credit risk assessment and allocation of public funding in an optimizing manner.

The scientific novelty of this study then is to find a relationship between dynamics of NPL for wheat production in Russia and sunspot cycles in the short and long run.

Materials and methods

Research methods

To test the hypothesis about relationship between sunspots, wheat yield, world wheat prices and cycles in agricultural lending, we use econometric techniques to analyze time series. The algorithm of the ongoing study is determined by several key stages. First and foremost, one should test sampled variables on stationarity or order of cointegration, since the time series must have the same order, as can be seen from equation (1). Secondly, it is necessary to determine presence/absence of correlation in long term between the variables in the equation. To check this assumption we use a Johansen cointegration test. If condition of stationarity of sampled time series in the first order I(1) is met, it is possible to use VEC model. In case of confirmation of presence of cointegration between the variables of the sample, residuals of the equilibrium regression can be used to estimate error correction model. Also based on VEC model it is possible to identify short-term causality between sampled variables. For this purpose, we use the Wald test. To determine predictive power of variables we use Granger Causality Test – for testing predictive causality of explanatory variables. The final stage of constructing a model is to conduct diagnostic tests to determine validity of the model. These include testing for heteroscedasticity, serial correlation, normality and stability of the model.

Unit Root Test

For the analysis of long-term relationships between the variables, Johansen and Juselieus (1990) admit that this form of testing is only possible after fulfilling the requirements of stationarity of the time series. In other words, if two series are co-integrated in order d (i.e. I (d)) then each series has to be differenced d times to restore stationarity. For d=0, each series would be stationary in levels, while for d=1, first differencing is needed to obtain stationarity. A stochastic process (a collection of random variables ordered in time) is said to be stationary if its mean and variance are constant over time, i.e. time invariant (along with its autocovariance). By contrast, a nonstationary time series have a time-varying mean or a time-varying variance or both. It is important to cover non-stationary variables into stationary process. Otherwise, they do not drift toward a long-term equilibrium. There are two approaches to test the stationarity: Augmented Dickey and Fuller (ADF) test (1979) and the Phillips-Perron (P-P) test (1988). Here, test is referred to as unit-root tests as they test for the presence of unit roots in the series. The use of these tests allows to eliminate serial correlation between the variables by adding the lagged changes in the residuals of regression. The equation for ADF test is presented below:

$$\Delta Y_t = \beta_1 + \beta_2 t + aY_{t-1} + \delta_3 \sum \Delta Y_{t-1} + \varepsilon_t \quad (1)$$

where ε_t is an error term, β_1 is a drift term and $\beta_2 t$ is the time trend and Δ is the differencing operator. In ADF test, it tests whether a = 0, therefore the null

and alternative hypothesis of unit root tests can be written as follows:

H0: a = 0 (Yt is non-stationary or there is a unit root).

H1: a < 0 (Yt is stationary or there is no unit root).

The null hypothesis can be rejected if the calculated t value (ADF statistics) lies to the left of the relevant critical value. The alternate hypothesis is that a < 0. This means that the variable to be estimated is stationary. Conversely, we cannot reject the null hypothesis if null hypothesis is that a = 0, and this means that the variables are non-stationary time series and have unit roots in level. However, normally after taking first differences, the variable will be stationary (Johansen and Juselius, 1990). On the other hand, the specification of P-P test is the same as ADF test, except that the P-P test uses nonparametric statistical method to take care of the serial correlation in the error terms without adding lagged differences (Gujarati, 2003). In this research, we use both ADF and P-P test to examine the stationary of the sampled time series.

Johansen co-integration test

To test for presence of cointegration we apply the Johansen test using non-stationary time series (values in levels). If between variables does exist a cointegration, the first-best solution would be using VECM model. An optimal number of lags according to Akaike information criterion for providing Johansen test is determined in VAR space. To conduct Johansen test, we estimate a VAR model of the following type:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \epsilon_t \quad (2)$$

in which each component of y_t is non-reposeful series and it is integrated of order 1. x_t is a fixed exogenous vector, indicating the constant term, trend term and other certain terms. ϵ_t is a disturbance vector of k dimension.

We can rewrite this model as:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} V_i \Delta y_{t-1} + Bx_t + \epsilon_t \quad (3)$$

Where

$$\prod = \sum_{i=1}^{p} A_i - I, \quad \mathrm{V}_i = -\sum_{j=i+1}^{p} A_j \quad (4)$$

if the coefficient matrix $\prod$ has reduced rank r < k, then there exist k x r matrices α and β each with rank r such that $\prod = \alpha\beta'$ and $\beta' y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the VEC model. Johansen's method is to estimate $\prod$ matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of $\prod$ (Johansen, 1991).

Vector error correction model

Granger (1988) suggested the application of Vector Error Correction methodology (VECM) in case if the variables are cointegrated in order to find short-run causal relationships. VECM, therefore, enables to discriminate between long-run equilibrium and short-run dynamics. In this sense, we employ following VECMs to estimate causal linkages among the variables:

$$\Delta ln\, l = a_0 + \sum_{i=1}^{k} a_1 \Delta\, lnl_{t-i} + \sum_{i=1}^{n} a_2 \Delta\, lns_{t-i} + \sum_{i=1}^{m} a_3 \Delta lny_{t-i} + \sum_{i=1}^{o} a_4 \Delta lnw_{t-i} + \lambda ECT_{t-1} + v_1$$

$$\Delta ln\, s = \beta_0 + \sum_{i=1}^{k} \beta_1 \Delta\, lns_{t-i} + \sum_{i=1}^{n} \beta_2 \Delta\, lnl_{t-i} + \sum_{i=1}^{m} \beta_3 \Delta lny_{t-i} + \sum_{i=1}^{o} \beta_4 \Delta lnw_{t-i} + \phi ECT_{t-1} + v_2$$

$$\Delta ln\, y = \eta_0 + \sum_{i=1}^{k} \eta_1 \Delta\, lny_{t-i} + \sum_{i=1}^{n} \eta_2 \Delta\, lnl_{t-i} + \sum_{i=1}^{m} \eta_3 \Delta lns_{t-i} + \sum_{i=1}^{o} \eta_4 \Delta lnw_{t-i} + \chi ECT_{t-1} + v_3$$

$$\Delta lnw = \theta_0 + \sum_{i=1}^{k} \theta_1 \Delta\, lnw_{t-i} + \sum_{i=1}^{n} \theta_2 \Delta\, lnl_{t-i} + \sum_{i=1}^{m} \theta_3 \Delta lns_{t-i} + \sum_{i=1}^{o} \theta_4 \Delta lny_{t-i} + \varphi ECT_{t-1} + v_4$$

where l *i*s non-performing loans for wheat production, s Wolf numbers for solar activity (sunspots), y wheat yield and w world wheat prices (Granger, 1988).

Providing regression analysis of the sampled variables by modeling VECM allows us to determine the existence of substantial and statistically significant dependence not only on the values of other variables in the sample, but also dependence on previous values of the variable.

However, VEC model must meet the requirements of serial correlation's absence, homoscedasticity of the residuals and to meet the requirement of stability and normality. Only in this case the results can be considered valid.

Granger causality test

The last stage to determine the relationship and its direction is the use of Granger causality test. So, rejection of the null hypothesis of Granger test (H0), according to which:

$$b_1 = b_2 = ... = b_p = 0, \quad (5)$$

in favor of the alternative hypothesis (H1) suggests that changes in sunspots or wheat yield or world wheat prices Granger cause changes in NPL share of loans for wheat production. (Granger, 1969)

Materials and data processing

We test a hypothesis of causality between sunspots and cycles of agricultural lending on example of Russian data for the period 1990 to 2015. The base period is one year. Unfortunately, use of quarterly or monthly values of variables for the analysis is hindered due to availability of only annual data on wheat yields and NPL granted for wheat production. Using VECM, we set ourselves a task to determine sensitivity of dynamics of NPL for wheat production to changes in solar activity, wheat yield and dynamics of world prices for wheat.

Data on wheat yield in Russia and NPL is obtained from the statistical database of Federal State Statistics Service of Russia (FSSR) (www.gks.ru) and statistical database of the Bank of Russia (BR) (www.cbr.ru). Data for world prices of wheat is obtained from the statistical database of Food and Agriculture Organization of the United Nations (FAOSTAT). Data for cycles of sunspots – the average values of the Wolf numbers is obtained from the statistical database of the Far Eastern Department for Hydrometeorology and Environmental Monitoring of Russia (FEDHEMR) (www.khabmeteo.ru).

To conduct time-series analysis, all variables were transformed into logarithms. To identify and formally assess the relationship between variables, we use simple correlation analysis. To study sensitivity and causal linkages between the variables in the sample in short-and long-run, we turn to regression analysis, which involves the construction of VEC model of certain type based on stationary time series, testing the model for heteroscedasticity of the residuals, autocorrelation as well as stability and normality. Based on the model, we study predictive causality between variables by applying Granger causality test in VEC domain.

Results and discussion

Table 2 presents the results of correlation analysis between the variables that make up the sample for testing our hypothesis. As can be seen from data presented in this Table, solar activity, expressed through Wolf numbers, has a moderate strength correlation with changes in NPL and wheat yield.

For example, correlation between Wolf numbers and NPL is negative – decline in solar activity leads to an increase of NPL on the background of positive correlation between Wolf numbers and wheat yield (coefficient is 0.54) – an increase in solar activity enhances vegetative processes in crops. The same is true for the relationship between wheat yield and NPL. An increase in productivity leads to a reduction in NPL and vice versa.

This table is notable for two features. First, the correlation analysis does not reflect a significant relationship between Wolf numbers and world wheat prices (the coefficient is only 0.25). The relation is reverse: an increase in solar activity leads to a reduction in world prices due to higher global wheat supply. Second, values of correlation coefficients are far from 1, as well as p-value being more than 5% significance level. This observation is explained quite logically, if we turn to assumptions put forward by Pustil'nik and Yom Din (2013) on effects of Earth's climate and atmospheric

Variable	Non-performing loans	Sunspots (Wolf numbers)	World wheat prices	Wheat yield
Non-performing loans	1			
Sunspots (Wolf numbers)	-0,461511 **[0.0101]**	1		
World wheat prices	0.009509 [0.4820]	-0.25582 [0.1085]	1	
Wheat yield	-0.51731 **[0.0040]**	0.54570 **[0.0023]**	0.43840 **[0.0141]**	1

Note: p-values are presented in brackets; statistically significant p-values – in bold; significance level – 0.05
Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 2: Correlation matrix.

processes to the direct cosmic radiation (solar radiation). Considering these assumptions the lack of a direct linear relationship is quite understandable.

However, the results of correlation analysis cannot be considered exhaustive and reliable due to possible problems of serial correlation, for example. Moreover, since the way of stochastic is different at each time point of the non-stationary series, general stochastic of the series is hard to capture. There is also the probability of obtaining spurious regression.

Building a regression model in our case deals with time series that often exhibit a seasonal pattern (solar activity, crop yields etc.). According to results of Maddala and Kim (1998), in finite samples standard ADF and PP statistics for testing unit root will be biased towards nonrejection of the unit root null if filtered (seasonally adjusted) data are used. In other words, since seasonal adjustment introduces a "non-revertible" moving average (MA) component into time series data, unit root tests will be biased towards non-rejection of the unit root null hypothesis (Maddala & Kim, 1998). Keeping this in mind, we use unadjusted annual values, given that seasonal adjustment could create turning points being randomness in data.

To resolve the problem with the nonstationarity of time series, it is necessary to test for the presence of unit root. The results of ADF and Phillipes-Perron tests are presented in Table 3.

As can be seen from the test results of variables for the presence of unit root in their differentiation to the first order, we can reject the null hypothesis of unit root in each of the variables. Thus, the condition of stationarity at I(1) is performed, which gives us reason to test variables for cointegration. However, it is necessary to determine the optimal time lag. In our case, the Akaike information criterion equals 2 (Table 4).

At first glance, the choice of the time lag value in two years seems inconsistent with empirical observations. However, given the fact that the process of granting a loan and determining its quality is associated with the cycle of production and harvesting of wheat, which requires at least 1 year on the one hand, and on the other, given the non-linear and cumulative nature of relationship between solar activity and its influence on terrestrial processes, it can be assumed that the maximum effect of cumulative amplification (attenuation) of solar activity is achieved in two years in case of our sample. This result is also indirectly supported by results of Marsh and Svensmark (2000), which developed a map of correlations between cosmic rays' penetration of Earth and cloud cover. For Russia's territories (Far East, Volga region, Stavropol Krai), providing most of wheat yield, correlation index is around 0.35 - 0.45, that can be interpreted as low penetration of solar radiation. So, process of radiation accumulation can be counted

	ADF		PP	
	Statistic	Prob.**	Statistic	Prob.**
Levels				
Intercept	10.2460	0.8394	8.7126	0.9422
Intercept and trend	8.1475	0.4164	5.4422	0.4268
First-difference				
Intercept	45.08	0.0000**	43.01	0.0000**
Intercept and trend	31.73	0.0001**	29.52	0.0003**

Note: ** denotes statistical significance at the 5% level of significance
Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 3: Results of individual unit root test.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-342.0658	NA	39330063	28.83881	29.03516	28.89090
1	-294.2712	18.35107	12297662	27.52260	28.39438*	27.99141
2	-308.9520	52.43009*	9683387*	27.41267*	29.28968	27.67312*

Note: * indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion
Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 4: Optimal lag length selection.

as a factor of a more prolonged effect, excluding sharp or abnormal climate changes (e.g. extremely low wheat yield due to temperature spike in 2010, resulting in low rainfalls). Interestingly, Schwarz criterion captures these anomalies, serving as an argument for choosing 1 year as an optimal lag. However, we choose the lag, according to AIC and FPE.

Once we have determined that all variables are stationary at first difference we can present Johansen cointegration test for determining the appropriate type of regression model to use in the study. For Johansen test, we use non-stationary data to check for presence of relationship between sampled variables (Table 5).

Johansen test results show presence of cointegration between a number of equations, which allows presuming the existence of a long-term relationship between them. Trace Statistics for null hypothesis of no cointegrating equations between variables being larger than the critical value, and p-value being less than significance level of 5% give us right to reject the null hypothesis. In other words, we can assume existence of long run causality between variables.

Starting from the results of the cointegration test, we can proceed to the construction of VEC model to reveal presence or absence of long-term and short-term relations between variables.

The model shows the relationship between NPL and explanatory variables (sunspots, wheat yield, and world wheat prices). The results of the model estimation, showing the relationship between above-mentioned variables are presented in Table 6. Dependent variable is dynamics of non-performing bank loans for agricultural sector. Explanatory variables include sunspots, world wheat prices and wheat yield in Russia. To test for causality in the long term running from explanatory variables to dependent variable error correction term C1 must be negative in sign and statistically significant to reject the null hypothesis on no long run causality.

As can be seen from the Table, the value of error correction term C(1) is negative in sign and statistically significant. This suggests the existence of long-run causality between the variables of the sample. In other words, we can assume that NPL, sunspot cycles, wheat yield and world wheat prices have similar trends of movement in the long run on the one hand. On the other hand, we can assume that sunspots, world wheat prices and wheat yield in Russia cause changes in the share of the NPL in the long-run.

This result confirms the existence of a relationship between long-term trends of agricultural (wheat)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
None*	0.861247	84.24884	47.85613	0.0000*
At most 1	0.499327	21.82239	29.79707	0.1035
At most 2	0.363965	11.18259	15.49471	0.2005
At most 3	0.033137	0.775061	3.841466	0.3787

Note: * denotes statistical significance at the 5% level of significance

Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 5: Results of Johansen co-integration test.

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.378891	0.096698	-3.918314	0.0018*
C(2)	0.003590	0.196963	0.018227	0.9857
C(3)	0.252026	0.197597	1.275452	0.2245
C(4)	-0.000981	0.008204	-0.119617	0.9066
C(5)	0.007553	0.008436	0.895265	0.3869
C(6)	-0.299510	0.092789	-3.227858	0.0066
C(7)	-0.246822	0.105264	-2.344797	0.0356
C(8)	-0.011227	0.007174	-1.564968	0.1416
C(9)	-0.004032	0.007287	-0.553355	0.5894
C(10)	-0.020823	0.203715	-0.102218	0.9201

Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 6: Results of VECM estimation.

lending cycles and sunspot cycles. The error correction term C(1) is a long run equilibrium coefficient. The C (1) shows speed of long run adjustment. In other words, this coefficient shows how fast the system of interrelated variables would be restored back to equilibrium in the long run or the disequilibrium would be corrected. Given statistical significance at 5% level (p-value being less than 5%) and negative meaning, the system of variables corrects its previous period disequilibrium at a speed of 37,88% in two years (given optimal lag meaning of two years for ECM). It implies that the model identifies the sizeable speed of adjustment by 37,88% of disequilibrium correction in 2 years for reaching long run equilibrium steady state position.

The result of long-run causality between solar cycles, crop yield and wheat price is in line with existing studies on this issue (e.g. Monteith,1972; Garnett et al., 2006; Pustil'nik and Yom Din, 2013). However, the causal linkage with bad bank debts dynamics can be viewed as a new founding in our case.

On the other hand, of interest is the question about short-term sensitivity of agricultural lending cycles to changes in solar activity. In case of short-term crop yield' dependence on sunspots directly or indirectly, one can argue about importance and need to consider cosmic and climate changes when building models for crops yield forecasting and, consequently, assessing credit risk and evaluating amounts of financial support to agriculture. The rest of error correction terms represent the base for determining short-run causality coming from solar cycles (C4, C5), wheat yield (C6, C7) and world wheat prices (C8, C9).

To identify short-term causality between the variables we refer to the Wald test results. This test allows determining the interrelationship between variables in the short term. In other words, under the null hypothesis of this test, the response of error correction term to explanatory variables equals zero, i.e. sensitivity of resulting variable to changes (shocks) in explaining is not observed. Results of Wald Test for the model are presented in Table 7.

Based on the results of Wald Test one can detect significant short run causality coming from wheat yield to NPL with rate of adjustment towards equilibrium of 24,68% in t-2 and almost 30% in t-1. As can be seen from the results of the Wald test in the short run cycles of agricultural lending are sensitive to changes in wheat yields, that is the logical manifestation of the relationship between operating and financial production cycles. A decrease in yield leads to emergence of NPL and vice versa. In the short run, sensitivity of NPL to dynamics of sunspots has not been found, which suggests a more long-term and possibly indirect effect of solar radiation on the cycles of agricultural lending. However, one should be aware that the level of NPL cannot directly be determined only by bursts of solar activity. As we noted in the previous section, many factors explain the lack of short-term sensitivity. These include climatic and natural factors. The lack of short-term relationship between NPL and the world prices for wheat is due to the exporting status of Russia on the one hand, and on the other, the fact that most of the wheat is consumed on the domestic market, leading to insignificance of this factor in the short term. (AEGIC,2016)

In order to determine predictive causal relationships between variables in an attempt to detect significance of solar activity for wheat yield and, consequently, on dynamics of NPL in the market for wheat,

Test Statistic	Value	df	Probability
Null Hypothesis: C(4) = C(5) = 0 (Sunspots)			
F-statistic	0.4295	(2, 13)	0.6597
Chi-square	0.8590	2	0.6508
Null Hypothesis: C(6) = C(7) = 0 (Wheat Yield)			
F-statistic	6.6216	(2, 13)	0.0104*
Chi-square	13.2432	2	0.0013*
Null Hypothesis: C(8) = C(9) = 0 (World Wheat Prices)			
F-statistic	1.4604	(2, 13)	0.2678
Chi-square	2.9208	2	0.2678

Note: * denotes statistical significance and rejection of Ho: no short-run relationship
Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 7. Wald test results for short run relationship

we present results of the Granger causality test (Table 8).

As can be seen from Table 8, solar cycles and changes in wheat yield do Granger cause changes in NPL, given p-values being less than the significance level of 5%, so we can reject the null.

Given these results we can assume that solar activity, represented in Wolf numbers as well as wheat yield are useful in forecasting dynamics of non-performing banks loans for agricultural market in part of market for wheat. According to Granger, causality in economics can be tested by measuring ability or potential of predicting future values of time series by using prior values of another time series. That is Granger causality test presents predictive causality. In our case, results show that wheat yield and solar cycles can be used to predict future values of NPL and wheat yield.

Since we have already detected presence of long run causality between the variables by estimation of error correction model, identified short term causality running from wheat yield to NPL, results of Granger test give additional support to our hypothesis that sunspots actually do matter for cycles in agricultural lending by testing for predictive causality. In other words, solar cycles data can be used to forecast wheat yield, which determines in short run dynamics of non-performing loans for wheat market.

The final stage of the analysis of the constructed model is checking its quality. To do this, we refer to the series of diagnostic tests to validate the model on the absence of serial correlation, partial autocorrelation in the residuals, presence of homoscedasticity, normality and stability. The test results are presented in Table 9 and Figures 1-3.

Dependent variable: Non-performing agricultural loans (wheat production)	Chi-sq	df	Probability (P-value)
Sunspots	0.859071	2	0.6508
Wheat Yield	13.24328	2	0.0013*
World wheat prices	2.920888	2	0.2321
All	18.75226	6	0.0046
Dependent variable: Wheat Yield	Chi-sq	df	Prob.
NPL	3.425512	2	0.1804
Sunspots	7.265984	2	0.0264*
World wheat prices	0.480445	2	0.7865

Note: * denotes rejection of null hypothesis of no Granger causality
Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 8: Results of Granger causality test.

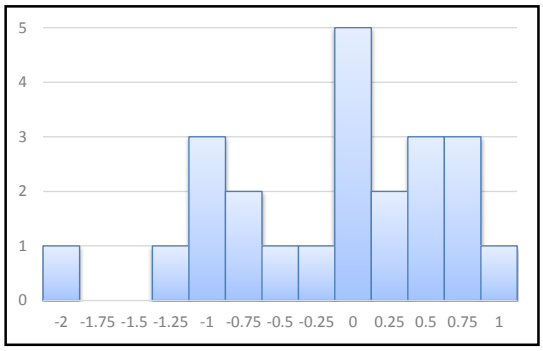
Auto, Partial auto correlation test results				
Lag number	AC	PAC	Q-Stat	Prob**
1	-0.239	-0.239	1,50	0.221**
2	0.030	-0.029	1,52	0.467**
Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	1.123842	Prob. F(2,11)	0.3597**	
Obs*R-squared	3.902321	Prob. Chi-Square(2)	0.1421**	
Heteroskedasticity Test: Breusch-Pagan-Godfrey				
F-statistic	0.244052	Prob. F(12,10)	0.9879*	
Obs*R-squared	5.210014	Prob. Chi-Square(12)	0.9506*	
Scaled explained SS	1.354953	Prob. Chi-Square(12)	0.9999*	
Heteroskedasticity Test: ARCH				
F-statistic	0.003995	Prob. F(1,20)	0.9502*	
Obs*R-squared	0.004394	Prob. Chi-Square(1)	0.9472*	

Note: **denotes acceptance of null hypothesis (Ho: there is no auto/partial, serial correlation).
* denotes acceptance of null hypothesis of homoscedasticity.
Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 9: Results of diagnostic testing.

As can be seen from Table 9, the model meets the criteria of homoscedasticity of residuals and absence of serial correlation. As can be seen from Figure 1 and Table 10, the requirement of normality is also met. Testing the model for stability by means of CUSUM and CUSUM of Squares tests also confirms its stability.

These results allow us to assume that the results obtained are valid and of undistorted nature.



Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Figure 1: Results of normality test (1).

Mean	3.26e-17
Median	0.138762
Maximum	1.093412
Minimum	-1,766345
Std. Dev.	0.730946
Skewness	-0,583602
Kurtosis	2.628112
Jarque-Bera	1.438136
Probability	0.487206

Source: FAOSTAT, FEDHEMR, FSSR and Bank of Russia; author's calculation

Table 10: Results of normality test (2).

Conclusion

This study focuses on finding the relationship between sunspot cycles and cycles in agricultural lending in the context of wheat market on example of Russia. According to our hypothesis, a relationship between solar cycles, wheat yield, non-performing bank loans and wheat prices should exist in long and short run.

The main objective of this study was to find arguments to justify the need to consider climatic factors in lending practice of commercial banks. In case of incorrect assessment of potential yields, the result may be a suboptimal amount of funding or the size of loans, which will lead the loss of solvency (creditworthiness) of the borrower-farmer or even to default.

The results of the study show that for the long run causality between NPL, solar cycles, wheat yield and wheat prices does exist. Particularly, according to results of ECM estimation, the speed of adjustment towards equilibrium between sampled variables is 37,88% with two years lag. In the short-run, we've detected causality between bad debts' dynamics and wheat yield, stating that the rate of adjustment towards equilibrium between NPL and wheat yield is 24,68% in t-2 and almost 30% in t-1 periods. Also, the analysis of predictive causality, using Granger causality test, shows that wheat yield and solar cycles do Granger cause NPL. In this sense, we receive additional confirmation of solar cycles and wheat yield being tools for predicting crop yield.

However, the part of the hypothesis stating that there exist a short-run causality between world wheat prices and NPL has gained no support in case of Russian wheat market. We assume that this result is largely due to exporting status of Russia on this market.

In any case, the obtained results give a certain theoretical background for improving lending practices for Russian commercial banks when dealing with agricultural sector, especially wheat market.

Corresponding author:
Dr. Dmitry Burakov
Department of Financial Markets & Banking,
Financial University under the Government of Russian Federation
Leningradsky prospect 49, 125993 Moscow, Russia,
E-mail: dbur89@yandex.ru
ORCID: 0000-0003-3019-5200.

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The Change of Comparative Advantage of Agricultural Activities in East Java Within the Context of Asean Economic Integration

M. A. Esquivias

Faculty of Economics and Business, Universitas Airlangga, Surabaya, Indonesia

Abstract

This paper analyses changes on agricultural trade patterns of East Java, Indonesia, versus six main ASEAN exporter countries. Based on the trade flow information, there are some dynamics of comparative advantage and export specialization from 2007 to 2013 in the 545 commodities comprising the agricultural sector. Products are mapped into four-different quadrants according to their level of comparative advantage and export specialization. Advantage-specialization appears to be important features of agro-trade for ASEAN countries because most of the growth in exports is under those competitive commodities. Little diversification towards new products has been found in the recent years. Gains appear to be larger than the losses due to international openness, while opportunities within the region have not been exploited. Agro-trade in the region still focuses towards extra-ASEAN and enjoys high levels of advantage-specialization in some key commodities. A large number of commodities were found to have little competition within ASEAN.

Keywords

Revealed comparative advantage, manufacturing, trade balance, factor intensities and products mapping, international trade, ASEAN.

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Introduction

Since more than two decades ago ASEAN has experienced a strong trade liberalization and integration process. ASEAN agriculture value trade has increased by more than 68% from US$ 89 billion in 2007 to US$ 150 billion in 2013, both pushed by a high demand from neighbouring India, China and East Asian countries and by a strong increase in global prices.

Indonesia is by far the largest economy in ASEAN, both in territory and labor. Indonesian economy has undergone a deep structural transformation shifting from 50% in agriculture as share to GDP in 1960 to 13.40% in 2014. The sector continues being strategic as it absorbs more than 40% of labor, feeds more than 240 million Indonesians and supplies materials for strategic natural-resource-base sectors. Food crops dominate Indonesian agricultural production; however, the largest contribution to exports comes from plantations (almost 50%), while horticulture, fisheries, and livestock experienced large trade deficits.

In 2011, Indonesian government launched a strategic plan called MP3I by defining six special economic corridors. Sulawesi and Papua-Maluku (East of Indonesia) were defined as agricultural-food areas. However, most of the processing of resources and the export are done from Java Island with East Java (henceforth JATIM) as the gate connecting Java Island with the East of Indonesia.

JATIM is the second largest province in Indonesia with nearly 37 million people, with a share of 7% to GDP and almost 15% share on agro-exports. The total JATIM exports experienced a 50% growth from US$10.35 billion in 2007 to US$15.47 billion in 2013. Agricultural exports grew by more than 180% in the same period. However, in the last few years GDP composition and exports of JATIM were challenged by periods of low commodity prices (2008-2009) and shrinking world demand, creating reverse effects in industry structure, policy focus, and dependency on few agricultural commodities. After a rise in exports to US$18.25 billion in 2011 (80% more than 2007), exports dropped to US$15.47 billion. The growth was strongly supported by few commodity groups such as vegetable oils (grew by 872%), machinery

& transport equipment (400%), crude materials (non-fuels, 306%), food and live animals (107%), and beverage and tobacco (100%). The 40% share of manufactured exports on 2007 declined by 15% in 2013. JATIM export partners also experienced a change as the 30% share of exports absorbed by ASEAN in 2007 fell to less than 20% in 2013.

These changes in export-import composition, destination, and volumes signal a change in the pattern of trade and comparative advantage of JATIM, shifting from manufacturing exports to natural resource goods (food, oils, crude materials, organic chemicals, tobacco, and so on) and manufacturing related to natural resources (paper, furniture, rubber, and so forth). Similar changes appear as well in some ASEAN countries, signalling a possible new pattern of trade. As competition among ASEAN members may be tight in the years to come, this paper analyses patterns of agricultural trade of East Java, Indonesia, versus six main ASEAN exporter countries. It looks at the role played by comparative advantage and export specialization in shaping the pattern of the region, as well as to find out changes in advantage-specialization. Finally it questions whether ASEAN liberalization offers opportunities or rather threats for the region by looking at products in which the members compete and collaborate. Looking at advantage-specialization patterns allows assessing the trade performance of the region and allows finding the strength, vulnerabilities and opportunities of each country to expand trade. As Indonesia is significantly larger than all other members, the focus on JATIM allows the researcher to question if the data found at a provincial level show more dynamic differences that are not visible at country level.

Various empirical approaches on comparative advantage

A number of empirical studies on comparative advantage focus their attention in the transformations produced in trade performance by changes in comparative advantage. Yuea and Hua (2002) found that a shift in comparative advantage to labor intensive industries in China together with adjustments in supply side supported economic growth and export performance. For Lee (1995), transferring resources from low to higher marginal labor productivity sectors, specialization, and institutions supported a change in advantage in Korea. Amoroso et al. (2011) found that factor-proportions have twice as much power in determining export patterns in developing countries.

Liberalization, integration, and industrialization are also the channels for improvements in productivity, scale, and export expansion and a way to improve comparative advantage as noted by Balassa (1986), Oladipo and Vasquez G (2009), De Hoyos and Lacovone (2013). Openness in agriculture trade is expected to promote productivity gains and alter specialization as presented by Huang and Chen (1999). Fang and Beghin (2000) found that the least competitive crops in China were the most protected by policies, unintentionally promoting inefficiencies in specialization patterns.

Studies on comparative advantage support that changes in patterns and performance are due to both demand and supply sides, both at domestic and international markets (Widodo, 2009), both in factor-intensities and productivity differentials. Esquivias and Heriqbaldi (2013) noted that improvements in capital, labor, and technology could affect specialization, productivity and resource allocation leading the country to higher levels of scale and lower costs.

Related to ASEAN Agricultural trade, Korinek and Melatos (2009) through a gravity model found that the FTA supports trade expansion within the region and is expected to lower extra-ASEAN trade. However, the RTA does not support significant changes in advantage, as trade base on factor endowments (ASEAN agriculture) had changed little over time. As members tend to produce similar goods, the effects of FTA are not as extensive as expected. Qui et al. (2007) identified that ASEAN enjoys advantage in land-intensive agriculture - vegetable oils, rubber, tropical fruit and vegetables - and positive trade balance versus China and other nations. However, most of ASEAN members have been net-importers on labour-intensive products. The full implementation of the ACFTA will allow some products to gain advantage versus other countries, as they will face lower import tariffs. Okabe and Urata (2014) found that the lowering of tariffs in AFTA has allowed larger intra-AFTA trade and increasing intra-exports. However, trade-flows are not maximal as non-tariff measures still exist.

An objective of this paper is to analyse changes on agricultural trade patterns of East Java, Indonesia, versus six main ASEAN exporter countries.

Materials and methods

The theoretical and empirical debate on the competitiveness of countries is present in a variety of approaches. A number of them use

Revealed Comparative Advantage (RCA), factors affecting changes in RCA and RCA relationship with the use of indicators of industrial specialization (Balassa and Noland, 1988; Bender and Li, 2002; Lee, 1995; Carolan, Singh and Talati, 1998; Das, 2009; Yuea and Hua, 2002; Widodo, 2009, and other scholars).

The present study makes use of two variables expressed as Revealed Comparative Advantage (RCA) indexes and Trade Balance Index (TBI) on the basis of exports to the whole world for 2007-2013 to identify trends in East Java (JATIM) agricultural exports and 6 largest ASEAN countries. Data from SITC Rev 3 at 5-digit level were used for the analysis. The computation of comparative advantage is based on RCA index developed by Balassa (1965). The index denotes "the relative export performance of a country in particular commodities". The advantages of the trading countries are based on both the cost factors as well as on other non-price factors. RCA indexes are obtained by dividing a country's share in the exports of a given commodity category by the share in the world exports.

$$\mathrm{RCA}_{i,j} = \frac{E_{i,j}/E_{tot,j}}{E_{i,world}/E_{tot,world}} \qquad (1)$$

RCA_{ij} = country's j revealed comparative advantage index for commodity group *i*

E_{ij} = exports of commodity *i* by exporter *j*

E_{tot} = total merchandise exports - not including services.

The values of the index vary from 0 to infinity ($RCA_{ij} \geq 0$). RCA_{ij} greater than one means that country *i* has comparative advantage in group of products *j* and vice versa.

Revealed Symmetric Comparative Advantage (RSCA) index developed by Dalum and Laursen (1998) was used to facilitate comparison analysis. RSCA is based on RCA with a "simple decreasing monotonic transformation" (Widodo, 2009) formulated as:

$$RSCA_{ij} = (RCA_{ij} - 1) / (RCA_{ij} + 1) \qquad (2)$$

With this adjustment, the values of $RSCA_{ij}$ index takes values in the range of minus one to one ($-1 \leq RSCA_{ij} \leq 1$). Values of $RSCA_{ij}$ above zero implies a comparative advantage of country *i* in group of commodities *j*. $RSCA_{ij}$ below zero implies a comparative disadvantage of country *i* in group of commodities *j*.

Trade Balance Index (TBI) helps to identify the export position of a country for a group of products, indicating whether the country has specialization in export (as net-exporter) or in import (as net-importer). The assumptions of this index are taken from Lafay (1992). The Index obtained from TBI may indicate whether a specific commodity contributes to the domestic economy (surplus), or whether it is a negative (deficit). TBI is formulated as:

$$TBI_{ij} = (X_{ij} - m_{ij}) / (x_{ij} + m_{ij}) \qquad (3)$$

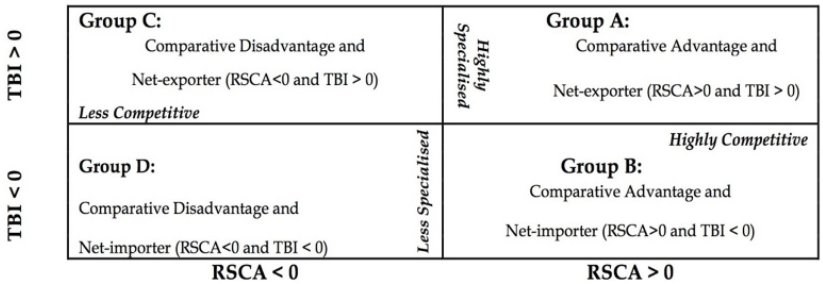
TBI_{ij} = Trade Balance Index of country *i* for group of products *j*

X_{ij} = Exports of group of products *j* by country *i*

m_{ij} = Imports of group of products *j* by country *i*

The values of the TBI index range from -1 to 1. The TBI will be equal -1 if a country only imports (net-importer) and 1 if only exports (net- exporter).

Complementing the analysis of indexes, the "Product Mapping", Widodo (2009), is used to examine comparative advantage from the point of view of the domestic trade balance and the international competitiveness. With RSCA and TBI indexes, products are categorized into four groups A, B, C and D as depicted in Figure 1.



Source: Widodo (2009), APINDO Working Paper No 1. 2013, and author

Figure 1. Product mapping chart.

Group A are products that enjoy both comparative advantage and export-specialization; **Group B** are products with comparative advantage but no export-specialization; **Group C** are products with export-specialization but no comparative advantage; and **Group D** are products with neither comparative advantage nor export-specialization.

All computations of RCA indexes are conducted at product level (5-digit SITC). For the purpose of the analysis, results are aggregated at sector level (1-digit) and 3-digit (sub-sector).

After the computation of the RCA, RSCA and TBI values, all the goods are categorized based on the four groups (A, B, C or D) for each year. Comparative advantage is also evaluated based on the magnitude of the RCA value: non-CA 0 > RCA, Weak 2 > RCA > 1, Medium 3 > RCA > 2, and Strong RCA > 3. Each good is also assigned a status (Fix, Gain or Loss) depending on whether the good has enjoyed and maintained CA (backbone) for the whole period, gain CA (New A), loss CA or never enjoyed CA. The magnitude and the status of the advantage allow tracing inter-temporal changes.

The study maps and does a cross-analysis of all RCA-TBI indicators for all countries identifying products that compete (same status A, to be referred from now on as ***group A*** or ***status A***), goods in which one country enjoys A status and the other B or D (Net-importer), goods in which ASEAN is net-importer (no competition), or goods in which neither has a dominant position but both are actively engaged in trade (combinations of B and C). This allows figuring out the competition environment as well as sizing opportunities-threats.

In order to measure concentration in specialization within particular groups of products (vertical), the number of goods enjoying status A are counted. If the share of total 5-digit products enjoying A is higher than 50% out of the total sub-products under 3-digit group, it is assumed that the country enjoys dominance (specialization) on that particular group.

Measuring RCA and TBI in different periods shows that trade performance is not static but in fact reflects positive and negative changes along time. Countries can reverse low comparative advantage or lose it base on policies. While manufacturing industries might appear less persistent in their nature of trade, low concentration in group A and higher shares of exports under group B or C, agriculture for ASEAN is likely to be highly dependent on goods enjoying advantage-specialization. It is because the main exports are concentrated in products highly competitive in price and volume, such as oils, rubber, coffee, fish, tobacco, seafood, cocoa, cereals, and so on, where ASEAN countries often Ranks in TOP 20's Worldwide.

Data

This study is limited to the six largest ASEAN countries: Indonesia, Thailand, Malaysia, Singapore, the Philippines and Vietnam* (until 2012). Data on Cambodia and Brunei appear with some irregularities, while data on Myanmar and Laos are incomplete. Data of Exports and Imports of East Java were collected from the Indonesian Statistic Bureau (Badan Pusat Statistik Indonesia, BPS) at 5-digit level, based on Standard International Trade Classification (SITC) Rev. 3. Data for the World - exports and imports- were collected from the United Nations Commodity Trade Statistics Database (UNCOMTRADE). This study includes agricultural production as defined by SITC Rev. 3, a total of 545 products at five digit level.

Results and discussion

General view on ASEAN

Singapore is the largest trader in the region, responsible for 32% of exports and 30% of imports, followed by Thailand and Malaysia (Table 1). Indonesia and Vietnam rank 4th and 5th; however, they registered the largest average annual growth of trade during the 2007-2013 period, both intra and extra-ASEAN. All countries experienced larger growth rates in imports than in exports. Except for Singapore and Vietnam, all countries faced larger intra-ASEAN trade growth rates indicating a possible improvement of trade linkages as trade liberalization advances, in line with the finding reported by Korinek and Melatos (2009), Qui et al. (2007).

Except for Singapore and Malaysia, all countries have more than 30% of employment under agricultural sector. However, average agriculture as export share and GDP share represents less than 12%. All ASEAN countries have larger GDP shares of services than industry and agriculture. Agriculture in national GDP is less important but plays an active role in employment, food security, and in creating trade surplus (except for Singapore) (Table 2).

From 2007 to 2013 the six largest ASEAN exporters registered a 75% increase in agricultural

	Total Exports	Total Imports	Total Trade	Intra ASEAN	Extra ASEAN	Export Growth	Imports Growth
Country	(in US $ Million)			Average Annual Growth 2007-2013			
Indonesia	182 551.80	186 628.70	12.5	13.99	12.02	8.85	17.3
Malaysia	228 331.30	205 897.40	6.17	7.18	5.81	5.47	6.99
Philippines	53 978.30	65 130.60	2.65	3.09	2.55	1.87	3.33
Singapore	410 249.70	373 015.80	6.31	5.07	6.78	6.06	6.58
Thailand	228 730.20	249 517.10	9.79	10.83	9.52	9.45	10.11
Vietnam	132 664.10	132 109.90	19.24	11.31	21.21	20.00	18.51
Total	1 271 128.10	1 212 299.50	8.65	8.10	8.33	7.81	9.57

Source: ASEAN Trade Statistics Database as of 20 December 2013

Table 1: Country trade performance (2007-2013).

	Agriculture in ASEAN (2012)				Total GDP		GDP Share 2006-2013		
	Agr POP (000)	Employment Share	Export Share	Import Share	(in US $ Million)	GDP growth 06-13	Agriculture	Industry	Services
Indonesia	49 963	34.8	17.04	8.97	860 850	6.0	12.3	39.9	47.8
Malaysia	1 513	12.7	10.54	7.67	312 072	4.6	7.2	36.9	55.9
Philippines	13 571	32.2	10.92	10.82	269 024	5.3	10.4	32.8	56.8
Singapore		-	2.41	3.55	297 941	5.3	0	28.0	71.9
Thailand	18 032	36.2	13.50	5.27	387 574	3.2	8.3	46.0	45.8
Vietnam	30 566	48.4	12.24	7.98	171 219	5.9	17.6	38.6	43.9
Total	142 186		9.60	6.40	2 395 253	5.2			

Source: ASEAN Trade Statistics Database as of 20 December 2013

Table 2: Country trade performance (2007-2013).

exports (from $79 billion US to $138 billion US). The largest contributions came from food, vegetable fats and oils. Beverages and tobacco had the largest rate of growth (151%).

Singapore has the largest export growth rate in ASEAN (152%), followed by the Philippines (113%) and Vietnam (105%). Among the four main groups of commodities (SITC 0, 1, 2, 4) the leadership is clearly determined (Figure 2). Indonesia and Malaysia dominate the exports of vegetable oils and fats; Singapore and Indonesia lead in beverage and tobacco; Thailand and Indonesia lead in crude materials; and Thailand in food with Vietnam catching up.

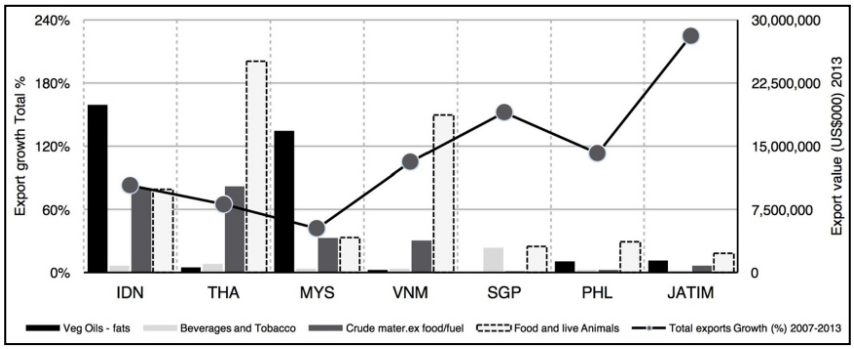
Figure 3 shows the number of commodities exported by each country based on status of comparative advantage, export specialization or both (status A). Thailand is the leader with 119 A goods while Indonesia ranks 2nd (97). JATIM (96) shows status A in 30 goods that do not reveal status A at country level, showing a benefit in looking at provincial data.

In terms of export specialization (TBI), Thailand ranks as the country with the largest number of specialized goods (233); Indonesia, Malaysia and Vietnam ranks 2nd, very near to each other in numbers but differing in the variety of goods. JATIM enjoyed specialization in 190 products, which were more various than Indonesia. RCA ranking follows the same pattern.

Analysis of comparative advantage of East Java (JATIM)

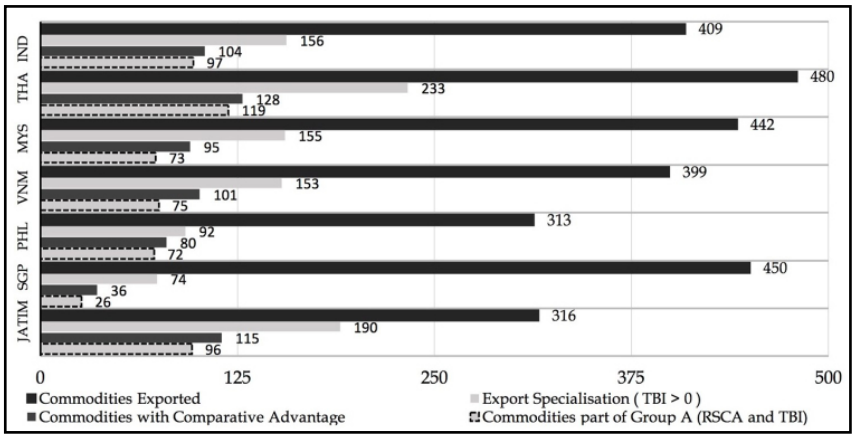
From 2007 to 2013 JATIM experienced a dramatic growth in agricultural exports of 180%. In 2013, JATIM exported 316 different agro-goods (12% more than in 2007) from which 115 enjoyed advantage, and 96 registered both advantage and specialization. Food was found very dynamic as it is the group with the largest number of goods with advantage and specialization, the largest contributor to exports and the largest new A goods (33); however, it also experienced the largest losses (25). Vegetable oils and fats represent 21% of exports (Table 3).

Table 3 shows the total percentage of commodities gaining or losing status A after 2007. While the number of goods is similar (33 – 34), the gains in value are much larger. The backbone of JATIM is



Source: WITS and BPS data (2007-2013) modified by author

Figure 2: Total value exports of agricultural goods (2013, $ 000) - at 1 SITClLevel - and total export growth (2007-2013).



Source: WITS and BPS data (2007-2013) calculated by author

Figure 3: Number of commodities exported, specialized, and with comparative advantage.

	RemainA from 2007-2013[a]		Gain A from 2007-2013[b]		Loss A from 2007-2013[c]		Non Status A (2013)[d]	
	Number Products	% Agro Exports	Number Products	% Agro Exports	Number Products	% Agro Exports	Number Products	% Agro Exports
Animal/veg oil/fat/wax	6	21%	6	6%	0	0%	10	0%
Beverages and tobacco	4	4%	1	0%	3	2%	11	2%
Crude mater.ex food/fuel	5	15%	8	1%	6	0%	43	0%
Food & live animals	48	41%	18	3%	25	2%	156	2%
Grand Total	63	81%	33	11%	34	4%	220	5%

Note: a) Remain A stands for commodities that kept export specialization and advantage (status A) for the whole period. b) Gain A commodities entered into A status during the period of analysis. c) Loss A indicates that a commodity lost status A during 2007-13. d) Non-A status indicates that the commodity never enjoyed status A

Source: WITS and BPS data (2007-2013) modified by author

Table 3: Number of commodities under Group A that remain-gain–loss status A JATIM.

composed by 63 goods representing 81% of exports and contributing to 82% of total growth in exports from 2007 to 2013 (Table 5). The group A (Remain A + Gain A) represents 92% of total agro-exports for JATIM and the new A goods (joining after 2007) added 17% to export growth. Those losing status A lowered its value exports by only 2%. These facts highlight the importance of the role of advantage-specialization in JATIM.

JATIM has also gained in its comparative advantage intensity over time (Table 4), with 89 commodity

groups enjoying strong comparative advantage (RCA > 3) in 2013 versus 69 in 2007. The largest contribution comes from food (60). All sectors (1-digit) registered improvement.

Features of export growth in ASEAN

All ASEAN members, except for Singapore and the Philippines, found the largest export share and largest contribution to exports growth from ***backbone*** products. Those goods grew more than 80% in their export value. For Indonesia, ***backbone*** goods represent 89% of total agro-exports and almost 99% of the total growth in exports (relative to 2007); Malaysia, Thailand, and Vietnam followed similar pattern. The region has depended very much in the same ***backbone*** goods since at least a decade ago. The change in ASEAN seems to be more in gaining specialization and competitiveness rather than shifting to new sectors.

The gain in exports from new commodity members of group A (gaining status A after 2007) has been far larger than the losses from products no longer competitive. JATIM lost 1% of exports from no longer A goods, but it gained 11% in exports value from new A products. Malaysia lost less than 1% and gained 15%, the Philippines lost 2% and gained 32%. This indicates that restructuring exports has offered far more gains than losses for ASEAN (Table 5).

Competition environment within ASEAN and JATIM

In food sector (SITC 4), JATIM enjoys the largest number of advantage-specialized goods (group A, 66) although it faces competition with Vietnam (31) and Thailand (29), as seen in Appendix 2. However,

	Weak CA (2>RCA>1)		**Medium CA** (3>RCA>2)		**Strong CA** (RCA>3)	
	2007	**2013**	**2007**	**2013**	**2007**	**2013**
Animal/veg oil/fat/wax	2	1	0	2	5	9
Beverages and tobacco	0	2	0	0	8	7
Crude mater.ex food/fuel	4	2	2	1	8	13
Food & live animals	28	11	10	7	48	60
Grand Total	**34**	**16**	**12**	**10**	**69**	**89**

Source: Authors calculation, WITS and BPS data (2007-2013)

Table 4: Number of commodities according to intensity of RCA in East Java.

	JATIM	IDN	MLY	PHL	SGP	THA	VNM*
Total expt 2013 ($ 000)	5 157 212	42 258 290	29 866 001	6 173 785	10 656 782	39 999 751	23 284 650
Total expt 2007 ($ 000)	1 844 808	23 608 380	20 458 038	3 134 117	5 819 319	24 769 726	11 290 952
Growth exports 2007-13 (%)	180%	44%	32%	49%	45%	38%	52%
Growth exp Group Fix A (07-13)	82%	92%	81%	55%	40%	85%	79%
Growth exp from New A (07-13)	17%	7%	14%	43%	38%	11%	14%
Loss exports (A Status, 07-13)	-1%	0%	0%	-2%	0%	-1%	-1%
Share of exports % (2013)							
- % commodities Group A	92%	96%	85%	91%	59%	92%	93%
-- % exports Group Fix A	81%	89%	82%	59%	34%	86%	79%
-- % exports New A	11%	7%	3%	32%	25%	6%	14%
- % from non-A commod	8%	4%	15%	9%	41%	8%	7%
Contribution exports Growth (07-13)							
- % From commodities group A	99%	99%	81%	98%	78%	96%	93%
- % from non-A commodities	1%	1%	19%	2%	22%	4%	7%

Note: [a] Fix A (07-13) commodities that remained Status A from 2007 until 2013; [b] New A: commodities that gained status A during the period of 2007-2013; [c] Loos A : products that loss status A during the period 2007-13.
[*] Data for Vietnam includes only until 2012.

Source: Authors calculation, WITS and BPS data (2007-2013)

Table 5: Agricultural export indicators in selected ASEAN countries.

the same group also includes those goods facing less competition.

In oils and fats (SITC 0), JATIM (12 A goods) faces strong competition with Malaysia (9) and the Philippines (8). However, there market is extra-ASEAN offering opportunities for cooperation as they dominate large share of global output. In tobacco (SITC 1) JATIM enjoys large advantage versus competitors offering opportunities for intra-ASEAN expansion. In crude materials (SITC 2) out of the 13 competitive goods in JATIM, it faces competition from the Philippines (7) but less with Malaysia and Thailand and almost non with the others.

In general terms competition among ASEAN countries is not that intense. For example (see Table 6 and Appendix 2) out of 73 commodities under group A in Malaysia, Indonesia enjoys the same status A in 31 of them (42%), the Philippines in 19 (26%), and Singapore in 9 (12%) giving a lot of room for expansion with most of them as the patterns are not clearly the same.

Malaysia faces a medium level of competition with Thailand and Indonesia in almost 30 products that they have in common. Thailand, Vietnam and Indonesia face a more aggressive competition since they have more than 40 common A status goods. Indonesia faces a medium level of competition with Malaysia and the Philippines. Singapore is the most diversified country in the region; it faces little competition with other ASEAN countries.

In 20 product groups JATIM does not face competition from ASEAN countries. However, this represents only 4% of total JATIM exports. In 34 goods JATIM has only one competitor within ASEAN (40% of exports). In 26 products there are two ASEAN countries competing with same goods (11% of exports). In 16 goods, it faces at least three competitors, equivalent to 37% of exports. This indicates a pattern in ASEAN agro-trade in which they share status A in strategic goods with at least one country but differing in less important ones.

Specialization and diversification

There are 13 product groups (3-digit SITC) in which JATIM enjoys advantage- specialization in more than 50% of the total sub-commodities (Table 7). In the remaining 52 groups in which JATIM enjoys status A, it covers less than 35% from total sub-products. Thailand, Vietnam and Malaysia follow a similar pattern with JATIM, but it is at lower degree of concentration since they spread along different categories in which they have relatively small share of sub-products with advantage-specialization. They cover more groups horizontally but less vertically. However, compared to the competition in 2007, the competition of JATIM versus ASEAN countries is now more pronounce. In 2007 only 3 out of 8 groups with more than 50% of sub-commodities enjoying A faced competition (see Appendix 2). By 2013, the number was of 7 out of 13. Interestingly, the main competitors of JATIM remain the same: Malaysia, Vietnam and Thailand.

	MYS	IDN	JATIM	PHL	SGP	THA	VNM	TOTAL A products /country
MYS		31	26	19	9	28	15	73
IND	31		66	33	9	42	42	97
JATIM	26	66		32	6	38	35	96
PHL	19	33	32		6	37	19	72
SGP	9	9	6	6		7	1	26
THA	28	42	38	37	7		43	119
VNM	15	42	35	19	1	43		75

Source: Authors calculation, WITS and BPS data (2007-2013)

Table 6: Competition JATIM A, V.S. ASEAN. Number of same commodities Class A.

	IDN	JATIM	MYS	PHL	SGP	THA	VNM
2013	13	13	9	7	2	11	10
2007	10	8	5	2	0	10	7

Source: Authors calculation, WITS and BPS data (2007-2013)

Table 7: Number of group categories (3-digit SITC) with more than 50% of total commodities under comparative advantage and export specialization (Group A).

In the last years ASEAN countries are becoming more vertically specialized rather than diversifying horizontally as previously. This new pattern adds more pressure and competition to JATIM, as well as among ASEAN countries. Comparative advantage enjoyed at industry level is helping specialization, supporting a rapid diversification towards sub-products and higher disaggregated level.

Backbone categories: Strong RCA and fix status as group A from 2007 - 2013

The share of exports under the backbone criteria is high for Indonesia (86%), JATIM (79%), Malaysia (75%), Thailand (80%), and Vietnam (77%); the share for the Philippines (56%) is considered as medium level and Singapore low (26%). ASEAN agro-exports are highly dependent on strong comparative advantage-specialization for success in exports. ASEAN has diversified only little in the last years, reinforcing advantage in few strategic goods rather than diversifying towards new products. It is noticeable that at provincial (JATIM) level RCA strengthened, while at country level (Indonesia) RCA weakened, indicating the benefits to look at lower aggregated level in sectors where RCA matters more (cost-volume) (Table 8).

Intra-ASEAN trade

Singapore is the only country that is more oriented towards ASEAN exporting more than 40% of its agro-goods. Other ASEAN members remain highly focused on extra-ASEAN trade (83%) often producing similar goods. Singapore also plays the role of trading hub connecting ASEAN with extra-ASEAN. The liberalization of trade in ASEAN has helped increase trade but has not changed the composition of markets (Table 9).

Analysis at country level: Indonesia

In 2013 Indonesia exported 409 different products (10% less than 2007) and enjoyed advantage in 102 of them (16% less than 2007). The loss was felt both in number of goods as well as in the intensity of the advantage, moving from 80 to only 68 products with high RCA.

From the total agro-exports in Indonesia (see Table 5), 96% comes from group A goods, with ***backbone*** exports responsible for 89% of agro-trade. In terms of exports growth, 92% came from backbone goods and 7% from new A ones. ***Backbone*** products are important both for trade success and expansion. In the other hand, it indicates that Indonesia's pattern of trade has not significantly changed

	Weak CA		Medium CA		Strong CA	
	2007	2013	2007	2013	2007	2013
IDN	23	20	19	16	80	68
JATIM	34	16	12	10	69	89
MYS	29	43	12	11	33	41
PHL	18	25	5	8	30	47
SGP	20	16	10	10	12	10
THA	47	50	23	16	64	62
VNM	30	11	10	8	65	54

Source: Authors calculation, WITS and BPS data (2007-2013)

Table 8: Degrees of comparative advantage 2007 and 2013 selected ASEAN countries.

Export from / to	IDN	MYS	PHL	SGP	THA	VNM	ASEAN	NON-ASEAN
IDN		4.80%	1.30%	3.60%	1.40%	1.60%	13.30%	86.70%
MYS	3.20%		2.00%	8.10%	3.20%	3.00%	20.20%	79.80%
PHL	2.30%	3.50%		2.60%	3.40%	1.60%	13.50%	86.50%
SGP	7.90%	13.80%	3.90%		5.70%	8.80%	42.00%	58.00%
THA	3.00%	5.10%	1.40%	1.50%		2.80%	16.50%	83.50%
VNM	1.10%	4.10%	2.00%	2.20%	1.60%		17.50%	87.10%
Share ASEAN	12.70%	25.50%	9.60%	19.60%	10.20%	14.30%	18%	82%

Source: Authors calculation, WITS and BPS data (2007-2013)

Table 9: Share of total agricultural exports to ASEAN countries and non-ASEAN.

into new (differentiated) agricultural products, but it has strengthened specialization in traditional goods. The loss of 25 A goods represents only 0.3% of value exports in 2013, while the 30 new ones give a 7% growth in exports. Openness has not resulted into dramatic losses but in important gains for the country.

Malaysia

Malaysia experienced more significant changes during the 2007-13 period than those of other partners. The number of commodities with advantage significantly increased from 21 to 95, most of which enjoyed high intensity (RCA>2). Malaysia also shifted its specialization to new varieties (lost 56 and gained 45). As a result, in 2013 Malaysia enjoyed 73 products with export specialization- advantage versus 60 in 2007, responsible for 85% of agro-exports and supporting 81% of growth in exports (Table 5). The contribution to trade expansion (14%) of new goods accounted for was far more than the losses (0.22%). The ***backbone*** groups of products are then strategic for Malaysia both as share from exports and as contribution to export expansion, but in a lower degree than that of other ASEAN partners. The growth is mainly vertical (within the same groups), and at a lower degree horizontal (new) (Figure 4).

Philippines

Exports of agricultural commodities in the Philippines recorded 49% growth from 2007 to 2013. The largest contribution comes from goods under group A (91% of agro-exports). The Philippines experienced a more dramatic change in specialization and in group A products than any other ASEAN partners. A total of 38 goods gained status A and only 7 groups lost their status as A. Half of the new products enjoyed strong RCA.

Most of the growth in exports was originated from group A (98% of growth share) indicating the importance of advantage-specialization for the Philippines. ***Backbone*** commodities account for almost 60% of total exports and are responsible for 55% growth of exports. However, versus other ASEAN countries, the Philippines relies more in new products rather than in backbone, contributing 32% to exports in 2013 and 43% of total exports growth. The country is diversifying but following the same pattern of advantage-specialization.

Singapore

The role of Singapore in agricultural exports is less important than most of the other ASEAN members. Only 26 products enjoyed advantage-specialization in 2013. However, Singapore exported 450 different agricultural goods, which were mainly differentiated and not under the pattern of advantage-specialization. 40% of total exports comes from products that neither enjoyed comparative advantage and/or export specialization, mainly differentiated products. However, 78% of growth in value exports came from group A goods. Singapore is less dependent on traditional products; they generate only 34% of exports. New A goods represent 25% of exports

Group C RSCA< 0 and TBI > 0				Group A RSCA and TBI > 0		
	# Products	% exports			# Products	% exports
IDN	214	2%	TBI 1	IDN	97	96%
THA	155	4%	Highly Specialised	THA	119	92%
MYS	130	4%		MYS	73	85%
VNM	78	2%		VNM	75	82%
SGP	221	18%		SGP	26	59%
PHL	194	3%		PHL	72	91%
JATIM	236	1%		JATIM	96	92%
Less Competitive				Highly Competitive		RSCA 1
RSCA -1						
IDN	227	1%	Less Specialised	IDN	7	0.4%
THA	262	2%		THA	9	1.7%
MYS	320	5%		MYS	22	5.3%
VNM	366	2%		VNM	26	13.7%
SGP	288	19%		SGP	10	4.2%
PHL	271	4%	TBI -1	PHL	8	3.0%
JATIM	194	1%		JATIM	19	6.3%
Group D RSCA < 0 and TBI < 0				Group B RSCA > 0 and TBI > 0		

Source: Authors modification from Widodo (2009) and APINDO 2013

Figure 4: Product mapping A-D ASEAN.

in 2013 and are responsible for 38% of export growth, meaning that the trade pattern of agricultural goods is dynamic and expanding towards new and differentiated goods.

Thailand

Agricultural exports in Thailand grew 38% from 2007 to 2013, with group A accounting for 92% of export value and responsible for 96% of export growth. Thailand has 92 groups of A products that remained the backbone of the country since 2007, accounting for 86% of total exports in 2013 and fostering exports in 85%. New A commodities (27) represented only 6% of agro-trade in 2013 and were responsible for 11% of export growth, meaning that they play a less important role in defining export-pattern, relative to ASEAN.

Versus other ASEAN countries, a large number of the goods exported (230) were highly specialized. The structure of commodities according to the intensity of comparative advantage (weak, medium, high) remained relatively the same from 2007 to 2013 (see Table 8).

Vietnam

Agricultural exports in Vietnam experienced the largest growth 52% in ASEAN from 2007 to 2012. Group A gave the largest contributor to exports value (93%) and fostered export growth by 93% in the same period, with 73% originated by backbone commodities. The new members of group A contributed with 14% in value trade, a good contribution to exports.

Vietnam has experienced a strong change in the groups of goods with Status A, with 54 that remained competitive, 39 gain A, and 24 lost status. Backbone goods generated 41% gain in exports, while new group A goods gave additional 7% in exports.

General analysis based on groups A, B, C, D and inter-temporal changes

During the period of analysis there were significant shifts of goods across quadrants. Group B (comparative advantage but less specialized), have the potential to turn into A products if volume escalates and the net-import status is turned into net-export. B goods are less commoditized, value-added becomes more relevant and differentiation matters. Indonesia exports only 0.4% of products under this B status. However, Vietnam exported 13.7% of its total agro exports. On the other hand, the number of products moving from A to B from 2007 to 2013 was small (25) for the whole ASEAN, while 45 moved from group B to A, indicating that B is not the main channel to move goods towards status A.

Group C includes products with lower comparative advantage but highly specialized. These products ordinarily are differentiated where volume is not the main characteristic. Singapore reports a much larger number of products under C status versus ASEAN countries, indicating a pattern in which differentiation and value-added are more relevant. The number of C products in ASEAN is large, but the share of exports is rather small. As countries become more vertically specialized (more value-added and products further processed), it is expected that some of the goods might move from group D to group C, or from group C to group A. For ASEAN case, most of the losses of A status were goods moving from A to C, meaning that the region experienced a loss in specialization rather than a loss in competitiveness. This might be positive if the differentiation leads to more value-added, but the share in exports is too small. On the other hand, the number of goods moving from C to A was large (74). The largest number of new A goods came from C group, indicating a common path towards A.

Group D played an important role as many goods (73) moved from D to A during 2007-2013. The largest shifts happened from quadrant D to C (825), meaning that it is rather easier for countries to gain in specialization than in competitiveness. It also points out a common path towards A. The second largest movement of goods was from group C to A (74).

The analysis indicates three periods of average growth in exports of 33%: from 2007-08, 2009-10 and 2010-11. On average, however, exports fell -17% from 2008 to 2009 and -8% from 2011 to 2012. Both the expansion and contraction of exports were led by group A goods which tend to concentrate in few strategic products, indicating high-risk to changes in prices. Based on the FAO food price index, positive export expansion of JATIM and ASEAN coincided with the rising Food Price Index (FPI) from 89.6 points in 2002 to 201.4 in 2008. However, a sharp decrease in the Index in 2009 from a peak of 201.4 to 160.3 coincided with a significant decrease in ASEAN exports. After a two-year period of strong recovery (a record Food Price Index in 2011 of 229.9) a second period of falling in prices occurred in 2011-13.

Comparison versus other empirical studies

Compared to other empirical studies on changes in comparative advantage as in Yuea and Hua (2002), Lee (1995), the findings in this study somehow differ mainly in four aspects: 1) the advantage did not significantly shifted to new sectors, but rather strengthened in backbone ones; 2) changes in composition of trade were not among the main reasons for trade expansion but rather a strengthening of advantage within group A; 3) relocation of resources from non-competitive to a competitive products is presumably based on productivity basis, while in this case gains are also associated with prices, endowments and demand; 4) the largest contribution to exports mainly belongs to a single quadrant of goods (A) with low share in exports by the other groups (B, C, D) typically important in manufacturing.

The findings are congruent with Ramos-Francia (2011) in which factor endowments (natural resources) have stronger influence in RCA. Versus Oladipo and Vasquez G (2009), De Hoyos and Lacovone (2013) coincides with liberalisation supporting scale, improvements in RCA and expansion. As presented by Huang and Chen (1999), it is possible that the liberalization placed pressure on non-competitive goods, which are in fact exported in relatively low volumes, allowing the most productive ones to gain strength and to spread to related sub-products. It is also in line with Korinek and Melatos (2009) who found that traditional patterns and ties were important determinants of trade flow, as this study finds that ASEAN agricultural trade pattern relies on traditional ***backbone***. The facilitation of trade through AFTA had changed little in terms of destinations as well as product diversification. On the other hand, Agro imports from non-ASEAN members had also increased under full implementation of FTA in line with some studies in trade diversion, e.g. Yang and Martínez Zarzoso (2014). The large increase in agro exports under the same goods might be due to the trade creation effect noted by Schaak et. al (2015) and Yang and Martínez Zarzoso (2014). They also found mix results in trade diversion effects with respect to exports.

While Esquivias and Heriqbaldi (2013) found more significant changes in advantage within manufacturing sector in Indonesia, less dramatic changes are found within agriculture sector. As transportation and logistic cost represent a significant component of ASEAN agro-trade flows as noted by Korinek and Melatos (2009), it is expected that AFTA will have large interaction within China (13.6%), India (6.3%) and the other ASEAN +6 members (representing all-in-all more than 55% of total agricultural exports).

Conclusion

The six largest ASEAN agricultural exporters, plus East Java, have experienced an important growth in agro-exports since 2007. Thailand, Indonesia, and Malaysia are the leaders in agricultural exports, with Vietnam catching up. A common feature is that the most significant contribution to export value (87%) and exports growth (92% on average) has come from commodities enjoying comparative advantage and export specialization (denoted as group A). Improvements in productivity and the increasing production capacity will allow the strengthening advantage (cost) and specialization (volumes and scales) for agribusiness.

All countries have lost some commodities under group A during the sample period (2007-2013). However the gains coming from new A commodities is far bigger. Exports have shrunk by an average of 1% due to losses on comparative advantage-specialization, while new products (group A) grew at an average of 21%, meaning that the strengthening of advantage-specialization has highly contributed to export growth. ASEAN and JATIM have grown vertically (within competitive-specialized products) rather than horizontally (new varieties).

The region remains highly focused on non-ASEAN markets (82 % exports share). However, competition among ASEAN countries and East Java has become more aggressive in some key goods, experiencing higher levels of concentration in competitiveness-specialization within particular groups. As some commodities across ASEAN enjoy very high levels of competitiveness-specialization, there are opportunities for coordinated efforts rather than cannibalizing competition for foreign markets.

The number of goods in which competition is weak or null is large. Malaysia, Thailand and Indonesia are facing medium level of competition. With the rest of the countries, they will have opportunities for trade expansion. Singapore is more diversified and faces little competition within the region. Thailand, Vietnam and Indonesia face stronger competition. 56% of the goods, in which JATIM enjoys advantage-specialization, faces low or null competition. 27% of products within group A

faces 2 competitors, and 17% (representing 37% of export) faces more than 3 countries. There are high opportunities for expansion within the region. A stronger focus within ASEAN will allow growth in agro exports, especially in new differentiated goods and in those in which there is currently little competition.

The pattern of trade towards new varieties and destinations has changed little in most of the ASEAN countries. The pattern has strengthened into the traditional products (***backbone***, enjoying status A since 2007) and slowly introduced new ones.

The use of a more disaggregated data - East Java -, rather than national data - Indonesia - allows the researcher to identify more clearly the patterns of trade, opportunities and challenges for the region. JATIM, when considered in itself, is more competitive than using the sample of Indonesia as proxy for the whole country.

Gains appear to be far larger than losses due to international trade and opportunities for trade expansion are large, giving incentives for countries to seek how to penetrate new markets rather than to enclose themselves in anti-trade policies. However, the development of new industries seems to demand more than business as usual efforts. As space is limited, detailed information on products that have the potential for trade both intra-ASEAN and towards extra-ASEAN are available upon request.

Corresponding author:
Miguel Angel Esquivias Padilla, Ph.D. Candidate on Economics
Faculty of Economic and Business, Airlangga University. Jl. Airlangga 4-6 Surabaya, Indonesia
Phone: 031 5033642, E-mail: miguel@feb.unair.ac.id or esquivias.miguel@gmail.com

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Appendix

	IDN	JATIM	MYS	PHL	SGP	THA	VNM
Animal/veg oil/fat/wax	10	12	17	9	3	7	5
Animal oil/fat	0	1	1	1	1	0	1
Animal/veg oils procesd	4	5	6	3	0	3	1
Fixed veg oils/fats	6	6	10	5	2	4	3
Beverages and tobacco	5	5	2	5	5	2	0
Beverages	0	1	1	0	4	2	0
Tobacco/manufactures	5	4	1	5	1	0	0
Crude mater.ex food/fuel	17	13	20	17	3	19	10
Crude/synthet/rec rubber	3	4	4	3	2	6	3
Textile fibres	8	6	5	8	0	10	5
Other	6	3	11	6	1	3	2
Food & live animals	65	66	34	41	15	91	60
Coffee/tea/cocoa/spices	18	15	10	1	8	5	13
Fish/shellfish/etc.	20	22	3	12	1	19	19
Vegetables and fruit	10	11	4	15	0	24	17
Other	17	18	17	13	6	43	11
Grand Total	97	96	73	72	26	119	75

Source: Authors calculation, WITS and BPS data (2007-2013)

Appendix 1: Number of products under A category (1-2 SITC) in selected countries ASEAN (2013).

	Product group (1 SITC Level)	JATIM	IDN	MLY	PHL	SGP	THA	VNM	TOTAL
JATIM	Animal/veg oil/fat/wax		9	9	8	0	5	0	12
	Beverages and tobacco		3	0	2	1	0	0	5
	Crude mater.ex food/fuel		7	5	7	1	4	4	13
	Food & live animals		47	12	15	4	29	31	66
IND	Animal/veg oil/fat/wax	9		8	5	0	5	0	10
	Beverages and tobacco	3		0	3	1	0	0	5
	Crude mater.ex food/fuel	7		7	5	1	9	8	17
	Food & live animals	47		16	20	7	28	34	65
MLY	Animal/veg oil/fat/wax	9	8		7	0	6	2	17
	Beverages and tobacco	0	0		0	0	1	0	2
	Crude mater.ex food/fuel	5	7		3	1	7	3	20
	Food & live animals	12	16		9	8	14	10	34
PHL	Animal/veg oil/fat/wax	8	5	7		0	3	1	9
	Beverages and tobacco	2	3	0		1	0	0	5
	Crude mater.ex food/fuel	7	5	3		1	6	4	17
	Food & live animals	15	20	9		4	28	14	41
SGP	Animal/veg oil/fat/wax	0	0	0	0		0	0	3
	Beverages and tobacco	1	1	0	1		0	0	5
	Crude mater.ex food/fuel	1	1	1	1		1	0	3
	Food & live animals	4	7	8	4		6	1	15
THA	Animal/veg oil/fat/wax	5	5	6	3	0		1	7
	Beverages and tobacco	0	0	1	0	0		0	2
	Crude mater.ex food/fuel	4	9	7	6	1		7	19
	Food & live animals	29	28	14	28	6	35		91
VNM	Animal/veg oil/fat/wax	0	0	2	1	0	1		5
	Crude mater.ex food/fuel	4	8	3	4	0	7		10
	Food & live animals	31	34	10	14	1	35		60

Source: Authors calculation, WITS and BPS data (2007-2013)

Appendix 2: Competition within ASEAN Members and JATIM (number of same A products).

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Information Security and Risk Analysis in Companies of Agriresort

M. Hallová[1], P. Polakovič[1], R. Virágh[1], I. Slováková[2]

[1] Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Slovak Republic

[2] The Institute of Foreign Languages, Technical University in Zvolen, Slovak Republic

Abstract

Information and communication technologies are a tool to streamline production, and therefore they must be properly secured. The article is aimed at solving security and protection of agribusiness ICT. For a more detailed analysis of this issue there has been carried out a research. Its partial results were submitted to statistical analysis and are presented in the following article. The basic prerequisite for the implementation of any safety measures is the risk analysis when properly conducted it enables the effective implementation of safety measures and the corresponding potential threats and protected values of organization. The main aim of this paper is to assess the impact of particular forms of ICTs on protection, determination of the possible impact of the implementation of the risk and threat analysis for the enterprise.

Keywords

Information and communication technologies, information security, security policy, risks, agriculture subject.

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Introduction

Nowadays means of information and communication technologies represent a considerable advantage for anyone who can use them properly. Information society gradually changes business, public administration as well as each individual's life. This trend is evident also in a classic, and in many ways relatively conservative branch, such as agriculture (Šimek et al., 2008). Therefore it is also necessary to know how to protect and secure them properly. The term information security is often used in the relation to the information provided. Information security can be defined as the protection of information and its critical elements, including the systems and hardware that use, store, and transmit that information (Whitman and Mattord, 2012). Following recent developments affecting the information security threat landscape, information security has become a complex managerial issue (Dor and Elovici, 2016). In business, but also in the overall economy we use information that can be regarded as an asset and it is therefore necessary to process and protect them. Assets ("asset") IS / ICT include the technologies, applications, data, and also people. Examples of the assets are hardware, software tools, data that the informatics uses and processes. It also includes the standardized and formalized processes and knowledge included in the informatics, as well as individuals such as operational staff, managers of individual applications, means of communication and other employees of the Department of Informatics (Gála et al., 2006).

The level of the usage of information and communication technologies (ICT) has a direct impact on the development and competitiveness of individuals, firms, production sectors, regions and even the whole continents. It is possible to state that the general characteristics and principles of ICT usage in the agriculture sector are beyond any doubt valid and will be valid in future (Jarolímek and Vaněk, 2003). Information assets are all processed data, equipment and people involved, or anything in the processing of information (Kaluža, 2006). Information assets are significant competitive and efficient sources of business in the globalizing knowledge economy. The significance of information security is therefore increasing. According to some other researches was also find that a risk taking firm may invest a larger amount in protecting and set than the risk neutral firm when the effectiveness of the investment in lowering breach probability is low (Mayadunne and Park, 2016). For evaluating the level of business information security there were created different methods to measure the effect of security. These

methods are dealt with by Kruger, Dervin and Steyn (2006). Their aim was to focus on areas of business that enhance information security - employees and their work with information.

Defining each level of information protection is quite difficult. Their vulnerability is on each level such as physical, organizational, procedural, personnel, management, administrative, also in terms of hardware and software (Oláhová, 2006). As stated in the document Information Security (2011), information security is achieved by implementing measures such as policies, processes, procedures, organizational structures and software and hardware functions. These measures must be implemented, monitored, reviewed and improved to fulfill the specific security and business objectives of the organization. It is also an information security from threats and vulnerabilities in order to ensure continuous and successful operation of the organization's activities to minimize business risk and maximize use of investment and business opportunities. Quality information and information technology must promote economic activity and this approach prevents their security (Kučera et al., 2009). Information security is not a management process that directly produces a profit, but they are necessary prerequisite for direct profit making processes. The aim of information security is to reduce the possibility of applying the threats and in case they appear it is to minimize their impact.

The properly defined security policy of the company is closely connected with the right implementation of information security. Selection and implementation of security products require properly defined information security infrastructure in the organization. Security infrastructure is a combination of measures, laws, government processes and experience with technologies and products that provide information security of organization. The aim of this security are the measures to prevent problems, detect problems, and alleviate damage, delay the effects of errors and attacks. Security infrastructure must also set certain standards for the assessment of the relevant factors in assessing the effectiveness of technologies, products and processes (Tarimo, 2006). Minimizing the impact of risks is a priority of security policy. Security policy is a basic plan that determines the information and assets and benefits of property which belong to organization as well as the manner of their protection. The employees have to have common rules when using the information sources, i.e what is allowed and what is not. It must also include the security policy components of the information system such as hardware, software, data and users. A properly constructed security policy is the basis for the development of projects aimed at safety. To minimize the risk of illegal use or misuse of information resources of the organization, the security policy is the first one as a safety measure (Danchev, 2004). Providing the IS risk analysis is needed to establish an effective security policy. Other necessities are to identify information assets that need to be protected, why they need to be protected and how the protection will be implemented (Tóthová, 2006). Overall, risk management is the total process used to identify, control, and minimize the impact of uncertain events (Peltier, 2005). Identified threats and risks need to be accepted or corrected. The analysis of risks includes the analysis of assets, analysis of threats and vulnerability analysis (Loveček, 2006). Another view of the risk analysis is obtaining objective basis so that security measures can be designed. Risk analysis is the process of identifying risks, evaluation of their size and the identification of areas that need to be provided by security measures (Hofreiter, 2006). Detection of possible operational threats which come from business interruptions and their financial impacts create the basic unit of the risk assessment (Kostrecová, 2008). There are many risk analysis methods available today, and the main task for an organization is to determine which one to use (Agrawal, 2017).

Overall, the management of data security is difficult. Quality management requires a combination of technical and business skills and knowledge of people, many of them are not intuitive. The basis of the information security is the risk management. Any extensive modern network can be ensured without a thorough understanding of the risk management process. It is important to understand the information security as a complex process consisting of the before mentioned parts. Additionally it is necessary to determine the correct security infrastructure, define the security policy and especially to analyze security risks. Information security and the overall security of information systems have been analyzed by researches of many authors such as Carlsson et al. (2009), Hennyeyová and Depeš (2010), Hennyeyová et al. (2013), Šilerová et al. (2016), Šilerová et al. (2015) or Bilozerov and Isomäki (2012), which focused mainly on the electronic exchange of business information between enterprises but also involvement and raising awareness of managers about information security and partly served as inspiration for our research.

Material and methods

From the year 2012 to 2016 the Department of Informatics carried out a research on issues of information security and security policy in agrirezort enterprises. This paper presents the parts of the research focusing on the assessment and evaluation of effective and safe use of ICT. The questionnaire survey was evaluated with statistical methods for the detection of relevance and relations of the data collected to confirm or refute the hypothesis of statistical indicators. A total number of hypotheses was 8, two of them were chosen for this article:

Hypothesis 1: Form of ICT administration is related to the security and protection of the ICT.

Hypothesis 2: Implementation of risk analysis threatening ICT affects the security solutions and ICT security.

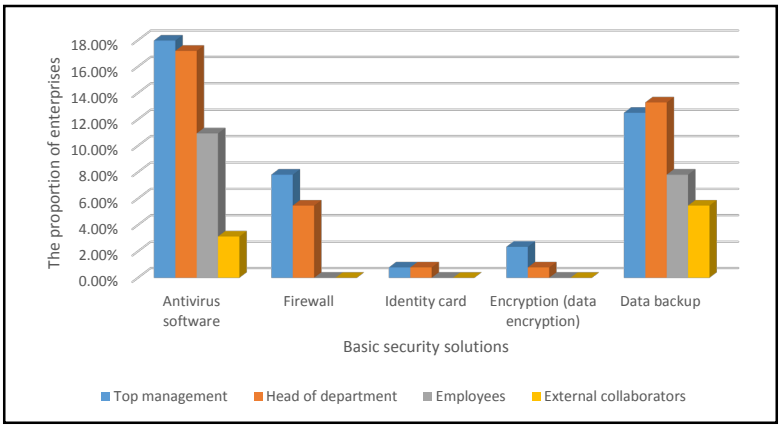
Several statistical methods have been used for the statistical evaluation. Verification of dependencies between the trait was carried out by use of chi-square test (χ^2), respectively. (χ^2) - square contingency. The test is based on comparing the theoretical and the empirical frequencies, e.i. which empirical frequency, if they were independent characters.

For the statistical analysis where the Chí-square test of independence could not be used, the Fisher's exact test was applied because the assumption numbers of cells in the pivot table was not followed. Fisher's exact test derives from the pivot table and verifies the null hypothesis of equality of the two units, namely the independence of two binary variables. This test is based on the assumption that all marginal frequencies (totals rows / columns) in the pivot table are fixed. This assumption is rarely met. They are mainly fixed in line frequency or in only the total frequency. If using the parametric methods was not possible because of failure in meeting the preconditions for their use, we applied nonparametric methods. Kruskal-Wallis H test is an extension of the Mann-Whitney test for three or more samples. The aim of the test was to find out whether the differences found in the sample medians of each group (according to the level factor) are statistically significant (between variables, the relationship) or could not be random (between variables, the relationship). The null hypotheses concerning equality of all medians was tested. If the P-value is lower than the chosen significance level (0.05), the null hypothesis is rejected. This means that the difference between at least one pair of median values calculated from the sample is too large, it can only be the result of random selection. Therefore it is statistically significant – there is the relationship between the variables. If the P-value equals to or is greater than the chosen significance level, the null hypothesis can not be rejected. This means that the difference between each pair of medians calculated from the sample can only be the result of random selection, therefore, not statistically significant – there is not the relationship between variables.

Results and discussion

The research sample consisted of 85% of cooperatives, 9% of joint stock companies and 6% of companies with limited liability. 69% of activities were in agriculture. The remaining businesses operate in the food industry. ICT security consists of items that the entity uses to ensure proper operation and protection of these technologies. All monitored entities have some form of security of ICT, especially at the technical level. This fact corresponds with the amount of funds spent on various forms of security and protection, the value of which is up to 500 EUR, while the survey shows that the vast majority of entities invest less than 1000 EUR for ICT in one year (40.63% enterprises). For other entities, it is smaller, but not insignificant amount because the adequate security and protection ICT cost less in opposition to the state of distortion of IS / ICT. According to the funds it is also important to know which organizational levels show interest in including the security solutions for IS / ICT. Research shows (Figure 1) that senior management has the greatest interest in the security solutions. It's relevant in incorporating ICT in the statutes, regulations, guidelines and regulations in the subject and their subsequent compliance.

ICT security does not fall only on the level of technical protection. An important part of the IS / ICT is non-technical protection presented as Security policy or project. The Security policy includes all the rules of the protection of IS / ICT as well as other assets of the company. Despite the fact that the Security policy and the Security project are the essential elements of asset protection in the enterprise, only a smaller proportion of companies actually create, apply and respect it. According to our research, 40% of subjects do not have these documents elaborated. Obeying the safety rules has important implications on how the enterprises manage their ICT. Usually in three ways, by internal employees, internal employees in cooperation

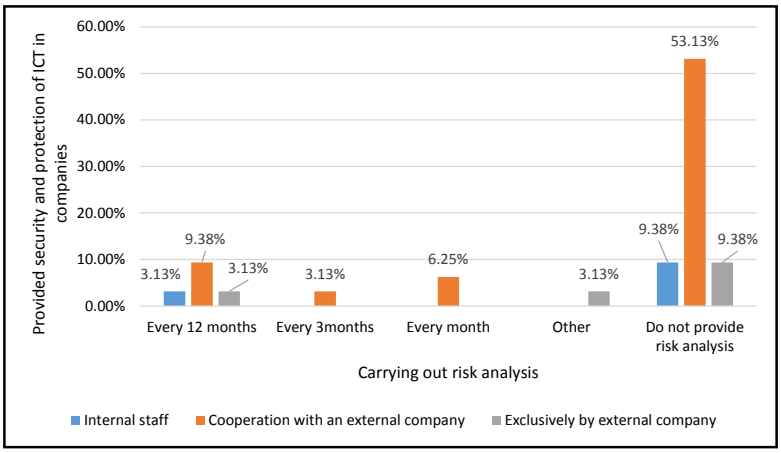


Source: own research and processing

Graph 1: Interest of the organizational levels in security solutions.

with the external company or solely an external company. The hypothesis 1 states how is the management of ICT related with enterprise security. The hypothesis 1 in this article was evaluated by using Fisher's exact test (for the Chí-square test of independence the assumption numbers of cells in the Pivot Table was not respected). The null hypothesis was formulated for the use of Fisher's exact test (H0: The form of management ICT and the protection and security of ICT is not statistically significant relationship.) and the alternative hypothesis (H1: The relationship between management of ICT and the protection and security of ICT is statistically significant.). Based on the Fisher's exact test P-value of the 5.167-13, and is thus lower than the significance level $\alpha = 0.05$. We accept the alternative hypothesis and reject the null hypothesis which means that the between the management of ICT and ICT security and protection is statistically significant relationship. Overall, the research shows that companies which have their own staff for ICT management are also responsible for ICT protection and security. On the other hand, companies that work with external companies for management of ICT cooperate with such companies also for ICT protection and security. Management of ICT by internal employees represents 6.25% of the companies; 3.13% in collaboration with an external company and 3.13% external company only. Although all parties ensure the protection of ICT, 71.88% of these entities does not perform an analysis of possible risks that may be threatening to their ICT. There also can be seen the connection between whether or not the businesses have own security policy or project. In this case the entities have the documents and they would follow the risk analysis in certain time intervals. Intervals of risk analysis directly derive from those documents and audit of information security. The hypothesis 2 in our article focuses on the analysis of risks and their impact on the security and protection of the ICT. The null hypothesis for Fisher's exact test was determined as follows: "There is not a statistically significant relationship between the implementation of risk analysis and management and security of ICT." The opposite hypothesis says that there is a statistically significant relationship. Based on the Fisher's exact test is the P-value 0.0095 and is thus lower than the significance level $\alpha = 0.05$. We reject the null hypothesis and accept the alternative hypothesis, so between the conducting a risk analysis of ICTs and solving the protection and security of ICT there is a statistically significant relationship. This is reflected on Figure 2, where the companies which cooperate with an external company in protection and security of the ICT do not perform risk analysis because they only focus on the situation, not on prevention. The relationship is visible, but it is negative more likely in agribusiness.

However it should be noted that companies should realize the importance of risk analysis. Without risk analysis the effective security measures in the organization can not be implemented. If such analysis is not part of building safety, it means that companies are not concerned with the security.



Source: own research and processing

Graph 2: The relationship between management of ICT protection and security and conducting a risk analysis of ICT in the company.

Conclusion

Many renowned authors state and confirm that the basis of adequate security environment of ICT should be directed by management of the company. This view can not be disagreed with. Peltier (2005) is indeed of the opinion that employees initiatively should encourage and highlight the potential safety risks of ICT in the company but confirms that the main proposals should come from top management. In all reported businesses the top management has the largest representation in protection and security of ICT. These forms of security are related to the funds that are spent and form part of the overall budget invested in ICT. The amount of about 500 EUR represents half of funds spent annually on ICT in the case of 40.63% of entities. For other entities, it is smaller, but not insignificant amount, as adequate security and protection of ICT represent lower costs in comparison to the situation of the violation of security of IS / ICT. Safety may not only be at the technical level, but may also be in the form of a document - Security policy or Security project, which form the base stone of ICT security in enterprises on non-technical level. However only a few entities have elaborated these documents Security policy (21.88%) and Security project (37.5%). ICT must not only manage but also provide the protection through either internal company employees (12.5%), in collaboration with an external company (71.88%) or exclusively external company (15.63%). Positive side, which can be noted after the survey, all parties address solve the protection and security of their ICT and leaves them in the risks and threats. Negative side may be finding that only 71.88% of entities does not perform an analysis of possible risks that may jeopardize their ICT. This can have a direct effect on the employees of the company and how they are informed about these risks. The vast majority of employees is not even aware of the security risks and the potential for ICT by businesses (11.72%). This is caused by the fact that these are the simpler systems and technologies that users commonly use in the private and therefore they expected to have basic knowledge of occupational safety and use of ICT. Finally, it is important to note that although they know the risks and try to develop security plans and projects, no ICT resources can be good in today's rapidly evolving technology for 100% protection.

Corresponding author:
Ing. Marcela Hallová, PhD.
Department of Informatics, Faculty of Economics and Management
Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, Nitra, 949 01, Slovak Republic
E-mail: marcela.hallova@uniag.sk

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Exploring the Use of Mobile Phones for Public Participation in the Buffalo City Metropolitan Municipality

T. S. Hobololo, T. Mawela

Department of Informatics, University of Pretoria, South Africa

Abstract

This study investigated the factors that influence the intention of citizens to use their mobile phones to increase their participation in local government. It examined whether gender and age can be used to moderate the effect of these factors. The research was conducted in Buffalo City, a municipality in South Africa. The research used a questionnaire survey to collect quantitative data and semi-structured interviews to collect qualitative data. Data was collected from people aged between 18 and 55 who have no access to fixed-line Internet at home but are instead primarily accessing the Internet via their mobile phones. The study found that the acceptance of mobile phones as a means for public participation is largely a matter of designing mobile participation solutions that support and enhance the performance of citizens. Citizens are fairly accustomed to mobile technology, and this increases the likelihood that they would willingly adopt mobile participation solutions if they offer tangible gains when compared to current methods. Older citizens would require support in familiarizing with the new technology, while all citizens place the availability of reliable organizational and technical infrastructure as an important predictor of their intention to use. The influence of friends and family members was an important factor in citizens' intention to use. Gender did not have any significant effects on the factors that affect intention to use. Age was a significant moderator with younger citizens requiring quick and convenient ways to interact with government while older people looked for more efficient ways of reaching government which should in turn lead to improved quality in services delivered.

Keywords

e-Government; m-Government; m-Participation; Mobile phones; Public Participation, Digital Public Services.

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Introduction

For governments to effectively service their citizenry, they need to create platforms for the public to take part in their planning processes and have an influence on the decisions taken (Komito, 2005). Traditionally, the most prevalent form of public participation in political discourse has been through voting. However, in recent times there has been a decrease in voter registration and turnout in both developed and developing countries (Van Belle and Cupido, 2013). This may indicate that the public does not see its opinions having any impact on the direction and activities of government.

Public participation should be the cornerstone of any democratic society. Promoting public participation is central to maintaining a democratic dispensation (Williams, 2006). It is also argued that the role of citizen participation in governance and service delivery efforts is becoming an increasingly important issue for governments (Ochara and Mawela, 2015). Development programmes that are constructed, implemented, and evaluated by people at the local level, such as South Africa's National Development Planning (NDP), must serve the needs of the communities ahead of partisan political interests (Kabemba, 2012). Citizens often view their role in government merely as voters and taxpayers (Carrim, 2011). When avenues for public participation are unavailable, there is a higher risk of having an aloof government that is ignorant to the needs of the communities it is intended to serve. Negative practices such as fraud and corruption also tend to prosper when the public is not involved in government (Bertot, et al., 2010).

Furthermore, good working relationships between government and civil society must exist in order for public participation to be sustained (Nyalunga, 2006). Non-governmental organizations (NGO's), traditional leaders, as well as municipalities must all work together to ensure that the legislative frameworks that govern public participation are upheld (Setsabi, 2010).

According to the South African Municipal Systems Act 32 of 2000, local government is intended to provide accountable and democratic government for local communities as well as encourage their involvement in local government matters (Venter, 2007). The goal of public participation is to establish a collaborative problem-solving mechanism between government and civil society aimed at achieving representative and more acceptable decisions. Public participation should not be seen as an occasional event such as voting or marching, but instead as a continuous process requiring change in public perception on government matters as well as commitment from government to find innovative ways of facilitating participation.

Mobile phones have a potential to increase public participation (Heeks and Bailur, 2007). The infrastructure for using mobile phones already exists, and much of the South African population is in possession of a working mobile phone (Carrim, 2011). Government is encouraged to explore this unique opportunity which is likely to require notably reduced capital expenditure than regular information technology solutions as has been the case in places where it has been implemented (O'Donnell, et al., 2007). By facilitating mobile participation, government can help alleviate the problem of alienated citizens who lack avenues to engage government (Norris and Moon, 2005). There is evidence to suggest that developed countries with mature mobile participation implementations have improved government to citizen relationships (Macintosh, 2004). Government departments in Europe have been able to lower their staff complement by providing certain services on a do-it-yourself basis online (Rashid and Elder, 2009). Government enjoys improved support from citizens when forums for consultation that influence decisions are made available (Gauld, et al., 2010). Citizens are able to achieve real benefits from mobile participation due to the efficiency of online tools for interacting with government (Welch, et al., 2005).

There is literature that acknowledges the potential of ICTs to improve interactions between government and citizens (Ebrahim and Irani, 2005). The role that mobile phones and applications can play in enabling citizens to participate in government matters is an emerging field of study (Ertiö, 2015). The focus of this research was on investigating how the participation of citizens in local government can be improved through the use of mobile phones. It investigated how governments can benefit from the capabilities of mobile phones since they are already widely used by citizens for social, financial and other personal applications.

Electronic citizen participation

Citizen participation helps governments receive support for policy initiatives from the public, identify unexpected dangers and possible clashes. As an electronic extension of citizen participation, e-participation refers to the use of technology as a medium for participating in government planning, decisions-making, and service implementation processes. It can be implemented at any of the levels of government, that is, local, provincial or national.

According to O'Donnell et al. (2007), e-participation enables citizens to interact amongst each other and with civil servants who can in turn respond to citizens or engage with their colleagues through the use of technology. This definition speaks to the common models of e-participation, namely, citizen to citizen (C2C), government to citizen (G2C), and government to government (G2G). Macintosh (2004) provides a view of e-participation that is more process-oriented by defining it as ICT-enabled participation in government processes including administration, policy formation, decision-making, and service delivery. M-Participation is an extension of e-participation and refers specifically to the use of mobile technology in public participation which involves mobile phones, tablets, laptops, and other mobile devices (Conroy and Evans-Cowley, 2006).

While e-participation aims to achieve more than mere digital provision of information, many of its implementations worldwide show higher numbers of citizens accessing government websites to get information as compared to citizens using technology to deliberate, consult and affect discourse in government matters (Komito, 2005). Instead of actively conceiving and constructing, citizens merely become endorsees of predefined planning programmes (Williams, 2006).

Younger South Africans, between the ages of 18 and 35, are not actively involved in community matters with a small percentage having attended

a hearing or meeting organized by the local council or government. Older members of the community still choose to interact with government through traditional means but this trend is likely to decrease over time as upcoming generations are more comfortable with ICT (Heeks and Bailur, 2007). The most common application of e-participation in South Africa is email which is used by municipalities to send monthly invoices to citizens for the consumption of municipal services.

Proliferation of mobile phones

It is reported that 91% of adult people (from age 16 and higher) in South Africa have a mobile phone (Pew Research Center, 2014). South African mobile web users on average consume 6.2 hours of media on a daily basis, and are active on their mobile phones for 30% of this time, which amounts to 114 minutes spent consuming mobile media per user per day (InMobi, 2013). The use of mobile ICT is one of the critical requirements to the socioeconomic development of sub-Saharan Africa (Meso, et al., 2005). In 2007, the people of Kenya were for the first time enabled to perform financial transactions such as sending and receiving money via their mobile phones through an electronic payment service named M-Pesa (Hughes and Lonie, 2007). This innovation promotes financial inclusion of previously marginalised communities and in so doing advances the developmental objectives of the country. M-banking or m-payment systems such as eWallet and Cash Send contribute to the reduction of the digital divide and unbanked citizens in South Africa by providing those who do not meet the stringent criteria for obtaining a traditional bank account access to transfer and withdraw funds using their mobile phones (Donner and Tellez, 2008). The cost of providing public services is significantly reduced by using networked systems where mobile telecommunications are leveraged to bridge network gaps and connect rural communities.

Rashid and Elder (2009) conducted an evaluation of mobile phones as an instrument in addressing problems related to development using evidence from projects supported by the International Development Research Centre. The projects cover multiple themes including livelihoods, education, poverty alleviation, provisioning of health care, the environment as well as natural disasters. The authors found that mobile phones improve the efficiency of farmers and/or fishermen and in the development of emerging enterprises (Rashid and Elder, 2009). Ghana and Senegal showed salient evidence of improved financial profits as a result of using mobile phones while poor communities in Asia view the role of mobile phones during emergencies as its most helpful use (Rashid and Elder, 2009).

Towards mobile participation

Collaborative planning creates a platform where the ideals of a participatory democracy can be realized. The lack of public participation creates difficulty for government administrators and planners when making decisions about the future of the communities (Evans-Cowley and Hollander, 2010). The traditional methods of public participation such as public meetings can be ineffective and inefficient in today's dynamic world where people have numerous other obligations which render them unable to attend meetings. Citizens usually prioritize work and family responsibilities ahead of local government meetings. Public meetings tend to be misused as platforms to pursue political agendas rather than focusing on issues that affect citizens. Scarcity of resources, power struggles between councillors, lack of trust between ward members who represent different political parties, all make the traditional forms of local government participation difficult (Nyalunga, 2006). Planners struggle to find means of engagement that provide a meaningful experience for citizens (Van Belle and Cupido, 2013). The costs of calls to government call centres, being restricted to working hours, long queues at government offices are all deterring factors to public participation (Patel and White, 2005).

Governments may be able to lower the impact of some of these challenges by introducing digital means of interfacing with government by exploiting the capabilities of mobile phones as that is a medium that citizens already possess. Technology mitigates the time and location constraints that hinder citizens who would otherwise be keen to participate. Better relationships between government and its citizens can be established by incorporating technology into public planning processes (Evans-Cowley and Hollander, 2010). The introduction of technology in public participation supports the development of a democratic political culture (Hermanns, 2008). Governments have been unable to fully exploit the capabilities of mobile phones to reverse the trend of increasing political apathy (Hermanns, 2008).

Government has an obligation to begin creating applications that take advantage of existing

mobile technology to provide beneficial services to citizens (Patel and White, 2005). According to Simons (1988), the degree to which the public finds information truly usable and therefore the extent to which participation is possible, may largely be an issue of how that information is presented. These concerns indicate that there is a requirement for considerable initial investment from government. Government may have to introduce incentives for mobile operators to lower voice and data costs so that participation can be affordable to citizens of all demographics.

While voice prices have been declining steadily in recent times, the use of voice services has also seen significant declines while there has been growth in data use (Gillwald, et al., 2012). Defining mobile phone costs in terms of voice and data is no longer valid as users increasingly tend to convert airtime to data when they run out of bundles (InMobi, 2013). Additionally, there is also an increase in using data services to make voice calls through voice over IP (VoIP). SMSs are becoming extinct almost entirely as they are being substituted by instant-messaging services (Gillwald, et al., 2012). Government must therefore build m-participation solutions that are aligned to the constant evolutions in the ICT sector. This may require governments to form partnerships with role players in ICT. Challenges such as limited time, money, and qualified personnel are compounded by changing technologies and can have significant cost implications if proper planning is not done.

The literature on public participation in government highlights several common issues that hinder the successful adoption of technology. Additionally it is argued that the human factor contributes much more than the actual technology in limiting adoption (Williams, 2006). It is suggested that humans are generally resistant to change and that extensive change management is required when introducing a new technology (Gillwald, et al., 2012). Resistance to m-participation is likely to be low as citizens are already accustomed to using their mobile phones to interact and transact (Trimi and Sheng, 2008). The use of ubiquitous mobile phones make it possible for even the poor and disadvantaged to consume e-government thus avoiding the pitfall of widening the digital divide which results from using technology that is only accessible to select segments of the population (Patel and White, 2005). M-participation takes advantage of already existing technologies to extend government's reach to segments of the population which do not have access to more costly technologies. Transforming from traditional face-oriented or file-based systems of public participation to digital can increase efficiency, improve public information dispersal, and also improve equity opportunities for citizens.

This study examined the factors that influence citizens' intention to use mobile phones in order to increase public participation in local government and whether the effects of these factors are moderated by gender and age. There is a need for studies that explore the potential role that mobile phones can play in enabling citizens to participate in government matters (Conroy and Evans-Cowley, 2006). South Africa is similar: while there are several published studies on e-government in South Africa, there is still a lack of literature on m-participation (Mawela, 2017). This is a crucial area to concentrate on as most of the South African citizens have continued access to mobile phones, are accustomed to using mobile phones for social interactions, sending and receiving professional and personal information, as well as performing transactions with private sector service providers (Gillwald, et al., 2012). This research reviewed the factors that affect the intention of citizens to use their mobile phones for participating in local government and the moderating effects of age and gender as the intrinsic characteristics of citizens. The study, which was positioned in Buffalo City Municipality, aimed to address the following research questions:

1. What are the factors that influence the intention of citizens to use mobile phones to participate in local government?
2. Does age and gender moderate the effects of these factors on the intention of citizens to use mobile phones to participate in local government?

Materials and methods

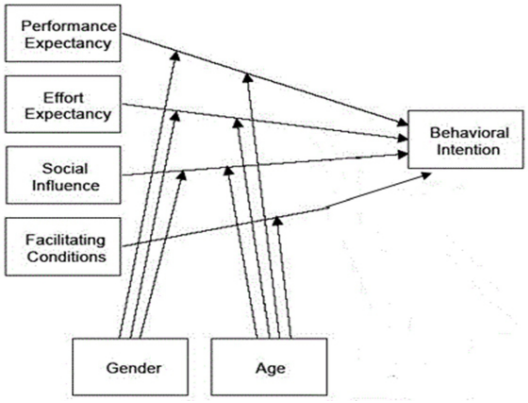
System implementers often use technology adoption models to assess how well a new technology is likely to be accepted by its intended users (Davis, 1989). Systems users have a reputation for resisting new systems. In order to successfully implement a new technology, the targeted users must be willing to adopt it. This often means abandoning old methods of doing things and learning the methods of the new technology. This requires extensive change management. Technology adoption models measure constructs such as perceived usefulness and ease of use. Users must be able to see the proposed value of a new technology in order to be willing

to adopt it. Usefulness and ease of use imply that the new technology satisfactorily solves a real problem and does not require an effort that is significantly more than what is required by current methods. Users must be able to see how a new technology will allow them to do more or work better in order to be receptive and show a strong intention to use.

Various models for understanding technology adoption have been previously proposed. Davis's Technology Acceptance Model (TAM) which was published in 1989 is based on the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) and has been adopted widely to determine user acceptance of new technology (Venkatesh and Bala, 2008). The TAM has since evolved into TAM2 and later TAM3 which includes constructs that measure the influence of social factors while the initial version had a primarily technological focus. The Unified Theory of Acceptance and Use of Technology (UTAUT) model published in 2003 was intended to consolidate 8 models including TAM, TRA, TPB, the Social Cognitive Theory, and others which have been used previously to determine technology acceptance (Pearlson and Saunders, 2010). UTAUT is made up of 4 core constructs namely Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC). With the exception of FC, these core constructs have an effect on Behavioural Intention (BI). While FC does not affect BI, both BI and FC have a direct impact on Use Behaviour (UB) (Venkatesh, et al., 2003). The UTAUT uses Gender, Age, Experience, and Voluntariness of Use to moderate BI. Each of these moderating constructs has a varying effect on each of the model's core constructs.

This study used the UTAUT model because it has been shown to provide a "better explained variance of the intention to use technologies" than other technology adoption models (Khechine, et al., 2014) such as Theory of Planned Behaviour, Theory of Reasoned Action, and Technology Acceptance Model. The study modified the UTAUT and produced a framework that uses only the constructs that are relevant to its context. The result was a framework that excludes UB and Experience on the basis that there is no extensive experience of government using mobile technology neither to deliver services nor to engage the public in the Buffalo City Municipality of South Africa. When a new technology is being introduced and no extensive usage data exists for it in a given context, previous researchers usually measure related experience such as, internet and computer use (Johnson, 2013).

This study borrows from that approach and measures the mobile phone capabilities of citizens. These capabilities are considered separately and not as variables of the UTAUT model. The reason is that the literature review showed that the prominence of mobile phones in South Africa has remained consistently high since the mid-2000's with various segments of the population using it to perform more or less the same functions (InMobi, 2013) (Pew Research Center, 2014), meaning their experience in terms of years would not have any significance for this study. We collected the mobile phone capabilities data purely to establish whether a respondent was a user of a basic or smart phone and was familiar with the various functions of an internet-enabled phone. It is our view that such data would impact their willingness to adopt m-participation as it is consumed via internet-based applications. Voluntariness of Use was excluded on the basis that the use of mobile phones by citizens to interact with government would under normal circumstance be voluntary. The theoretical model for this study is depicted below:



Source: Adapted from Venkatesh, et al., 2003

Figure 1: Research theoretical model.

Research philosophy

The underlying philosophy of this research was positivist. Positivist research is primarily used to identify quantitative data with propositions that can be tested or identified. The purpose of positivist research is to discover causal relationships between variables. This study aimed to explain the relationships between variables namely the core constructs on the modified UTAUT model and the moderating constructs as we investigate the factors that affect the intention of citizens to use mobile phones for public participation. By studying these relationships, the study was able to identify

and explain the factors that influence the adoption of mobile phones as a tool for public participation in local government and whether their effects on behavioural intention are moderated by age and gender.

The study collected both quantitative and qualitative data. A questionnaire survey was used to collect the data required for quantitative analysis, whereas semi-structured interviews were used to collect data for qualitative analysis. This research tested predefined hypotheses for the quantitative aspect (see Table 1). The qualitative data collected through interviews was used to support the quantitative data. The quantitative and qualitative data collection methods are not opponents of one another but can instead be used to examine different aspects of the same phenomenon. The use of both quantitative and qualitative data allowed for triangulation. The target population included the citizens of Buffalo City Municipality between the ages of 18 and 55. Data was collected from people who have no access to fixed-line Internet at home but are instead primarily accessing the Internet via their mobile phones.

Results and discussion

A total of 156 questionnaires were included for the analysis. Both genders were well represented with males making up 51% of the sample and females making up 49%. The majority of respondents were youth from the 18-23 and 24-29 age group categories. English and Xhosa were the prominent home languages amongst respondents with the majority of them having achieved up to a secondary school education. Respondents were asked to assess their mobile phone capabilities. The majority of respondents (94%) were in ownership of a smartphone and were comfortable in using its functionalities. 14% of the respondents did not use their mobile phones to play games, while 6% said they did not download apps with their phones. Listening to the radio via mobile was unpopular with 88% choosing 'no'. Respondents used the normal functions of a smart phone such as sending and receiving messages, taking pictures, going online, and listening to music.

Mobile participation adoption

The first part of the research sought to address the question: What are the factors that influence the intention of citizens to use mobile phones to participate in local government?

The hypotheses were tested using multiple regression analysis. The research aimed to establish whether there are any direct links between the independent variables and the dependent

Hypothesis number	Hypothesis Description
H1	Performance Expectancy (PE) will have a positive effect on the intention to use mobile phones as a medium for public participation in local government.
H2	Effort Expectancy (EE) will have a positive effect on the intention to use mobile phones as a medium for public participation in local government.
H3	Social Influence (SI) will have a positive effect on the intention to use mobile phones as a medium for public participation in local government.
H4	Facilitating Conditions (FC) will have a positive effect on the intention to use mobile phones as a medium for public participation in local government.
H5	The positive effect of performance expectancy (PE) on the intention to use mobile phones as a medium for public participation is moderated by gender, such that the effect is stronger for males.
H6	The positive effect of effort expectancy (EE) on the intention to use mobile phones as a medium for public participation is moderated by gender, such that the effect is stronger for females.
H7	The positive effect of social influence (SI) on the intention to use mobile phones as a medium for public participation is moderated by gender, such that the effect is stronger for females.
H8	The positive effect of performance expectancy (PE) on the intention to use mobile phones as a medium for public participation in local government is moderated by age, such that the effect is stronger for younger citizens.
H9	The positive effect of effort expectancy (EE) on the intention to use mobile phones as a medium for public participation in local government is moderated by age, such that the effect is stronger for older citizens.
H10	The positive effect of social influence (SI) on the intention to use mobile phones as a medium for public participation in local government is moderated by age, such that the effect is stronger for older citizens.
H11	The positive effect of facilitating conditions (FC) on the intention to use mobile phones as a medium for public participation in local government is moderated by age, such that the effect is stronger for older citizens.

Source: own processing

Table 1: Research study hypothesis.

variable. The study found that direct links exist between 3 of the independent variables and Behavioral Intention. The data showed significant regression coefficients for the direct links between PE, SI, and FC and the dependent variable. Hypotheses were tested at a significance level of 0.05. P-values were adjusted for unidirectionality. The R^2 value was 0.528, meaning that almost 53% of the variance in the BI construct was explained by the 3 independent constructs.

Performance expectancy (PE) had a positive effect on the BI construct. This result supported the 1st hypothesis and is consistent with results from other related studies (Venkatesh and Bala, 2008) (Zhang, et al., 2012). Additionally, PE was the strongest predictor of BI which is a finding that is consistent with results from previous research (Yang and Zhou, 2011). This finding can be explained by the fact 72% of respondents fell into the wider youth age group, i.e. 18-35. This finding was also supported by the qualitative data wherein respondents expressed that they hoped m-participation would enable them to efficiently apply and receive services such as identity documents, driving licenses, matric certificates, etc. from the responsible departments and regulating bodies which would in turn enable them to apply for job opportunities. The inability to apply for advertised posts due to unavailable documentation emerged as a major concern for the respondents. The respondents saw m-participation as a technological tool that could help link them with government and make the job application process as hassle-free and cost-effective as possible.

Respondents also thought m-participation would be useful in that they would not need to take time out of their regular business to visit government offices, saving them money on transportation and time on travelling and queuing. Understanding the foremost predictors of user acceptance would be invaluable to a government and its technology partners. This knowledge can help those in administration make sound decisions regarding what technology to implement in order to support mobile participation. The technology solutions would have to be designed such that they are effective in terms of supporting and enhancing citizens' performance. This would in turn encourage the citizens to be more willing to use the technology.

Effort expectancy was not a predictor of Behavioral Intention. Subsequently the 2nd hypothesis is rejected. This finding is supported by Park et al. (2009), which theorizes that when users are familiar with a particular technology, effort expectancy cannot have a meaningful effect on their perceptions towards that technology. Respondents are already fluent in the use of mobile phone technology and view an electronic government solution as just another application that they would easily become used to. This supports the core notion of this study which is to take advantage of mobile phone technology to increase public participation as it is already largely diffused and used in South African communities.

Respondents in the semi-structured interviews mentioned that data costs are indeed a concern to them even in their current use of their mobile phones. The qualitative data showed that while users are conscious of data costs, such costs do not discourage them from using mobile applications as long as the applications allowed them to perform their desired functions effectively. Technology acceptance in developing countries often hinges on users having to weigh the effect of communication costs against the expected gains associated with using a technology (Ruxwana, et al., 2010). Users tend to manage their data spend by enabling and disabling application services as and when necessary. Government should view this finding as a hint to pair the deployment of m-government with the installation of free wi-fi hotspots in areas where data costs are a concern as a strategy to promote m-participation. Older respondents expressed that learning a new application would be a welcomed temporary discomfort if it meant that they would no longer have to put their jobs at risk by taking time out to visit government offices. Many of the people in Buffalo City Municipality work as unskilled labour in factories, farms, and construction sites which makes them vulnerable to lay-offs and replacement.

The social influence (SI) construct was a predictor of BI and thus supports the 3rd hypothesis. This finding is consistent with previous research (Bertot, et al., 2010). The opinions of others regarding the m-participation were important for citizens. When the people closest to an individual were favourable towards the use of mobile phones to interact with government, the more likely a citizen would be to participate in m-government. Users have no expectation to raise their social status by m-participation but only to feel part of a group with which they identify with. The semi-structured interviews revealed that friends and family have an influence because people usually chat about their online experiences and often suggest interesting applications

and websites to one another. Government would therefore have to implement community-wide awareness campaigns when launching m-participation as individuals do not like to feel isolated by choosing to use a new technology. The people in one's social circle must also subscribe to m-participation in order to achieve a successful implementation. The qualitative data revealed that many of the popular applications become so through word of mouth and that people do not enjoy using applications that are not used by people they know.

Facilitating conditions (FC) is a predictor of BI and therefore supports the 4th hypothesis. Citizens are more willing to use mobile phones for public participation when there are sufficient facilitating conditions. The availability of resources and help from government would be greatly important in influencing the intention to use of citizens. This should be coupled with a reliable infrastructure which would include systems and computing networks with high availability. Government would be advised to provide support staff and online help facilities to assist users as part of its change management process when transitioning into m-government. Providing help and support is a critical aspect in ensuring the successful implementation of a new technology (Gillwald, et al., 2012) (Gauld, et al., 2010). Citizens with a tertiary education were not concerned about receiving extensive hand-holding but were instead worried about the availability of good network coverage and systems that can remain online and available irrespective of the amount of users that are accessing the systems at any given point. This can be explained by the fact that learned citizens are likely to already have extensive experience with new systems in their workplaces, and have learned that unavailability is a common teething problem. The lack of a reliable ICT infrastructure is a major barrier to the successful implementation of ICT applications in developing countries (Ruxwana, et al., 2010).

The role of gender and age in mobile participation adoption

The second part of the research sought to address the question: Does age and gender moderate the effects of these factors on the intention of citizens to use mobile phones to participate in local government?

The effects of the moderating variables, gender and age, were evaluated to test hypotheses H5 to H11. We tested hypotheses H5 to H7 to establish whether gender could have a moderating effect on the factors that influence BI. We then tested hypotheses H8 to H11 to determine whether age could moderate the factors that influence intention to use.

We found that age indeed had a moderating effect on the relationship between 2 independent variables (PE and FC), and the dependent variable BI. Gender did not prove to have any significant effect on any of the variables. Hypotheses 5, 6, and 7 were subsequently rejected. Previous studies which use the UTAUT model to measure technology acceptance have found gender to have had some moderating effects (Venkatesh, et al., 2003) (Quan-Haase and Wellman, 2004). This difference in findings may be explained by the time/era at which those studies were conducted versus the present at which this study has taken place. In the early 2000's technology was relatively new in developing countries, and was primarily a sphere for intelligent young men interested in science and engineering innovation (Brown, et al., 2010). In the present day, this has changed and females are as involved with technology as their male counterparts (Orji, 2010). The respondents in this study had essentially similar characteristics because they shared similar social backgrounds, e.g. unemployment, inability to study beyond high school due to lack of funding, etc. Additionally, they had relatively the same level of experience in using mobile technology as revealed by the data collected from Part A of the questionnaire regarding mobile phone capabilities.

As stated previously the study uses a unilateral significance level of 0.05 to test its hypotheses. Based on the results the 8th hypothesis is supported. The positive effect of performance expectancy on the intention to use mobile phones as a medium for public participation was moderated by age, such that the effect was stronger for younger citizens. Several studies found age to be a strong influence on differences in performance between the usual versus the new-age methods of interacting with government (Welch, et al., 2005). The questionnaire measured performance expectancy in terms of its perceived usefulness, with statements centred on the efficiency and effectiveness of m-participation solutions. Moreover, the questionnaire sought to establish whether there were any perceived benefits, for example improved productivity and cost savings. The older citizens showed that they expected m-participation to spare them from absconding from work which was a paramount concern

for them as they could access the applications at their convenience (anytime, anywhere). Younger citizens who were primarily financially dependent expected m-participation to free them from the expenses associated with travelling to government offices. Younger citizens expected the turnaround on applications for government services to be reduced as they would be able to track and follow-up on their applications remotely.

The qualitative data supports this finding as citizens expressed a need to have the ability to track their requests. Younger citizens were concerned with attaining a speedy service at a low cost. Older citizens wanted to have their requests resolved without them being physically involved every step of the way, but being able to tell what is happening with their requests at any given time. Older citizens tend to look for improvements in the quality of service while younger people tend to look for speed and efficiency when evaluating a new technology (Chan, et al., 2010).

The study also found that the positive effect of facilitating conditions on the intention to use mobile phones as a medium for public participation was moderated by age, such that the effect was stronger for older citizens. This result supports the 11th hypothesis and may be due to older citizens' disillusionment regarding the standard of help and support that government has brought to communities through the years. Older citizens may also exhibit more anxiety with learning a new technology as compared to young people and would therefore require more support. People in the 18-23 and 24-29 age groups showed strongly that they had enough knowledge and social support to successfully adopt m-participation. People in the higher age groups showed that they had the resources needed to take up m-participation but were skeptical about the level of support they would receive from government. In the semi-structured interviews, an older woman in the 50-55 age group expressed that she usually relies on her young adult daughter to show her things on her phone and would do the same with m-participation.

ICTs enhance service delivery by increasing efficiency through enhanced connectivity and opening channels of communication between a government and its citizens so that comparative advantages can be attained (Park, et al., 2009). The need to increase the involvement of citizens in local government politics and service delivery stems from the position that without citizen involvement authorities often take decisions which are not aligned with the needs on their constituencies (Bertot, et al., 2010). By analysing the variables that affect the adoption of mobile phones as a medium to increase participation, the study exposes the expectations of citizens from a digital government interface. The said interface should in the end serve a purpose beyond just getting people to go online, but the quality of services delivered to citizens must improve as a direct result of using the online government system. In state-building efforts, ICT processes are intended to play a central role in closing the digital divide and improving service delivery particularly in underdeveloped societies (Kabemba, 2012).

Conclusion

This study explored the potential of implementing mobile participation in the Buffalo City Municipality of South Africa. It was argued that mobile participation may improve public participation since citizen participation is touted as the corner stone of a democratic society. This study analysed the predictors of the intention to use m-participation. We also evaluated the effects of 2 moderating variables, gender and age, on the relationship between the predictors and behavioural intention. The study allowed us to gain insight into the factors that would encourage citizens to accept m-participation. Government should give special consideration to the needs of its people in order to meet their expectations. The results showed that effort expectancy was not an important factor for citizens in adopting m-participation as citizens were already accustomed to using mobile applications. The expectation to perform more efficiently and effectively was however a major requirement. Government and its technology partners should design interfaces that ensure that this expectation is met. M-participation solutions should be designed in such a manner that users can see its accrued benefits in the form of improved service delivery, savings in time and costs, and perhaps better relationships between government and citizens. For example, allowing easy navigation between municipal account statements, municipal debt querying, and online payment facilities would reduce the need to contact call centres or travel to municipality offices in order to resolve bill related issues. The results show age as having a moderating effect, as younger citizens were more concerned with rapidity (getting things done quickly), and older citizens with utility (getting things done effectively with improved quality).

Corresponding author:
Dr. Tendani Mawela
Department of Informatics, Faculty of Engineering, the Built Environment and Information Technology,
University of Pretoria, Room 5-102, Information Technology Building,
Corner of Lynnwood Road and Roper Street, Hatfield, Pretoria, 0083, South Africa
Phone: +27 12 420 3372, Email: tendani.mawela@up.ac.za

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User-Technological Index of Precision Agriculture

J. Jarolímek, M. Stočes, J. Masner, J. Vaněk, P. Šimek, J. Pavlík, J. Rajtr

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

Abstract

User-Technological Index of Precision Agriculture (UTIPA) is a comprehensive system based on mutual sharing of opinions and experience within community of people related to precision agriculture - farmers, technology suppliers and researchers. The main benefit of UTIPA is the possibility to use the calculated index level for particular technology (method) for precision agriculture and compare it to other technology with regards to different users, crops, regions etc. It evaluates the principle of a technology but does not take into account concrete products, brands or manufacturers. The index has significance for the presentation of the potential of precision agriculture, development planning and especially for the connection between technological innovativeness and usefulness for practice.

The entire solution includes the methodology for the collection, processing and presentation of data and software and is available via a Web interface for all common device platforms. Anyone who has interest in precision agriculture and contributes their knowledge can use the collected data.

Keywords

Precision agriculture, technological sophistication, user accessibility, knowledge sharing.

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Introduction

The increasing population and the associated increasing demands on the efficient utilization of the agricultural potential lead to the incorporation of new technologies in many sectors of agriculture. Along with the rapid climate changes taking place in recent years there is overall change in the conditions and methods of agricultural land use. Emerging countries need to apply the principles of precision agriculture to secure their sustainable development (Shen et al., 2010).

The concept of precision agriculture is in the interest of the professional public since the 1990s. It generalizes the effort to identify solutions, tools and processes that can improve productivity and profitability while protecting the environment (Cambouris et al., 2014). Precision agriculture plays a vital role in increasing production and is seen as part of the agricultural process efficiency and environment-friendliness. In summary, the concept of precision agriculture is based on observations and measurements followed by the appropriate responses - for example through the introduction of new technology or by changing manufacturing processes. Precision agriculture technologies allow farmers to identify problems and opportunities and apply solutions with far greater accuracy (Lindblom et al., 2016).

The use of precision agriculture constitutes a crucial role in reducing the environmental burden, especially in reducing the amount of pesticides used. When using precision agriculture it is possible to achieve 8-10% reduction in the volume of pesticides compared to traditional agriculture. Such reduction not only has an impact on the financial cost of production but also for environmental protection (Katalin et al., 2014). In many countries precision agriculture is the only possible starting point for sustainable development. As mentioned by (Akdemir et al., 2014) for example, Turkey has no limits on the use of pesticides and fertilizers and the use of precision agriculture is therefore essential for the future of this country.

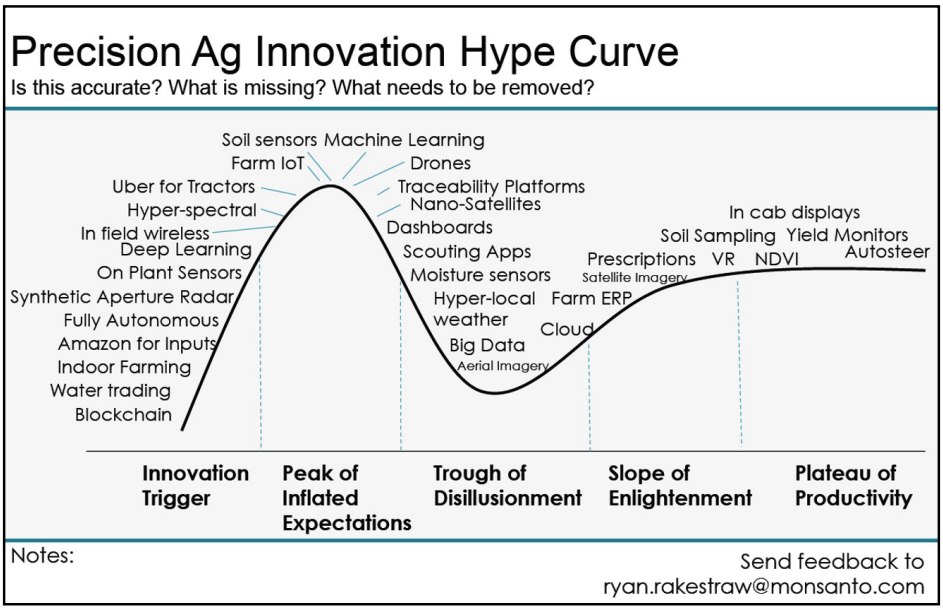
Along with the advancement of technology from a technical point of view, it is also necessary to understand the development of technologies for precision agriculture from the user perspective - for example within the field of human-computer interaction (Lindblom et al. 2016). Specifics of interaction between users and technology can

then be vital for successful utilization of precision agriculture in practice (Kroulík et al., 2009). In some cases, the user comfort, stress and workload reduction can even be the primary benefit of a particular technology. As demonstrated by (Holpp et al. 2013) using the RTK (real time kinematic) navigation has in addition to improving the accuracy of driving and increasing turn speeds also a major impact on reducing stress for drivers of agricultural machinery.

A key factor in deciding whether a particular technology should be incorporated to practice is the understanding of agricultural production processes. Workers in agriculture management must choose among various options for applied research and technology and in this decision-making process it is the necessary to merge the previous experience of the staff and the introduction of new technologies and procedures (Kumhála et al., 2003). It is vital to establish effective decision models and support resources for that particular phase of the production process. The basic premise for appropriate decision is quick availability of quality data. However, the situation in European agriculture is that most of the data is fragmented and difficult to interpret. The actual potential of data associated with precision agriculture is not fully exploited (Fountas et al., 2015).

Expansion of precision agriculture elements into practice is slow process, as evidenced for example by (Schimmelpfennig and Ebel, 2016). From the perspective of farmers the implementation of precision agriculture technology also represents an important economic decision. The most important factor that can accelerate the application of precision agriculture is profitability or investment rate of return. For efficient transfer of precision agriculture technology into practice it is therefore necessary to ensure farmers' awareness about the economic benefits of these technologies (Katalin et al., 2014). The amount and type of actual real-world technologies and processes is closely related not only to the reasons for deploying these technologies, but especially to economic efficiency (Paustian and Theuvsen, 2016). Different forms of presentation are used to illustrate these phenomena, one example might be a characteristic of technological developments in precision agriculture using hype cycle (Figure 1).

When analyzing current models and procedures for the use of precision agriculture it is necessary to take into account phenomena that primarily lead to the adoption of precision agriculture. Recent studies ignore the information, behavioral and social aspects leading to the decision to use precision agriculture. The studies also ignore the political aspects within which agriculture operates. Understanding these conditions, which may go beyond the primary motivation for using precision agriculture, is essential for a better integration of new technologies in precision agriculture into practice (Tey and Brindal, 2012).



Source: Rakestraw (2016)

Figure 1: Precision Ag Innovation Hype Curve .

Materials and methods

User-technological Index of Precision Agriculture is a complex system that includes a methodology for the collection, processing and presentation of data and software and is available via a Web interface for all common device platforms.

Technical solution

Based on the analyses, UTIPA software solution was developed as a modular web application that reflects the state of the art processes and technology. The app uses freely available software. The portal runs on the Apache Web server and is written in PHP 7 using Nette Framework (Nette Foundation, 2015). Data are stored in a database system MySQL. The technologies Google chart tools (Lee et al., 2014), HTML, CSS and JS Framework Bootstrap are used for graphical visualization of the content.

The user interface is designed using responsive web technologies (Šmejkalova et al., 2015), which allows use of the website on different devices (mobile, tablet, desktop) via a Web browser.

Answer relevance

Data is collected through an online questionnaire, which is available on the Internet, resulting in two major threats to the data base, which is the attack on the questionnaire by a robot (Wang et al., 2015) and the other are users who fill out the questionnaire without sufficient examination. To avert these threats the software solution employs two mechanisms:

- Input data must be verified by clicking on the link in the sent email.
- Work with user questionnaire is constantly monitored by self-learning algorithm that is used to verify the relevance of input data. The principle of the algorithm can not be published for safety reasons.

UTIPA and G-UTIPA calculation

UTIPA (User-Technological Index of Precision Agriculture) is calculated for each technology separately from obtained relevant data. These calculations do not include data from general public. Index consists of two parts, the numeric values and additional character. The numeric part of the index has value between 0 and 1 and reflects the degree of usefulness and sophistication of the technology. The numeric value can be supplemented by character which can be either "u" or "t" and expresses better ranking in favor of usefulness for practice or technological advancement - the location in the chart in Figure 5.

The numeric index is calculated as the sum of averages of responses in technological advancement and usefulness for practice. The result is then normalized to the interval <0-1>. The exact formula for calculating numerical value of UTIPA is as follows:

$$UTIPA = \frac{y_{max} - y_{min}}{x_{max} - x_{min}} \left(\frac{1}{n} \sum_{i=1}^{n} (u_i + t_i) - x_{min} \right)$$

where:

n – number of respondents

u – respondent answer – usability in practice

t – respondent answer – technological sophistication

x_{min} – minimum value of the original interval

x_{max} – maximum value of the original interval

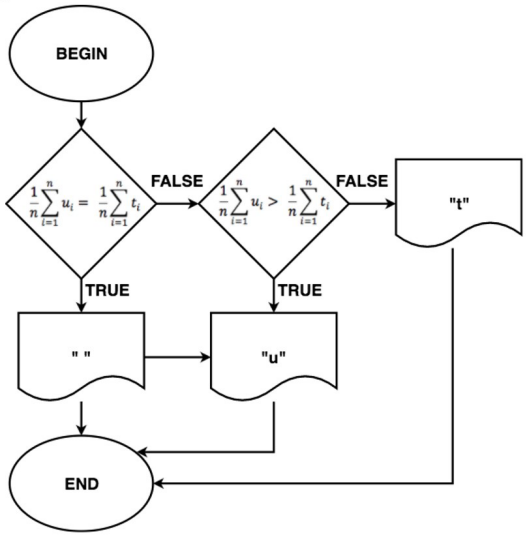
y_{min} – minimum value of the new interval

y_{max} – maximum value of the new interval

Once the minimum and maximum values of the original and the new interval are input into the formula it can be simplified to the following form:

$$UTIPA = \frac{0.125}{n} \left(\sum_{i=1}^{n} (u_i + t_i) \right) - 0.25$$

According to the algorithm in (Figure 2) it is decided whether to use the additional character.



Source: author

Figure 2: The algorithm for making additional character for UTIPA.

n – number of respondents

u – respondent answer – usability in practice

t – respondent answer – technological sophistication

Comparison of assessments

One of the main functionalities of the UTIPA application is that it allows you to view and compare various assessments to each other, for example different groups of respondents, land development over time or own assessment of individual technologies with the assessment of other evaluators. This comparison consists of two parts - the graphical display and a number expressing the distance of the self-evaluation from assessment of other respondents. This distance is calculated by the following formula:

$$d = \sqrt{\left(u_r - \frac{1}{n}\sum_{i=1}^{n} u_i\right)^2 + \left(t_r - \frac{1}{n}\sum_{i=1}^{n} t_i\right)^2}$$

where:

d – distance of own assessment from assessment of other respondents

n – number of respondents

u_r – own answer – usability in practice

u – respondent answer – usability in practice

t_r – own answer – technological sophistication

t – respondent answer – technological sophistication

Results and discussion

The purpose of the "User-Technological Index of Precision Agriculture" is to convey the knowledge of users, suppliers and researchers in the use of modern technology in agriculture. It is primarily based on a five-point evaluation of selected technologies (methods) of precision agriculture in terms of technological advancement and usefulness for agricultural practice. It evaluates technologies in principle and does not reflect specific products, brands or manufacturers.

To achieve the best level of technological sophistication (5 points) evaluated methods of precision agriculture generally need to have proven performance and reliability, contain user interface for use in agricultural practice and have to be mass produced, ideally by several manufacturers. As the worst level in this context (1 point), we consider technologies based only on theoretical considerations.

For the highest level of usefulness for practice (5 points) evaluated methods must show tangible increase in economic efficiency, quality and quantity of production, organization and level of control of the production process, welfare, etc.

The perception of the potential of assessed methods for solving production shortcomings of currently used technologies also contributes for higher scores in this regard, as it shows needs for innovation in the production area. The worst level in this evaluation means there is high ambiguity in usage and potential benefits.

Rating is based on individual knowledge and experience of the respondents. An important characteristic of the evaluated technology is also its unfamiliarity among the respondents. The index is calculated on the basis of awarded points and can be used to compare the various technologies, respondent groups, countries and changes over time, etc., but also to compare one's ratings with rating of other respondents. At the same time the obtained values allow for visualization which offers many new insights and findings, e.g. to compare and split rated technologies into four basic groups (Figure 3):

Source: author

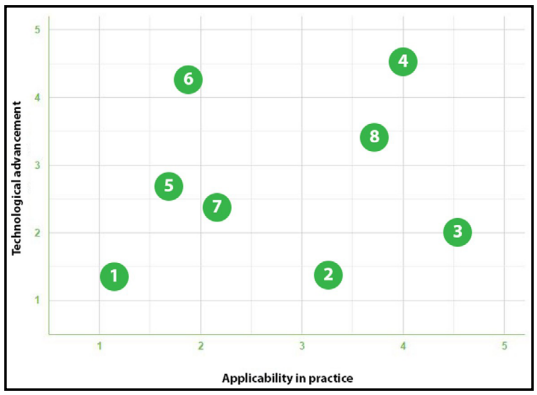
Figure 3: Comparing the potential of technologies in precision agriculture.

- **Vision** - this expresses the intention, finding technological solutions and method of use
- **Potential** - perfect technological solution, the problem is with efficiency and usability
- **The need** - the need in practice, the problem is with technological development
- **Practice** - target state of perfect technological solutions, economic efficiency and high user applicability in practice

Basic forms of presentation of data

Comparing technologies

Basic display of User-Technological Index of Precision Agriculture. The X axis shows the "usefulness in practice" and Y axis shows the "technological advancement." By plotting the values that are statistically treated we get a quick overview diagram for comparing the selected precision agriculture methods and their use in practice (Figure 4).

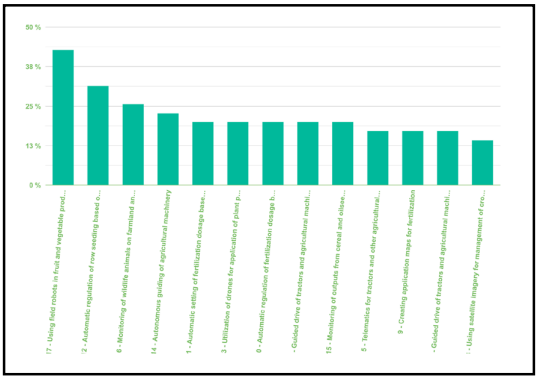


Source: author

Figure 4: Visualization of comparing precision agriculture technologies with UTIPA.

Technology unfamiliarity

UTIPA calculation is based only on assessments that have been assigned points (1-5). A specific evaluation method of precision agriculture is the ratio of respondents who lack the knowledge about a technology and choose the "I cannot judge." option when assigning their evaluation. The output is then a comparison of unfamiliarity of technologies (Figure 5).

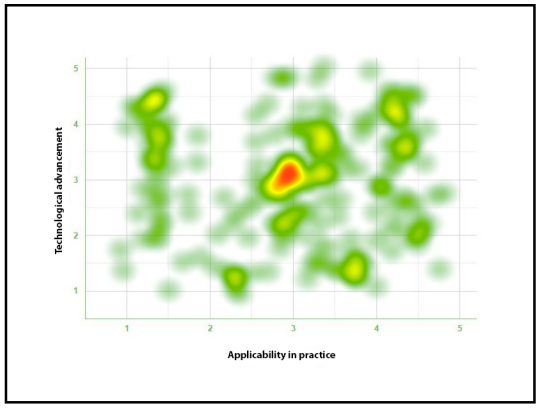


Source: author

Figure 5: Ratio of respondents, who are unfamiliar with given precision agriculture technology.

Rating scattering

The principle of a heatmap is used for graphical presentation of scatter of the individual technology ratings. The red color represents the greatest occurrence, yellow represents successively smaller occurrence and green to turquoise denotes the smallest incidence (Figure 6).

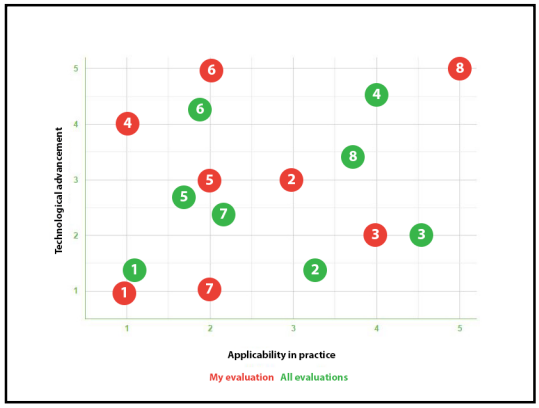


Source: author

Figure 6: Heat map of occurrence of assessments by individual respondents.

Comparing assessments

One of the main benefits of UTIPA is that it allows us to compare the level of use of precision agriculture methods with each other, according to different users, crops, regions etc. In the basic XY chart it displays a color-coded comparison of ratings. Figure. 7 shows the comparison of self-evaluation with the overall average.



Source: author

Figure 7: An example of comparison of assessments from different respondents.

Conclusion

Finding the relationship between technological innovations, economic efficiency and practicality is addressed from the beginning of the development of precision agriculture. There are a number of technologically advanced methods, which did not achieve the expected use in practice. On the other hand, there is real demand of farmers for technological development in many areas. Efficiency and usability depends on local conditions and type of cultivated crops and varies in different countries and evolves over time.

User-Technological Index of Precision Agriculture is a complex system for the international community of people related to precision agriculture, it is accessible to anyone who respects the rules of use. It works on the principle of "what data I provide is the type of data I gain access to". It enables long-term monitoring of developments and trends in precision agriculture. It has significance for the presentation of the potential of precision agriculture, development planning and above all to find the relationship between technological innovativeness and usefulness for practice.

This benefits all the stakeholders. Farmers can find out whether a given technology is useful and has real importance. Suppliers need to know what their customers (farmers) want or expect, but also how they perceive their products. For academia it can be a source of data for science and research. Finally, it can help to raise awareness about the technologies of precision agriculture among professionals.

During following research activities the software solution will continue to be developed. It is expected to include a detailed overview of the various technologies in the web application so that it can be used as a reliable source of information. Visualization will be subject to further research as to deliver significant outputs for individual target groups. One of the goals is to tighten the links and cooperation between farmers, suppliers, academia and the professional community.

UTIPA system is freely available as a web application at **https://www.utipa.info/.**

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Corresponding author:
Ing. Jan Jarolímek, Ph.D.
Department of Information Technologies, Faculty of Economics and Management
Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Prague, Czech Republic
Phone: +00420 224 382 293, E-mail: jarolimek@pef.czu.cz

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Comparative Study of Short-Term Time Series Models: Use of Mobile Telecommunication Services in CR Regions

J. Köppelová, A. Jindrová

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

Abstract

In the area of time series analysis and prediction there are comparatively many methods available, out of which the extrapolation method has been practically applied most often. Currently, combined models have been serving more and more in experimentation. This study is aimed at construction of adequate models of the indicators observed development tendencies, assessment of selected individual models and subsequent aggregation of these into combined models, including a comparative analysis of both types of models. To find suitable candidates for predicting within the time series analysed, SAS system has been used. Outcomes of the empirical study have shown promising results in the use of combined models for time series processing. The techniques presented in the paper are illustrated with examples of short-term time series on monthly and quarterly basis, in the field of mobile telecommunication services, their consumption and use in various regions of the Czech Republic. A description of the current state of use of selected services in separate CR regions, including urban and rural areas, is a natural part of the paper. ICT including mobile phones and use of mobile services, especially in rural areas, is still widely discussed topic.

The research was prepared with the support of the Internal Grant Agency of the Faculty of Economics and Management of the Czech University of Life Sciences, within the project „Methodological Approaches to Identify Economically Weak Regions in the Border Areas of the Czech Republic“(No. 20151035).

Keywords

Time series models, Box-Jenkins Methodology, mobile telecommunications, regions in CR, combined forecasting models, regional policies.

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Introduction

The issue of regional support is one of the most debated topics worldwide. Regional policies are focused at all regions and cities in the European Union. The principal target of those is the support of jobs creation, competitiveness of companies, growth of economics, sustainable development and improvement of the EU citizens´ life quality (European Commission, 2016). Special attention is paid by the regional policies to special development problems of cities and country regions, too.

Regional policies are the principal EU investment policies and are materialized by means of three main funds: European Fund for Regional Development (ERDF), Cohesion Fund (CF), and European Social Fund (ESF). Thereby the necessary scope for investment aimed at the Europe 2020 strategy for the intelligent and sustainable growth targets reaching, supporting inclusion in the EU, is provided. Financing within the scope of cohesion policy for the 2014-2020 period is concentrated at eleven topical targets, out of which the following four are ERDF key priorities: research and innovations, information and communication technologies, competitiveness of small and medium enterprises and low-carbon economics (European Commission, 2016).

This paper is concerned with one of the priorities from above, namely, the information and communication technologies (ICT). Many authors have already dealt with ICT, with mobile telecom and availability of mobile services in separate regions or country areas particularly. In the Czech Republic the issue of high-speed connection to internet and its application in country regions, inclusive of programme equipment analysis of the companies working in such regions,

was studied by Vaněk et al. (2010), within the scope of an extensive survey of ICT development in CR regions.

The authors have continued immediately next year, besides studying the high-speed internet connection issue as such, by analysing acquirement of it by agricultural enterprises in the country (Vaněk et al., 2011). Next, Reigadas et al. (2015) analysed the issue of small country areas in Spain, having bad, or none at all, approach to mobile telecommunication services and chance of wireless infrastructures exploitation, what could, according to the study outcomes, help in solving this problem to a degree. Baro and Endouware (2013) studied the problem of mobile services use in country areas of Nigeria, affecting population´s socio-economic life within the areas. Core of the study by Sundquist and Markendahl (2015) is situated in cost analysis of the regulation measures accessible, that could help improving coverage of country areas by the mobile operators´ signals. Use of mobile phones by Cyprus farmers has been analysed by Adamides and Stylianou (2013). They examined first of all methods of information sharing in agriculture in their study, and they reached a conclusion that, in 98 % of the cases, mobile phone has been exploited for it. Lim et al. (2012) studied the possibility of 3G mobile subscription prediction in separate Chinese provinces, with regard to regional differences.

This paper is aimed at offering a short synoptical study of mobile telecommunications services use in a broader sense - not just in the country but in the whole Czech Republic at the level of individual CR regions. Area of regional development as well as the development of rural areas is still highly topical. This problematic is well known to mobile operators too. Each of mobile operators goes for the greatest possible coverage. They are aimed at coverage of every piece of Czech territory, especially country areas. This effort will bring them greater satisfaction of existing customers and also opportunity to gain new customers. At present is the attention focused on increasing the availability of broadband services, but this is not the only issue. For people living in the country is very important to use all mobile services provided to them by their mobile operators – especially voice services as well as SMS and MMS. Unfortunately problems with coverage in the country still persists and therefore it is not enabled to everyone to make a call or send SMS.

The object of analysis are the services, let us say, revenues from the services, offered by the youngest mobile operator acting on the Czech telecom market - the Vodafone Czech Republic, a.s. (VF) - to their final customers. VF acts as direct provider (SMS services, voice and data services subject to VAT - called TELCO services in the following), as well as an intermediary covering the Audiotex service analysed here (payments to third parties not subject to VAT), inclusive of the numbers of customers generating the revenues. In this study, the indicator of customer numbers is limited on natural persons only (non-company customers) not using the prepaid cards, rather paying for the services after their use only, once a month, by means of invoice (so called consumer postpaid customers). Adequate development trend models construction for time series of the indicators studied, especially the quality assessment of time series models offered by the SAS system, inclusive of comparative analysis of individual and combined models, is going to be the object of this study. Meade and Islam (2015) were engaged in their work with various techniques of time series forecasting, but primarily analyzed the importance of ICT in the field of forecasting and conversely the importance of forecasting for ICT.

Time series analysis, inclusive of their future behaviour prediction, became a very dynamically developing discipline recently. A lot of new efficient and untraditional procedures and methods of time series modelling arose. The principal reason of growing importance of this discipline is the fact of its success in description of the frequently encountered dynamic systems. Modern methodology of statistical procedures has recommended the following sequence of stages when processing time series analyses and forecasting (SAS/ETS User´s Guide, Version 6, 1993):

- data collection
- data examination and possibly cleaning of those
- data preparation for modelling
- preliminary data analysis
- design of a suitable candidate for prognosticating
- obtaining a sample of variables (as far as a multivariate series is being processed
- processing of preliminary modelling
- accuracy and stability of the model detection
- selection and adjustment of the final model

- implementation of the final model.

This research has been mainly focused at one of the stages of the sequence presented above, namely at the design of appropriate candidates for the purpose of making extrapolation forecasts and assessment of these based on selected assessment criteria, inclusive of the mentioned comparison of single models and combined models aggregating forecasts obtained from various single models (Evans, 2002).

The approach to solution of univariate models is possible either using classical trend models (Hindls et al., 2000), or by means of the Box-Jenkins methodology. Interpretation of the Box-Jenkins methodology outcomes is relatively complex. In spite of it, this methodology is considered universal framework of modelling techniques and time series prognosticating. This methodology serves primarily as a starting point for modelling of non-stationary time series and seasonal time series with a complex stochastic structure. Models based on this methodology are considerably flexible and capable of fast adaptation to changes of the modelled process nature. They can describe such time series, too, where the classical analysis models fail (Cipra, 1986). In order to efficiently exploit these methods usually time series long enough are needed, covering about 50 observations. One of the simplest special models, employed by this methodology, is the so-called moving averages model, MA model. Another important special case of Box-Jenkins models are the autoregressive models, AR models. By means of combination, the mixed so-called ARMA model arises. The mixed model is based on an assumption of stationarity of the time series given (Martin et al., 2013). Most of the real economic time series do not satisfy this assumption and in order to apply ARMA models they have to be stationarized somehow. A suitable device to reach this end is to obtain differences of neighbouring time series values. An ARMA model applied on a time series modified this way is denoted the integrated model - ARIMA model. Models of this type are widely applied in various fields. E.g., in the area of hydrology, Dastorani et al. (2016) were dealing with individual cases of the models in their work aimed at examining utility of separate ARIMA model structures for monthly rainfall forecasting in Iran. Success of ARIMA models has been confirmed by Mishra and Singh (2013) in their study dealing with monthly forecasting of peanut prices in Delhi, just applying ARIMA and ANN models. According to all the indicators of predictive model quality assessment selected, the Box-Jenkins methodology, i.e., the ARIMA models, presented itself as more appropriate for prices forecasting of a farm commodity chosen.

Materials and methods

Time series analysis is becoming one of the most important areas in the development of statistics. It finds application in all fields of human activity, such a for example social sciences, medicine engineering. Area of ICT is not the exception. Development of ICT is one of the four main investment priorities for regional policy that targets all areas, urban or rural. For ERDF will be a priority to expand the deployment of broadband connectivity, as well as the development of ICT products and services and foster the use of ICT in these areas (European Commission, 2016).

For the empirical analysis, total of 70 short-term time series provided by Vodafone Czech Republic, Ltd. have been used, out of which 42 with monthly data collection frequency and 28 with quarterly frequency. In all the cases these were time series from the area of mobile telecommunication services in the Czech Republic. The time series concerning indicators of receipts originally were collected on monthly frequency and for the purpose of this analysis they were aggregated into quarterly time series. Length of the reference period ranged from 12 to 36 data.

The current positions of separate CR regions from the viewpoint of the indicators studied have been presented by means of basic statistical measures of location. For the description of development of the indicators studied index analysis has been employed.

Searching for an optimal time series analysis model can sometimes be very lengthy. In order to accelerate this process the model selection regime offered by the Time Series Forecasting System (TSFS) module can be employed. This module brings a chance to diagnose the time series from the viewpoint of trend or seasonality presence, or a necessity of logarithmic transformation of data. The model selection regime then is based on these diagnostic tests when looking for the most appropriate model. The generated models already take into account all the necessary adjustments in the data analysed, e.g. seasonal adjustment in case of detection of significant seasonal component in the time series analysed.

Three best models from the wide supply

of the adaptive, classical analytical and ARIMA models have been chosen for each of the time series analysed, based on diagnostic tests. Single models obtained this way have been then subjected to experimentation concerning their aggregation, i.e., forming of combined models offering forecasts as certain combinations of the forecasts supplied by separate individual models. The SAS System offers a chance of combining separate forecasts by way of a simple or weighted arithmetic average with varying system of weights. In this particular case weighted arithmetic average with the so-called regression weights offered has been chosen. The weights somehow penalize forecasts burdened by higher prediction errors.

In order to compare quality of the models estimated for all time series analyzed, be it the individual or the combined ones, the Mean Absolute Percent Error (MAPE) has been used, defined as

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

where y_t , or y'_t (t = 1, 2, ..., n) are the actual or predicted values of the time series given and n is the number of the time series observations. MAPE is the most common measure of forecast error. This statistics is widely used by many organizations when assessing forecast accuracy. MAPE is easy to interpret because thinking in percentage terms is very comfortable for most people. In order to support appropriateness of the models chosen the determination coefficient R^2 has been used, defined as

$$R^2=\frac{\sum_{t=1}^{n}(y_t-y_t')^2}{\sum_{t=1}^{n}(y_t-\bar{y})^2} \quad (2)$$

R^2 is often used by many authors around the world. It has ben applied, together with the MAPE measure, by Papagera et al. (2014), too, in their research dealing with water balance analysis and water supply changes in the area of Lake Koronia and with forecasting of the indicators studied by means of Artificial Neural Networks (ANN). Another criterion for ANN models quality assessment has been the Root Mean Square Error (RMSE).

The coefficient of determination has been applied, too, by Dastorani et al. (2016) in their work where they analysed and assessed appropriateness of forecasting models for monthly forecasts of rainfall based on time data collected from nine stations in the north-east of Iran, together with analysis of autocorrelation and partial autocorrelation functions of the models, which was employed as a further quality assessment criterion of the models constructed, in this paper, too. Applicability of most time series analytical models, namely, is dependent on satisfaction of the assumption, that, a lot of the residues has a nature of the so-called white noise, which is an uncorrelated random quantity with zero mean and constant variance (Seger and Hindls, 1993). Autocorrelation function (ACF) and partial autocorrelation function (PACF) graphs are one of the devices for the time series models quality assessment (Ranjit et al., 2015).

Autocorrelation function of the residues serves in estimation of autocorrelations between residues with varying time shift. The outcome of autocorrelation function looks like a column where there are the coefficients of correlation presented, between the Y_t series analysed and the Y_{t+k} series, where t = 2, 3, 4, …,T. Besides these correlation coefficients the SAS system offers 95% confidence intervals for the coefficients, in graphical form, too. If the autocorrelation function value exceeds the limit of such interval, it is statistically significant. It means that, the residues need not be of the white noise type, and it is giving a signal to the processing body to introduce a modification of the data, such as, e.g., an adequate transformation of these.

Autocorrelation function supplies an information on the level of relationship between the Y_t and Y_{t+k} quantities, regardless of the impact of other quantities situated between them. In some cases this information is not sufficient. The function expressing level of relationship between the Y and Y_{t+k}, where t = 2, 3, 4, …,T and it is also taking into question correlation coefficients obtained for all the lower time shifts, is the so-called partial autocorrelation function (PACF). The partial autocorrelation function outcomes are interpreted same as with the autocorrelation function, graphically it can be presented by means of correlogram. PACF is a very useful device when establishing the order of autoregression, if autoregression models (SAS/ETS User´s Guide, Version 6, 1993) are being constructed.

Results and discussion

Current state and development analysis of the indicators studied

A total of three indicators were analysed in separate regions of the Czech Republic: number of consumer postpaid customers, total revenues paid by these customers from TELCO services and revenues from Auditex service. Table 1 presents average shares of separate CR regions on the total number of customers and total volume of revenues from the given operator services studied over the period July 2013 - June 2016. The results obtained demonstrate that, the strongest region, i.e., region with the highest share both of the number of customers and of the total volume of revenues from the services by the given operator is Prague Region. The second and third place are occupied by Central Bohemia Region and South Moravian Region. At the last place of the fictitious ladder then is Karlovy Vary Region.

For description of development of the indicators studied of customer numbers and volumes of revenues from TELCO services, value of the basic index from the last period under study can be used, since its values support the total development tendency of the indicators over the period given. Values of the index numbers are summarized in Table 2. The customer numbers in separate regions same as the revenues from TELCO services sold do not present any significant deviations - increase or decrease on the contrary. The customer numbers indicator shows a gradual slight downward trend in most of the CR regions, except for Prague Region, Central Bohemia Region, Liberec Region, Karlovy Vary Region and Ústí nad Labem Region. The revenues from TELCO services sold indicator shows in almost all the regions a slight upward trend, in the regions Hradec Králové Region and Zlín Region there is a constant trend, what is confirmed by the time series diagnostic tests results in the following part of the paper, too. In 6 cases of monthly time series - two of these have been represented just by this indicator - no trend was identified in the tests (sometimes a time series with constant trend may be denoted as trendless series). What concerns the indicator of Audiotex services sold revenues volumes, this indicator shows a very irregular course in all the regions and the base index would have a zero predictive value when analysed from the development viewpoint. Therefore, it is not included in the table 2.

Diagnostic test results of the time series studied

The Table 3 presents results of diagnostic tests of the time series analysed, in an overview. The results are presented not only in absolute terms but in percentages, too.

The table contains absolute numbers of time series studied, showing a trend, seasonality or a need of logarithmic transformation considering

Region	avg share of the total customer base	avg share in total sales of TELCO svc	avg share in total sales of ATX svc
South Bohemia Region	5%	5%	5%
South Moravian Region	12%	12%	12%
Karlovy Vary Region	3%	3%	3%
Hradec Králové Region	5%	5%	5%
Liberec Region	4%	4%	4%
Moravian-Silesian Region	9%	8%	8%
Olomouc Region	6%	5%	6%
Pardubice Region	5%	5%	5%
Plzeň Region	5%	5%	4%
Prague Region	17%	20%	16%
Central Bohemia Region	12%	13%	13%
Ústí nad Labem Region	7%	8%	8%
Vysočina Region	4%	3%	5%
Zlín Region	6%	5%	5%
TOTAL	**100%**	**100%**	**100%**

Source: Own processing based on data provided by Vodafone Czech Republic, Ltd.

Table 1: Average shares of separate regions on total values of the indicators studied.

Region	number of customers - base index in %	revenue from TELCO svc - base index in %	revenue from ATX svc - base index in %
South Bohemia Region	93	102	63
South Moravian Region	96	104	64
Karlovy Vary Region	102	112	75
Hradec Králové Region	91	100	50
Liberec Region	105	115	75
Moravian-Silesian Region	91	107	58
Olomouc Region	90	101	76
Pardubice Region	90	98	58
Plzeň Region	98	109	68
Prague Region	105	110	91
Central Bohemia Region	104	112	64
Ústí nad Labem Region	103	114	100
Vysočina Region	91	102	105
Zlín Region	91	100	68

Source: Own processing based on data provided by Vodafone Czech Republic, Ltd.

Table 2: The base index values of customer numbers and TELCO services revenues.

	Type of time series	monthly	monthly in %	quarterly	quarterly in %	Grand Total	Grand Total
Trend	**no**	6	14%		0%	6	9%
	yes	36	86%	28	100%	64	91%
	Grand Total	42	100%	28	100%	70	100%
Seasonality	**maybe**		0%	28	100%	28	40%
	no	30	71%		0%	30	43%
	yes	12	29%		0%	12	17%
	Grand Total	42	100%	28	100%	70	100%
Log transformation	**maybe**	28	67%	28	100%	56	80%
	no	14	33%		0%	14	20%
	Grand Total	42	100%	28	100%	70	100%
ACF/PACF	**no**	8	19%	3	11%	11	16%
	yes	34	81%	25	89%	59	84%
	Grand Total	42	100%	28	100%	70	100%

Source: Own processing

Table 3: Absolute and percentage results of diagnostic tests.

periodicity of the series given, further on their relative shares on the total number of indicators studied, also in distinction into monthly and quarterly time series. Need of logarithmic transformation has not been proven by the diagnostic test at all, only a possibility to transform the original time series this way has been found. This concerns 56 time series analysed, out of these exactly one half being those quarterly and one half monthly. Presence of the trend component has been identified in most series, only in 6 cases of those monthly has not.

Seasonal component has been proven in monthly time series only, in 29 % cases of the total number of series with monthly frequency. In all cases of quarterly time series there was a chance of seasonal element detected, but this was neither confirmed nor excluded, either.

Assessment of individual models

In Table 4 the models are presented proven as those most appropriate for analysis and prognostication of the time series processed, as based on the diagnostic tests mentioned above and on the assessment criterion chosen. Besides the most appropriate models also the share of these, let us say, their percentage on separate time series under study groups, classified according to data collection periodicity, inclusive of the absolute number of models with the MAPE measure within a certain interval.

	monthly time series		quarterly time series		summary	
Overview of selected individual models	**Models proportion**	**Number of models**	**Models proportion**	**Number of models**	**Models proportion**	**Number of models**
Linear (HOLT) Exponential Smoothing	11%	13	0%		6%	13
MAPE - 5 and smaller	9%	11	0%		5%	11
MAPE - 20 and higher	2%	2	0%		1%	2
Damped Trend Exponential Smoothing	14%	17	0%		8%	17
MAPE - 5 and smaller	9%	11	0%		5%	11
MAPE - between 15 and 20	1%	1	0%		0%	1
MAPE - 20 and higher	4%	5	0%		2%	5
Random Walk with Drift	3%	4	0%		2%	4
MAPE - 5 and smaller	3%	4	0%		2%	4
Log Winters Method Additive	6%	7	25%	21	14%	28
MAPE - between 10 and 15	1%	1	2%	2	1%	3
MAPE - 5 and smaller	5%	6	11%	9	7%	15
MAPE - between 15 and 20	0%		6%	5	2%	5
MAPE - 20 and higher	0%		6%	5	2%	5
Winters Method Additive	10%	12	23%	19	15%	31
MAPE - between 10 and 15	1%	1	1%	1	1%	2
MAPE - 5 and smaller	9%	11	14%	12	11%	23
MAPE - between 15 and 20	0%		4%	3	1%	3
MAPE - 20 and higher	0%		4%	3	1%	3
Log Damped Trend Exponential Smoothing	12%	14	0%		7%	14
MAPE - 5 and smaller	6%	7	0%		3%	7
MAPE - between 15 and 20	1%	1	0%		0%	1
MAPE - 20 and higher	5%	6	0%		3%	6
Winters Method Multiplicative	6%	7	10%	8	7%	15
MAPE - between 10 and 15	0%		1%	1	0%	1
MAPE - 5 and smaller	6%	7	4%	3	5%	10
MAPE - between 15 and 20	0%		2%	2	1%	2
MAPE - 20 and higher	0%		2%	2	1%	2
Linear Trend	1%	1	0%		0%	1
MAPE - 5 and smaller	1%	1	0%		0%	1
Log Linear Trend	1%	1	0%		0%	1
MAPE - 5 and smaller	1%	1	0%		0%	1
Log Linear (HOLT) Exponential Smoothing	11%	13	0%		6%	13
MAPE - 5 and smaller	4%	5	0%		2%	5
MAPE - between 15 and 20	1%	1	0%		0%	1
MAPE - 20 and higher	6%	7	0%		3%	7
Double (Brown) Exponential Smoothing	5%	6	0%		3%	6
MAPE - 5 and smaller	5%	6	0%		3%	6
Log Double (Brown) Exponential Smoothing	2%	2	1%	1	1%	3
MAPE - 5 and smaller	2%	2	0%		1%	2
MAPE - 20 and higher	0%		1%	1	0%	1
Simple Exponential Smoothing	5%	6	0%		3%	6
MAPE - 5 and smaller	1%	1	0%		0%	1
MAPE - 20 and higher	4%	5	0%		2%	5

Source: Own processing

Table 4: Percentages of selected models in the time series groups classified by periodicity.

	monthly time series		quarterly time series		summary	
Overview of selected individual models	**Models proportion**	**Number of models**	**Models proportion**	**Number of models**	**Models proportion**	**Number of models**
Log Simple Exponential Smoothing	4%	5	0%		2%	5
MAPE - 5 and smaller	1%	1	0%		0%	1
MAPE - 20 and higher	3%	4	0%		2%	4
Log Random Walk with Drift	1%	1	0%		0%	1
MAPE - 20 and higher	1%	1	0%		0%	1
Log Winters Method Multiplicative	4%	5	7%	6	5%	11
MAPE - between 10 and 15	1%	1	1%	1	1%	2
MAPE - 5 and smaller	3%	4	1%	1	2%	5
MAPE - between 15 and 20	0%		2%	2	1%	2
MAPE - 20 and higher	0%		2%	2	1%	2
Linera Trend with Autoregressive Errors	0%		4%	3	1%	3
MAPE - between 15 and 20	0%		2%	2	1%	2
MAPE - 20 and higher	0%		1%	1	0%	1
Log ARIMA (0,1,1,)(1,0,0,)s NOINT	0%		4%	3	1%	3
MAPE - between 15 and 20	0%		1%	1	0%	1
MAPE - 20 and higher	0%		2%	2	1%	2
ARIMA (0,1,1,)(1,0,0,)s NOINT	0%		1%	1	0%	1
MAPE - 20 and higher	0%		1%	1	0%	1
Linear Trend with Seasonal Terms	3%	4	12%	10	7%	14
MAPE - between 10 and 15	0%		1%	1	0%	1
MAPE - 5 and smaller	3%	4	11%	9	6%	13
Log Linear Trend with Seasonal Terms	0%		12%	10	5%	10
MAPE - 5 and smaller	0%		10%	8	4%	8
MAPE - between 15 and 20	0%		1%	1	0%	1
MAPE - 20 and higher	0%		1%	1	0%	1
Log Linear Trend with Autoregressive Errors	0%		1%	1	0%	1
MAPE - between 15 and 20	0%		1%	1	0%	1
Linear Trend with Autoregressive Errors	1%	1	1%	1	1%	2
MAPE - 5 and smaller	1%	1	0%		0%	1
MAPE - between 15 and 20	0%		1%	1	0%	1
Summary	**100.00%**	**119**	**100%**	**84**	**100%**	**203**

Source: Own processing

Table 4: Percentages of selected models in the time series groups classified by periodicity (continuation).

It is seen from the outcomes obtained that, in most cases one of the exponential smoothing models and its possible modifications have been selected. As the most appropriate models for analysis and forecasting of short-term time series with monthly periodicity the following models have been found of use:

- Linear (Holt) Exponential Smoothing and its logarithmic transformation
- Damped Trend Exponential Smoothing and its log transformation
- Winters Method (both additive and multiplicative) and its log transformation.

In the quarterly time series the following models have been found of use primarily:

- Winters Method Additive and Log Winters Method Additive
- Winters Method Multiplicative and Log Winters Method Multiplicative
- Linear Trend with Seasonal Term and log Linear Trend with Seasonal Term.

The Box-Jenkins ARIMA models have, in case of looking for the most appropriate model, almost in all the cases where they have been offered for time series modelling by SAS system, placed themselves at the third to fifth place.

The *MAPE* value (its amount) fluctuates according

to situation given. No universally accepted limit has been established for it. Practically, it is possible to meet a situation when a value at 15 % is required, or 5 % otherwise. Anyway, a model showing the *MAPE* value at about 10 % is acceptable. The outcomes obtained show that, in 63 % of time series analysed, models with *MAPE* below 15% have been set up.

The R^2 coefficient of determination has been employed in order to confirm appropriateness of the time series models chosen. Table 5 below demonstrates the results of the two measures used, (*MAPE* and R^2). It is possible to regard these separately, or in aggregation as well. It is seen from Table 5 that, were the two measures of appropriateness assessment considered together, the desired R^2 value would be above 80 % and the *MAPE* value at the same time up to 15 %. Then 81 models out of the total of 203 would present themselves as those very appropriate for modelling of the time series studied. In such a case always 3 best models would be selected for 64 time series as to the *MAPE* value, 2 models would be offered by SAS system to 5 time series and one series would be processed by one only model.

Furthermore, analysis of autocorrelation functions and partial autocorrelation functions has been applied as the next assessment criterion of the models employed quality. In 84 % cases of time series analysed the selected models have satisfied this criterion.

Comparative analysis and combined models assessment

In most individual models chosen the outcomes have been obtained that only slightly differed as to MAPE levels. These were the reasons, too, why construction of aggregated prediction models has been tried. Combined predictions were obtained for separate time series with MAPE values as given in Table 6. For 47 time series the combined models have been loaded by a lower MAPE prediction error - a not very significant one, mostly, anyway - than the single models originally selected. Out of the total of 70 time series analysed the combined models presented themselves as more appropriate for analysis and forecasting of the indicators analysed, as to the MAPE viewpoint, in 55 % of the time series with monthly frequency and in 86 % with quarterly frequency.

In the most successful combinations the models of simple exponential smoothing, exponential smoothing with muffled trend and the Winters´ model of exponential smoothing have been represented most often. As for the number of single models of which the combined models have been constructed, the combination of three single models was the most frequented, in five cases only two models have been involved.

Time series in the area of telecommunications, especially in the domain of third parties services supply (Audiotex, here) frequently record a complex structure, their development is affected by many factors and their modelling can present a difficult problem. Outcomes of the studies dealing with time series modelling and prognosticating using Box-Jenkins methodology show that, this problem could be solvable just through its application. However, the time series studied in this paper do not satisfy the B-J methodology condition concerning the extent of data files. A further research could aim at an empirical analysis of still more extensive set of time series, experimentation with various lengths of the reference period and collection of longer short-term time series but those long-term ones, too.

type of series/R-square	MAPE - 20 and higher	MAPE - between 10 and 15	MAPE - between 15 and 20	MAPE - 5 and smaller	Total number of models
monthly	30	3	3	83	119
more than 80%				55	55
between 30% and 80%	9	3	3	21	36
less than 30%	21			7	28
quarterly	18	6	18	42	84
more than 80%				26	26
between 30% and 80%	8	4	14	16	42
less than 30%	10	2	4		16
Total number of models	48	9	21	125	203

Source: Own processing

Table 5: Overview of the *MAPE* and R^2 results.

INDICATOR	type of series	Type of combination	MAPE
Karlovy Vary Region - ATX revenue	monthly	Combination of 2 best models	29.4698
Hradec Králové Region - ATX revenue	monthly	Combination of 2 best models	**28.4011**
Moravian-Silesian Region - ATX revenue	monthly	Combination of 2 best models	**26.5839**
Zlín Region - ATX revenue	monthly	Combination of 2 best models	**24.0700**
Hradec Králové Region - revenue from TELCO services	monthly	Combination of 2 best models	21.8686
Prague Region - number of costumers (CP)	monthly	Combination of 3 best models	0.5813
South Bohemia Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7892
South Moravian Region - number of costumers (CP)	monthly	Combination of 3 best models	**0.6547**
Karlovy Vary Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7291
Hradec Králové Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7721
Liberec Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7084
Moravian-Silesian Region - number of costumers (CP)	monthly	Combination of 3 best models	0.8596
Olomouc Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7963
Pardubice Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7399
Plzeň Region - number of costumers (CP)	monthly	Combination of 3 best models	0.6618
Central Bohemia Region - number of costumers (CP)	monthly	Combination of 3 best models	0.5739
Ústí nad Labem Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7315
Vysočina Region - number of costumers (CP)	monthly	Combination of 3 best models	0.8099
Zlín Region - number of costumers (CP)	monthly	Combination of 3 best models	0.7259
Prague Region - ATX revenue	monthly	Combination of 3 best models	**17.2691**
South Bohemia Region - ATX revenue	monthly	Combination of 3 best models	**22.3199**
Liberec Region - ATX revenue	monthly	Combination of 3 best models	27.4538
Olomouc Region - ATX revenue	monthly	Combination of 3 best models	**30.2340**
Pardubice Region - ATX revenue	monthly	Combination of 3 best models	**20.8409**
Plzeň Region - ATX revenue	monthly	Combination of 3 best models	**28.1354**
Central Bohemia Region - ATX revenue	monthly	Combination of 3 best models	**20.3211**
Ústí nad Labem Region - ATX revenue	monthly	Combination of 3 best models	**20.4871**
Vysočina Region - ATX revenue	monthly	Combination of 3 best models	**11.6700**
Prague Region - ATX revenue	quarterly	Combination of 3 best models	**15.1758**
South Bohemia Region - ATX revenue	quarterly	Combination of 3 best models	19.0482
South Moravian Region - ATX revenue	quarterly	Combination of 3 best models	**12.0788**
Karlovy Vary Region - ATX revenue	quarterly	Combination of 3 best models	**17.2793**
Hradec Králové Region - ATX revenue	quarterly	Combination of 3 best models	**19.7755**
Liberec Region - ATX revenue	quarterly	Combination of 3 best models	**14.2904**
Moravian-Silesian Region - ATX revenue	quarterly	Combination of 3 best models	23.6456
Olomouc Region - ATX revenue	quarterly	Combination of 3 best models	28.0381
Pardubice Region - ATX revenue	quarterly	Combination of 3 best models	**19.1458**
Plzeň Region - ATX revenue	quarterly	Combination of 3 best models	**14.3764**
Central Bohemia Region - ATX revenue	quarterly	Combination of 3 best models	**23.2126**
Ústí nad Labem Region - ATX revenue	quarterly	Combination of 3 best models	**17.5013**
Vysočina Region - ATX revenue	quarterly	Combination of 3 best models	**13.1043**
Zlín Region - ATX revenue	quarterly	Combination of 3 best models	17.1540
Prague Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.6276**
South Bohemia Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.6532**
South Moravian Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.5062**
Karlovy Vary Region - revenue from TELCO services	monthly	Combination of 3 best models	14.7589
Liberec Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.7244**
Moravian-Silesian Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.5628**

Source: Own processing

Table 6: The *MAPE* values of combined models for all the indicators studied.

INDICATOR	type of series	Type of combination	MAPE
Olomouc Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.4959**
Pardubice Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.6477**
Plzeň Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.5230**
Central Bohemia Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.4832**
Ústí nad Labem Region - revenue from TELCO services	monthly	Combination of 3 best models	14.5551
Vysočina Region - revenue from TELCO services	monthly	Combination of 3 best models	0.6289
Zlín Region - revenue from TELCO services	monthly	Combination of 3 best models	**0.5389**
Prague Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.4933**
South Bohemia Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.7126**
South Moravian Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.4981**
Karlovy Vary Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.6053**
Hradec Králové Region - revenue from TELCO services	quarterly	Combination of 3 best models	**10.4817**
Liberec Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.7252**
Moravian-Silesian Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.6778**
Olomouc Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.6251**
Pardubice Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.6157**
Plzeň Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.5067**
Central Bohemia Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.5666**
Ústí nad Labem Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.6812**
Vysočina Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.4489**
Zlín Region - revenue from TELCO services	quarterly	Combination of 3 best models	**0.6593**
South Moravian Region - ATX revenue	monthly	No combintion	

Source: Own processing

Table 6: The *MAPE* values of combined models for all the indicators studied (continuation).

Conclusion

Mobile telecommunications services are primarily a source of information and enable to improve the quality of life, particularly in rural areas. The importance of mobile services lies especially in the expanding information base, which results in greater availability of various services (internet banking, reservation systems - the purchase of tickets, self-learning etc.). In contrast, mobile services also allow to inform the public about life in the village, local products offer, community events or accommodation options, which are a source of income (tourism = Rural Development).

Consumption of selected mobile services in the Czech Republic has been found as one quite evenly distributed from the CR regional breakdown viewpoint. The separate regions, let us say, the consumer postpaid customers from separate regions, have been using given services of Vodafone Czech Republic Ltd., with almost equal shares as to their numbers in all the regions, as it is shown in the Table 1. Separate regions include urban areas as well as rural areas. Rural and the sparsely populated areas are still disadvantaged because of weakening telecommunication systems, although access to high-capacity telecommunications is essential for the social, cultural and economic life of each of us. ICT development and access to all mobile services is very important for everyone of us whether we live in the city or in the countryside.

In spite of a very irregular development in some of the time series analysed, the models generated for their development description and possible forecasts of their future behaviour have been loaded by comparatively low prediction errors, be it for the single models, or for the aggregation of these. Outcomes of this study show that, the SAS System generated models can be successfully employed for extrapolation forecasting in time series under study. In order to assess whether it is recommendable to apply this process of forecasting, it will be needed to provide empirical analyses in larger extent than the one described in this paper.

It is obvious, too, from the empirical research outcomes that, in order to obtain a more exact forecast, construction of combined models is definitely recommendable. This has been confirmed, e.g., in the research results by Oliveira and Ludermir (2016), the core of which has been laid in quality assessment of the forecasts obtained

through aggregation, let us say, combination of single models. A more detailed exploration of combined forecasts has to be provided applying experimental ways.

Models of exponential smoothing and logarithmic transformations of these have primarily pushed through and participated in the combined models construction, out of all the models examined. The Box-Jenkins ARIMA models ranked almost always at the third to fifth place in the sequence of models when looking for the most appropriate one, as seen from the MAPE assessment measure viewpoint. ARIMA model estimation is a very complex matter and it is processed over several stages (identification, estimation, verification) that assume experience and perfect knowledge of the methodology. SAS System facilitates the procedure to the analyst by means of the TSFS module, since it processes the stages mentioned automatically. It is needed to underline, anyway, that this procedure need not bring an optimal, let us say, satisfactory result.

Zahan and Kenett (2013) applied TSFS in forecasting energy consumption in selected countries of Asia, inclusive of the development analysis of the indicator. Quality of the prognostic models here was assessed by means of MAPE.

Corresponding author:
Ing. Jana Köppelová
Department of Statistics, Faculty of Economics and Management
Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Prague, Czech Republic
Phone: +420 777 352 035, E-mail: koppelova@pef.czu.cz

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Agricultural Insurance and Bounded Rationality

J. Křečkova, H. Brožová

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

Abstract

Bounded rationality influences the individuals making decisions. Rationality of decisions is limited by the complexity of the decision problem, the cognitive limitations of decision makers, and the time available to make the decision. One specific case of this situation is decision on the agricultural insurance. The success of agricultural activity is highly dependent on environmental influences in the region. These risks can destroy entire harvest or exterminate a whole herd of livestock. The Czech Republic, through the Support and Guarantee Fund for Farmers and Forestry, provides farmers and forest managers with a contribution to cover the costs of the payment of insurance against unforeseen damage for already several years by which it affects decision-making about insurance. The article discusses the rationality of decision on the agricultural insurance using decision model under risk.

Keywords

Decision-making, agricultural insurance, claim, alternative, payoff, risk.

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Introduction

The modern theory of economic decision-making assumes that rational decision-making is based on maximizing the expected utility, which means that one would have to be equipped with unlimited knowledge, information, time and ability to process these data. The possible impact of emotions on decision-making is generally ignored by this theory. However, the expected utility theory in its original form included the idea that persons generated their wealth based on the pain and the joy that it will bring them.

Bechara and Damasio (2005) examined the hypothesis of somatic markers, which assigns each decision some subsequent emotional experience, which allows us rapidly eliminate unfavourable alternatives. Therefore, they proposed a neuronal model of economic decision-making in which emotions are seen as the major factor in decision-making. They further proved that rational decision-making is influenced by previous emotional processing. It causes a situation whereby the human factor rarely behaves as homo economicus, maximizing utility. Using the somatic marker hypothesis, it has also been proved that people often base their judgement on hunches, feelings and subjective assessments of consequences (Loewenstein et al., 2001).

Exact economic models usually do not take into consideration these emotional factors and do not use them in their theories.

One of the first who dealt with the theory of rational decision-making is Simon (1955, 1972). He arrived at a conclusion that, objectively, rational decision-making is not realistic because of excessive demands on the cognitive capacity of decision-makers for whom it is too difficult to handle the complete set of information or who has only partial information about decision-making alternatives. He admits that in such a case it is difficult to choose the alternative that maximizes the expected utility. As a solution, he offers the use of models, the finding of acceptable solutions and possible replacement of the optimization criteria with criteria of satisfactory performance. According to Stigler (1961), one can deal with incomplete information using Theories of the allocation of resources. What falls into this category is, for example, the Sequential sampling theory, which deals with issues like: should I decide now or wait until I gather more information? This problem is addressed by comparing incremental costs of the extension of the sample with an expected gain, i.e. with regard to how the potential decision improves.

Rubinstein (1988) uses in his work the Allais

paradox that deals with human behaviour during the decision-making process when, while actual choices are made by individual decision-makers, there is a conflict with the prediction according to the expected utility theory. Decision-making is based on similarity relations on the probability and prize spaces. Rubinstein points out certain characteristics of decision-making schemes used to determine the preferences of decision-making alternatives and also supports the idea of Herbert Simon in his work: "There is an urgent need to expand the established body of economics analysis... to encompass the procedural aspects of decision-making."

However, some authors, for example von Neumann and Morgenstern (1944), approach the expected utility theory while understanding the decision-maker to be a rational economic entity who is trying to choose the alternative with the highest expected value or utility. This traditional understanding of economic decision-making, however, is undermined by the Prospect Theory which describes decision-making based on the implementation of possible losses or profits, not the final outcome, so the decision-maker selects decisions which, however, may not be optimal (Tversky and Kahneman, 1981; 1974). This theory, however, achieves different results for optimistic and pessimistic decision-makers and it has been proven that optimistic decision-makers make better decisions (Abramson et al., 1978).

An appropriate way of modelling of the decision-making process and the analysis of the consequences of bounded rationality is the use of decision-making models, models of games against the nature (Smith, 2004; Rubinstein, 1998; Tversky and Kahneman, 1981; Kahneman and Tversky, 2000). Tversky and Kahneman also deal with the influence of the framing effect of the decision-maker's view of a problem. Rydval et al. (2014; 2012) discuss the limited rationality through the framing effect and its impact on the loss of information and information asymmetry in the market environment. They define the framing effect as a set of expectations and opinions of entities involved in the given decision-making process where there are elements of bounded rationality.

The decision-making in the agricultural insurance is very complicated task because it needs to estimate many parameters. Some results of these topics can be found for instance in Špička and Vilhem (2012), Liu et al. (2016) or Šturcová (2013). This article discusses the rationality of decision-making concerning the agricultural insurance using decision-making models under risk. The paper is organised as follows: the first part consists of a description of the decision-making model, the second part shows its practical application to the agricultural insurance, the third part analyses results of the mathematical model and human approach based on bounded rationality.

Materials and methods

Model of decision-making under risk

The aim of the decision-making model under risk is to help a decision-maker to select one of his strategies – alternatives that are available. The alternatives effect depends on possible future states of nature and is expressed as payoffs associated with each alternative /state of nature combination. The future result of a selected alternative depends also on the probabilities with which the states of nature are realized (Pratt et al., 1964; Bonini et al., 1997). The general format of a decision model under risk is provided in Table 1.

		States of nature			
		S_1	S_2	.....	S_n
Alternatives	A_1	v_{11}	v_{12}	.....	v_{1n}
	A_2	v_{21}	v_{22}	.....	v_{2n}
	.....	.....	.....	.....	.....
	A_m	v_{m1}	v_{m2}	.....	v_{m3}
Probabilities		p_1	p_2	.....	p_n

Source: own processing

Table 1: Decision-making table

where

- A_i is the i-th alternative, $i = 1, ..., m$,
- S_j is the j-th state of nature, $j = 1, ..., n$,
- v_{ij} is the payoff of alternative A_i and state of nature S_j combination, and
- p_j is probability of state of nature S_j.

The selection of the best alternative is the goal of the decision-making model. The appropriated alternative is specified according to a decision-making criterion typically the maximisation of the output. So we will suppose hereafter that the best alternative maximises the payoffs value. A commonly used criterion is the Expected Monetary Value Criterion (EMV); the alternative is selected if it has the maximal mean value of the payoffs (1).

$$EMV_i = \sum_{j=1}^{n} p_j v_{ij} \quad i = 1,...,m$$
$$A_I: \quad EMV_I = \max_{i=1,...,m} EMV_i \tag{1}$$

Another approach is the estimation of the fitness of the alternatives depending on the analysis of their dominance. The simplest case of dominance is the outcome dominance, defined as follows: alternative A is dominant over alternative B if A always gives at least as good a result as does B, $\min_{j=1,\ldots,n} v_{Aj} \geq \max_{j=1,\ldots,n} v_{Bj}$. It is the strongest form of dominance.

Event dominance is the second form of dominance. Alternative A is dominant over alternative B if A always gives better result as does B, $v_{Aj} \geq v_{Bj}$ $j = 1,\ldots,n$.

An interesting case of dominance of decision alternatives is the canonical first-order stochastic dominance which is defined as follows: alternative A has a first-order stochastic dominance over alternative B if, for the required outcome x. A gives at least as high probability of receiving at least x as does B, and for some x, A gives a higher probability of receiving at least x, $P(v_A \geq x) \geq P(v_B \geq x)$. It is the weakest form of dominance but it describes an overall behaviour of alternatives from the point of view of the outcome. It can be graphically displayed as a graph of cumulative probability $P(v_A \geq x)$ which is called a risk profile (Pratt et al., 1964; Bonini et al., 1997).

Data

To build the models, data of one of the largest Czech insurance companies providing agricultural insurance were used. Generally, the livestock insurance covers almost 80 % of the livestock and crop insurance covers about 60 % (SZIF, 2014). In this paper, only active insurance policies for the period 2010 - 2015 and to them related insured events from the area of insurance of animals, crops and forests were processed. For the analysis almost 10.000 records of annual policies were used.

Table 2 contains information on the distribution of individual types of damage in this sense, their average premium and the average insurance settlement for each group of damages.

From the values listed in Table 2, it is clear that in the event that the client decides "To get insured" but will not have any damage, he or she will have, as a consequence of this decision, the average costs given by the sum of premium in the amount of CZK 61,222. The biggest costs will be incurred in a situation when the state of nature "Small claim" will be sustained since the average small claim accounts for only less than 24% of the average premium. In "Medium claim", it's already almost 73%. At the same time, from Table 2 it ensues that, in the event of "High claim", we can cover damages at twice the amount than we have pay as a premium.

In the case that the client decides "Not to get insured" and there is "No claim", the client has no costs but, in the opposite extreme case, the client can sustain a loss of more than CZK 0.5 million (not receiving insurance settlement). Any damage will probably have to be covered only using the client's own funds.

Results and discussion

Analysis of the best decision in problem of agricultural insurance

To select an optimal decision, a decision-making model was put together, in which there are two alternatives for a decision. We assume that the decision-maker chooses the alternative either "To get insured" or "Not to get insured". The impact of both of the decisions depends on the future, on whether an insured event occurs or not.

Individual states of nature are formed by states of the insured event. Insured events were divided

Type of damage		No claim	Small claim	Medium claim	High claim
Interpretation		No insurance settlement	Insurance settlement at maximum 1/2 of the premium	Insurance settlement from 1/2 of the premium up to the premium	Insurance settlement higher than the premium
Representation (%)		91.33	2.78	2.13	3.76
Premium (CZK)	Min	360	1 676	1 063	500
	Avg	61 222	373 898	491 751	265 210
	Max	2 888 988	5 700 051	6 141 176	2 041 188
Average insurance settlement (CZK)	Min	0	759	768	800
	Avg	0	89 685	356 870	553 142
	Max	0	2 593 651	3 622 259	6 871 716

Source: own processing

Table 2: Distribution of damages according to the premium of individual clients and their premium and damages.

into four categories, namely: “No claim”; “Small claim”; “Medium claim” and “High claim”. A small claim is such whose insurance settlement does not exceed half of the premium paid by a specific client. The amount of insurance settlement in a medium claim is in the interval from half of the premium to the whole premium in a specific client and the amount of insurance settlement in case of a high claim exceeds the value of the given premium.

The decision-making table contains individual payoffs for combinations of decision alternatives and states of nature. In this case, the payoffs are determined based on the difference between costs associated with the payment/non-payment of premium and the paid/unpaid insurance settlement. The actual amount of damage/ claim is not necessary to take into consideration because payoffs for each state of nature would be changed in both alternatives by an equal value. If the decision-maker is insured, the payoff is equal to the difference between the insurance settlement and paid premium. If the decision-maker is not insured, the payoff is equal to the loss of the expected but not received insurance settlement.

The decision-making model is shown in Table 3 where the average payoffs are set out as well as objective probabilities of each of the state of nature (the risk vector) that have been determined based on the occurrence of damages in the previous years. It is most likely (91.33%) that the client will not sustain any damage and unlikely (3.76%) that the client will sustain high claim.

The best alternative

Payoffs of individual alternative of decisions move in the following intervals:

To get insured:

$$v_1 \in \langle d_1, h_1 \rangle = \langle \min_{j=1,2} v_{1j}\,, \max_{j=1,2} v_{1j} \rangle = \langle -284{,}213;\ 287{,}932 \rangle$$

Not to get insured:

$$v_2 \in \langle d_2, h_2 \rangle = \langle \min_{j=1,2} v_{2j}\,, \max_{j=1,2} v_{2j} \rangle = \langle -553{,}142;\ 0 \rangle$$

The final payoffs in this decision-making situation may therefore be in the range of values:

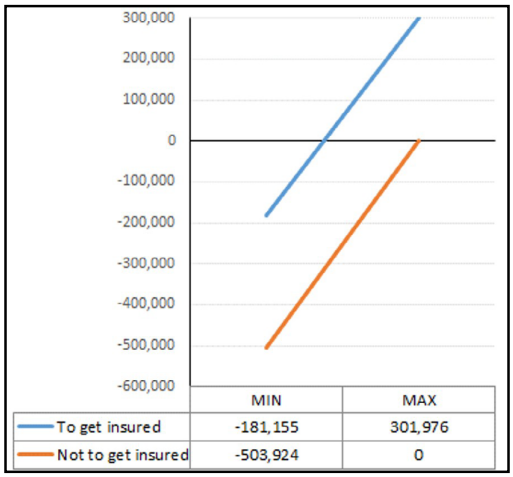
$$v \in \langle D, H \rangle = \langle \min_{j=1,2} \min_{j=1,2} v_{ij}\,, \max_{j=1,2} \max_{j=1,2} v_{ij} \rangle = \langle -553{,}142;\ 287{,}932 \rangle$$

Decisions about the best alternative may be made based on the EMV. The alternative with the maximum value of the EMV is chosen if the payoffs are of the profitable type. In the first alternative, the decision-maker can expect a payoff in the amount of CZK -55,865 while in the "Not to get insured" alternative, the expected payoff amounts to CZK -30,881. According to this method and the information set out in Table 3, the client should therefore not get insured, the best alternative is the "Not to get insured".

The alternatives were further analysed and evaluated by the outcome dominance, event dominance and stochastic dominance.

Outcome dominance

This is the strongest form of dominance. In order to be able to exclude one of the decision-making alternative, it would be necessary for the dominant alternative to have each payoff better than or at least as good as payoff of the dominated alternative.



Source: own processing

Figure 1: Outcome dominance.

(in CZK)	No claim	Small claim	Medium claim	High claim	EMV
To get insured	-61,222	-284,213	-134,881	287,932	-55,865
Not to get insured	0	-89,685	-356,870	-553,142	-30,881
Probability of the occurrence	91.33 %	2.78 %	2.13 %	3.76 %	

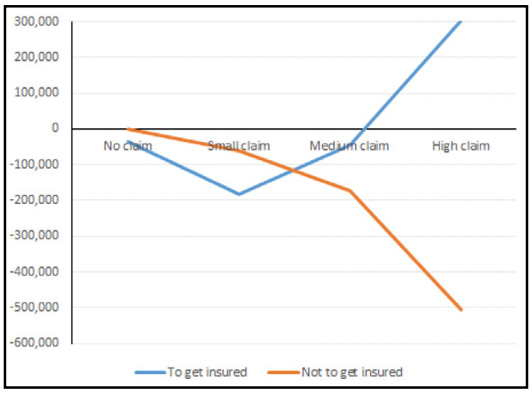
Source: own processing

Table 3: Decision-making model and EMV criterion.

According to Figure 1, there is no dominance among the alternatives depending on the payoffs since the worst payoff of the "To get insured" alternative is not better than or as good as the best payoff of the "Not to get insured" alternative.

Event dominance

This is a weaker form of dominance since it is sufficient if the dominant alternative provides for each state of nature a payoff better or as good as the dominated alternative. From Figure 2, it is evident that between individual alternatives of the decision "To get insured" and "Not to get insured" there is again no dominance depending on the states of nature. However, what is important is the progress of payoffs of individual alternatives, which shows the distribution of payoffs for individual states of nature. It can be stated that for the case of a medium and high claims, it is more beneficial for the client to have insurance since without insurance the client could sustain a loss ranging from more than CZK 350,000 to more than CZK 550,000 (Table 3). In the case of a small or even no claim, the opposite is true. The client will sustain lower costs in case of a decision "Not to get insured" - the amount of premium would indeed have exceeded the insurance settlement.



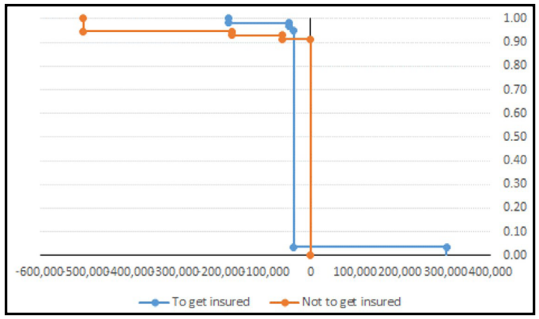
Source: own processing

Figure 2: Event dominance.

Stochastic dominance

This is the weakest and the most complex form of dominance, which analyses the cumulative probability of achieving the required amount of payoff. From the data presented in Table 3, it is possible to construct the risk profile - a graph of cumulative probabilities, which shows the comprehensive view of the probability of achieving a certain level of payoffs by individual alternatives.

From Figure 3, it is clear that no alternative dominates based on stochastic dominance. There is a 97% probability that if the client is insured, he or she will sustain a loss of more than CZK 134,000. And there is an almost zero probability that the client would be paid the insurance settlement for the damage that would be twice the value of the premium the client paid. On the other hand, if the client does not get insured, he or she risks a big loss but the probability of this loss drops rapidly to zero. It is true that the client may sustain a loss of more than CZK 0.5 million with the probability of 96% but, at the same time, with 91% probability he or she will not sustain any damage.



Source: own processing

Figure 3: Stochastic dominance.

Discussion

A rational decision-maker is able to choose the best alternative after a decision-making process based on all available information according to the selected criteria. In the case of the decision under risk, the best alternative is selected according to the EMV criterion. The proposed model shows as the best alternative "Not to get insured" although the both expected payoffs are negative.

In the case of the alternative "Not to get insured", however, even the actual payoffs is non-positive. Either the damage does not occur and the payoff is zero - premium is not paid, or some damage occurs and the decision-maker is forced to pay it using his or her own funds (which is modelled as the amount of a not received insurance settlement). In the case of the alternative "To get insured", the results are negative, the decision-maker sustains a loss because the premium is higher than the supply, only in case of a high claim the payoff is positive, the decision-maker gets considerable funds to cover it.

The question is, why do decision-makers get insured then? From the emotional standpoint, the decision "To get insured" is easily justifiable by a fear of a high loss. The analysis of the stochastic dominance, however, shows that this situation has a very small probability. On the other hand,

the event dominance analysis shows a significant advantage of the alternative "To get insured" in the state of nature "High claim". This view is the basis for decision-making of the risk aversion decision-maker. Additionally, the decision-maker has incomplete information on the possible occurrence of the uncertain states of nature.

Considering the actual amount of damages, payoffs of individual alternatives for a specific amount of damages were further reduced by this amount – the entire behaviour of the payoffs would thus be even more moved towards negative values. The decision-maker should then choose a "Not to get insured" alternative even more. However, due to the size of the potential loss, the decision-maker is not able to rationally process the information about the probability of the occurrence of an adverse event and the respective payoff and chooses the "To get insured" alternative. It is a manifestation of the paradigm of bounded rationality. The irrational choice of alternative "To get insured" is also supported by the effect of subsidies provided by the Support and Guarantee Fund for Farmers and Forestry (PGRLF, 2016) which reduces the insurance costs by 30 - 50% of the premium paid, however the decision model with 40 % discount showed similar results as original one. The psychological effect of this relatively high subsidy moves the decision-making closer to the "To get insured" alternative. Therefore the total premium paid slightly increases in agricultural insurance (Špička and Vilhelm, 2012).

Conclusion

The result of this article is to confirm the existence of bounded rationality in agricultural insurance in the Czech Republic since the clients, according to the results of EMV and based on individual analyses, should not get insured. Bounded rationality seems to originate here due to insufficient information on payments in the insurance industry, excessive complexity related to the selection of the best solution and, of course, due to the fear of an impending loss. It seems to be financially more acceptable to clients to pay regular but smaller amounts than to pay eventually a one-time but a very high amount of money.

The decision-making about agricultural insurance is discussed by Liu et al. (2016) and Šturcová (2013). Both authors show that the cost of agricultural insurance and probability of damage occurrence are important factors in the decision process whether to get insured or not.

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Corresponding author:
Ing. Jana Křečková
Department of Systems Engineering, Faculty of Economics and Management
Czech University of Life Sciences Prague, Kamycka 129, 165 00 Prague 6, Czech Republic
Phone: +420 224 382 374, E-mail: kreckova@pef.czu.cz

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Valuation of Public Goods: The Case of Emissions from Livestock Holdings in the Czech Republic

M. Malý, P. Hálová, M. Havlíková, Z. Žáková-Kroupová

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

Abstract

Designed paper is focused on the analysis of public goods in the form of greenhouse gas emissions in livestock production in Czechia. The main aim of the paper is to quantify the amount and valuation of greenhouse gas emissions produced in beef cattle breed (dairy and meat), pig breed, and poultry breed (meat and eggs). The partial aim of this paper is to compare greenhouse gas emissions production across sectors of livestock production and to evaluate a development of volume, value and share of emissions as a form of public goods. The methodology is based on the conceptual model MITERRA-Europe (The model was developed to assess the effects and interactions of policies and measures in agriculture on N losses and P balances at a regional level in EU-27), which is partly based on the CAPRI (Common Agricultural Policy Regionalised Impact) and the GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) models using the tools for quantification of the emission factors indicators defined by the IPCC (Intergovernmental Panel for Climate Change) organizations. Part of the solution is to determine the value of public goods quantified through a European platform for carbon emissions trading with its futures contract based on the EU Allowances. The result of this paper is quantified emission value of public goods in livestock production in Czechia and their appreciation in the period 2000-2014. In the final consequence is quantified the proportion of the value of public goods in the total production of the analyzed livestock sector.

Keywords

Public goods, greenhouse gas, emissions, valuation, livestock, polluter, emission factor, conversion ratio, agriculture, willingness to pay.

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Introduction

Production of public goods in the form of greenhouse gases is currently an integral component of a number of processes which are, unfortunately, connected with a wide range of human activities. In the present paper between public goods included greenhouse gas emissions. Classification, respectively designation of greenhouse gases as public goods is not entirely clear where the differences arise classifications of different scientific disciplines. At the political level, public goods are replaced by synonymous with "public benefit or harm" and are referred to as products or services available to the public, which can be stated as well as greenhouse gases. Therefore, their emissions seen as a public good. The amounts and growth of the total emissions is a very serious problem which humanity will have to tackle in a relatively short term if it wants to continue inhabiting this planet sustainably. The total emission has been growing massively in the long term; according to the Intergovernmental Panel for Climate Change (IPCC, 2006), greenhouse gases themselves are largely liable for the climate change on the planet. The structure of origin of the global production of said gases is an interesting fact. Generally speaking, it can be concluded that the transport sector is primarily responsible for the production, but a considerable part is produced by the agricultural sector, in which livestock production is the chief producer (see e.g. Dace and Blumberga, 2016). The paper at hand is then focused on an analysis of production and valuation of greenhouse gases in the livestock production sector in the Czech Republic. The current rate of knowledge derived from scientific publications in the Czech Republic is aimed quite generally to the production of greenhouse gases without sufficient disaggregation to the agricultural sector, see e.g. (Picek et al., 2007), (Exnerová and Cienciala, 2009) or (Andrlík, 2014).

At the same time it is not currently published research on the valuation of public assets in the form of coherent emission (carbon dioxide - CO_2, nitrogen oxides - NO_x, methane - CH_4) from livestock production broken down into sub-sectors. Given the above, the main objective is to quantify the amount and value of greenhouse gases generated by the breeding of beef and dairy cattle, pigs and poultry, and to compare the structure of the polluters. The analysis will deal with emissions of the three most debated gases, namely methane (CH_4), nitrogen oxides (NO_x) and carbon dioxide (CO_2). A secondary goal is to compare the production of gases both among sectors in Czechia. Last but not least, we will also make an assessment of the development of the amount and value of emissions produced by livestock production including the determination of the ratio value of the share of public goods in production in the direction of the utility. Determining the value of public assets in the form of greenhouse gases were carried out in accordance with the methodology of the European Climate Foundation (ECF, 2015), which uses the tools of indirect valuation of public goods by willingness to pay (WTP).

Materials and methods

The achievement of the set objective is conditioned by acquisition of information and data, which in this case means sectoral indicators for the different branches of livestock production in Czechia. The resulting dataset is composed of aggregate indicators of livestock production emissions in the form of time series with an annual periodicity from 2000 to 2014. The final database is then expanded with emission indicators for the studied country; the total extent of the database is 927 observations. The dataset is generated from databases provided by the Czech Statistical Office - CSO CR (CSO, 2016), Ministry of Agriculture - MA CZ (MA, 2016), EUROSTAT (Eurostat, 2016), European Climate Exchange - ECX (ECX, 2016) and the Directorate General for Energy of the EU (DG Energy, 2013) and of course, all data (using basic indicators of the sectoral economy) were recalculated to adequate (comparable) units. The solution is then based on the conceptual model MITERRA-Europe, which is partly based on the CAPRI (Common Agricultural Policy Regionalized Impact) and GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) models, (Lesschen et al., 2011). Based on the above approach, we construct indicators of feed conversion, specify the development of utility trends in the disciplines in question, and last but not least, determine indicators of areal burden as an indicator of the degree of concentration to account for the different types of animal breeding, notably divided into intensive and extensive. The above is then quantified into "conversion ratios", used to express the so-called emission factor, which is decisive for the production of each gas by the specific livestock production category. The methodology described has been applied in similar studies; see, e.g., Lesschen et al. (2011), Monteny (2006), etc. The derivation of the emission factor can be illustrated on an example based on Equation (1) (IPCC, 2006), but it is advisable to keep in mind that the necessity to include a specific constant makes the resulting equation only applicable for the derivation of the emission factor for methane. Nitrogen oxides and carbon oxides require an adequate transformation of the specific constant.

$$EF_i = VS_i \times 365 \times B_i \times 0{,}67 \times \sum_{jk} CF_{jk} \times MS_{jk} \quad (1)$$

Where:

EEF_i annual emission factor (kg) for animal type i

VS_i daily VS - volatile solids[1] excreted (kg) for animal type *i*

B_i maximum gas production capacity (m^3/kg of *VS*) for manure produced by animal type *i*

CF_{jk} conversion factors for each manure management system j by climate region *k*

MS_{jk} fraction (%) of animal type *i*`s manure handled using manure system *j* in climate region *k*

From the defined equation (1), a simple modification (see equation 2) is used to derive the total production of the gas in question in the given year by the specific livestock production category.

$$E = \frac{EF \times P}{10^6} \quad (2)$$

Where:

E Emissions (Gg[2]/yr.)

EF Emission Factor (kg/head/yr.)

P Population (head), alternatively animal production (kg)

Due to the possible adjustment to the emission factor,

[1] Volatile solids are the organic fraction of total solids in manure that will oxidize and be driven off gas at a temperature of 600°C.

[2] Gg = Gigagrams

or its units, the total gas emission is quantifiable in a number of alternative forms. The most commonly used include the "per head" gas emission, but a number of studies (e.g., Herd et al., 2015, Solilová and Nerudová, 2015, and Turčeková et al., 2015) use probably more accurate calculations, which most frequently employ a conversion to a final production unit, but that requires further corrections, particularly in the category of beef, pork and poultry meat, consisting in a conversion of production of slaughter-processed meat to "edible meat" using a fixed coefficient; see, e.g., Lesschen et al. (2006). The same procedure will be applied by the paper at hand. The above correction does not apply to production of milk and eggs, but they too require some adjustments when converting units, particularly between litres and kilograms of milk, and pieces and kilograms of eggs.

For pricing of agricultural production were quantified weighted price of the analyzed sectors, in the form of weighted prices of the agricultural producer (MA CZ, 2016). To determine the appropriate weight ratios were quantified representation of individual utility lines in the output of which was using the session set the final price. Determining the value of public goods in the form of greenhouse gases were carried out in accordance with the methodology of the European Climate Foundation (ECF, 2015) and European Environment Agency (EEA), which uses the tools of indirect valuation of public goods by willingness to pay (WTP). WTP method is based on the valuation of the output of greenhouse gases through the European Climate Exchange (ECX), which is a form of commodity exchanges set the price of CO_2 emission allowances. ECX futures is the most liquid, pan-European platform for carbon emissions trading, with its futures contract based on the underlying EU Allowances (EUAs) and Certified Emissions Allowances (CERs) attracting over 80% of the exchange-traded volume in the European market (EEA, 2016). The value of emission allowances (ECX/ivesting.com [cit.on-line 06.12.2016]) is determined exchange-only CO_2 and is therefore also used the methodology of the Ministry of Industry of the Czech Republic, which determines the possible conversion coefficients (Global Warming Potential - GWP) for the conversion of NO_x and CH_4 to CO_2 equivalent. Total greenhouse gas emissions is defined as the sum of the products of the greenhouse gas emissions of the relevant conversion coefficients GWP. These coefficients indicate how many times a given gas absorption of terrestrial radiation more effective than carbon dioxide. GWP values for basic gases and time horizon of 100 years are as follows: CO_2 1, CH_4 21 a NO_x 310.

Results and discussion

With reference to the methodology formulated above, we first derived the emission factors, see Table 1, which make significant contributions to the final emissions from the livestock production category.

As part of the assessment of the emission factors attained, it can be said that there are significant differences among the livestock production branches in terms of predisposition for production of the gases assessed, which constitutes, with respect to the methodology, a fundamental basis for a comparison among the livestock production branches.

In the following, an analysis of the production of the gases in question is made based on the Emission factors (EF) attained (see Table 2), with an assessment of the amount and overall development of the emissions, including a quantification of the structure of emitters in livestock production in Czechia. Table 2 below shows an insight into the estimated development of the methane emissions in Czechia for the branches analyzed.

The results indicate that the cattle breeding sector is an absolutely dominant branch of livestock production in Czechia in terms of the CH_4 emission – its total contribution (summing up the meat and milk) is almost 90%. The remaining branches are incomparable by orders of magnitude, primarily due to the different composition of the feed rations, which is the primary reason

Emission	*Beef*	*Crow (milk)*	*Pork*	*Poultry*	*Eggs*	
CH_4	57.5	101.3	3.0	0.3	0.1	kg/animal/year
CO_2	13.3	1.3	3.5	1.6	1.7	kg /kg production
NO_x	20.0	30.0	40.0	14.6	12.7	g/kg production

Source: own calculation by Cederberg et al. (2009), IPCC (2006), Monteny et al. (2006), Jelínek and Plíva (2003)

Table 1: Emission factors.

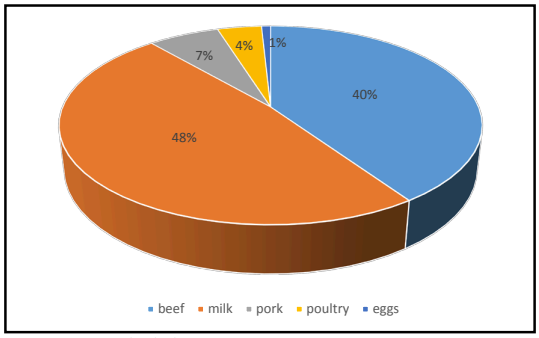
Year	Beef	Milk	Pork	Poultry	Eggs	SUM
2000	55128	62247	11156	4952	1643	135126
2001	55809	61907	10871	5295	1635	135518
2002	53121	60375	10409	6008	957	130870
2003	50802	59770	10172	5156	986	126886
2004	49188	58005	9458	4966	895	122512
2005	47356	58090	8702	5052	832	120032
2006	46571	57077	8592	5049	884	118173
2007	47536	57174	8562	4759	880	118912
2008	47892	57580	7360	5462	883	119178
2009	46196	56680	5964	5207	905	114952
2010	45887	55814	5775	4842	870	113188
2011	45549	55843	5291	3929	859	111471
2012	46141	55812	4776	3988	750	111466
2013	46052	55882	4800	4166	1014	111913
2014	46552	57101	4892	3824	946	113315
ø	**40.46%**	**48.20%**	**6.48%**	**4.03%**	**0.83%**	**100%**

Source: own calculation

Table 2: Emission CH_4 (t).

for the extremely different emission factor of cattle. This is manifested even when comparing the dairy and beef sectors of cattle breeding. An interesting fact is that the overall development of the emission has one identical element in all the branches but totally different trends. The common feature is an overall decrease in the emissions, clearly due to a reduction in the numbers. The most radical decrease of the emission during the study period was that in methane production from pig breeding, showing a slump to almost one-third of the period-initial figures. The second-biggest decrease was realized on average in the egg production sector. The cattle breeding sectors assessed then differ slightly from each other – beef production showed a more noticeable decrease in the emission than the dairy sector, but the overall amount of the emission from these two branches determines that the volume decrease significantly exceeds the total production from all the other sectors, which documents the importance of environmental policy interventions in exactly this branch. Another remarkable aspect is the relatively high variability in the emission amounts in the poultry sector, which does not quite match the development of the numbers, probably indicating a change in the structure of the fodder dose, which influenced the emission factor in the individual years. A detailed definition of the structure (on average for the study period) of the methane emissions in Czechia is shown in Figure 1.

The other area of study is the emissions of nitrogen oxides (NO_x), among which primary attention is paid to nitrous oxide, which currently represents the greatest threat to the climate, since its negative effects are multiplicatively stronger than those of methane and carbon oxides due to its ease of reaction with ozone (see, e.g., Araujo et al., 2006).



Source: own calculation

Figure 1: Structure of CH_4 emitters in Czechia.

Based on equations (1) and (2), we quantified the emissions of NO_x associated with livestock production emissions in Czechia; see Table 3.

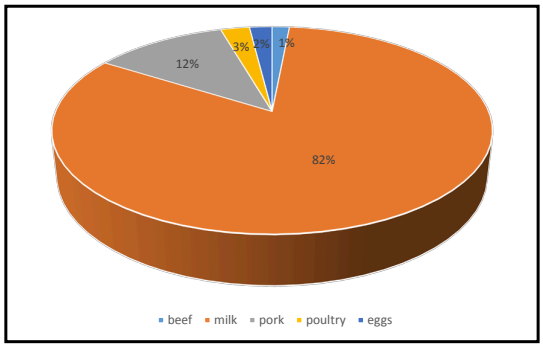
The derived outcomes are relatively shocking, as it can be concluded that the dairy production sector is absolutely the biggest polluter, generating by itself more than 82% of the overall production of nitrogen oxides. The high proportion is all the more surprising that the beef cattle breeding sector is conversely the smallest emitter. In this connection, the second biggest emitter

Year	Beef	Milk	Pork	Poultry	Eggs	SUM
2000	1947	83680	14260	2608	2653	105148
2001	1909	84296	14420	2728	2427	105780
2002	1971	83433	14785	2913	2249	105352
2003	1946	83249	14803	2787	2341	105126
2004	1740	84050	13562	2860	2151	104363
2005	1459	81523	12227	2980	2085	100274
2006	1425	80168	11989	2840	1947	98369
2007	1428	84389	12271	2705	1785	102577
2008	1440	83002	11411	2650	1817	100322
2009	1386	82694	10245	2552	1891	98768
2010	1337	84050	9933	2473	1943	99734
2011	1298	83433	9466	2235	1897	98329
2012	1183	80476	8631	2005	1560	93855
2013	1167	82068	8434	1947	1591	95207
2014	1180	84440	8496	1963	1469	97548
ø	**1.51%**	**82.41%**	**11.58%**	**2.53%**	**1.97%**	**100%**

Source: own calculation

Table 3: Emission NO_x (t).

is the pig breeding sector, making an almost 12% contribution, followed by the meat poultry and egg poultry sectors (for the exact breakdown of the structure, see also Figure 2). The documented results are considerable different from the structure of emitters of the other greenhouse gases; the possible cause may be the high degree of dependency on the final production amount, not the numbers of animals in the different livestock production categories. Therefore, viewing the high overproduction of milk and the representation of pork in the overall meat consumption in Czechia, the proportional composition of the emitters is matching. Nevertheless, another significant effect is the development of the emission amount, which, unfortunately, does not decrease for the dominant polluter.

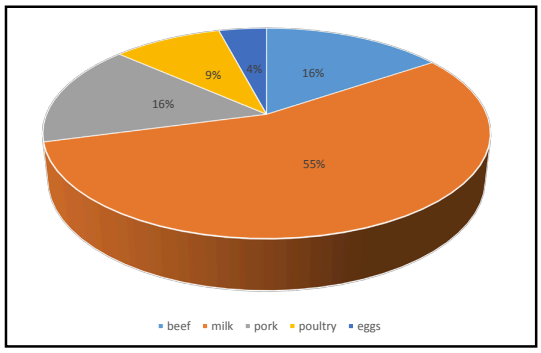


Source: own calculation

Figure 2: Structure of NO_x emitters in Czechia.

Afterwards, based on the results in Table 1 and the quantified values of net production and its conversion to "edible meat production", we made a quantification of the CO_2 emissions, with a comparison of the emission structure of livestock production in Czechia. The results of the emission estimate are shown in summary in Table 4.

Based on the derived outcomes, we can determine the shares of the livestock production branches in the total CO_2 emission; their relative contributions are then provided in Figure 3.



Source: own calculation

Figure 3: Share of categories of livestock production on the CO_2 emissions.

From this point of view, the dairy sector is the biggest emitter in Czechia, contributing approx. 55% to the total emission from agriculture in Czechia. The joint second/third-biggest polluter is the pig breeding sector (approx. 16%)

Year	Beef	Milk	Pork	Poultry	Eggs	SUM of the analyzed sectors	Total agriculture emissions	Livestock/ total emission CZ	Total emission CZ
2000	1294675	3626132	1247737	625140	356439	7150122	9094860	5.57%	128350000
2001	1269359	3652834	1261720	654047	326070	7164029	9220880	5.60%	128040000
2002	1310655	3615451	1293721	698415	302110	7220352	8955860	5.78%	124870000
2003	1294256	3607440	1295261	668118	314534	7179610	8314940	5.57%	128850000
2004	1157020	3642153	1186677	685686	288997	6960533	8750490	5.37%	129730000
2005	969941	3532675	1069850	714300	280123	6566889	8385030	5.16%	127370000
2006	947868	3473930	1048997	680750	261586	6413131	8249770	4.98%	128720000
2007	949556	3656839	1073718	648352	239795	6568261	8403040	5.06%	129780000
2008	957839	3596759	998503	635333	244134	6432568	8583060	5.16%	124690000
2009	922001	3583408	896402	611894	253994	6267699	8134290	5.38%	116510000
2010	888880	3642153	869101	592758	260994	6253886	7964570	5.30%	118060000
2011	863334	3615451	828274	535765	254782	6097607	8064840	5.24%	116300000
2012	786585	3487281	755222	480731	209525	5719344	8019420	5.11%	111860000
2013	775955	3556283	737960	466748	213785	5750731	8008490	5.27%	109170000
2014	784382	3659083	743372	470642	197332	5854810	8002780	5.42%	108050000
ø	**15.55%**	**55.27%**	**15.68%**	**9.39%**	**4.10%**	**77.37%**	100%	5.33%	

Source: own calculation

Table 4: Emission CO_2 (t).

and the beef cattle breeding sector (16%), followed by the meat poultry sector (about 9%) and egg production (4%).

Moreover, the research compared the production of the analyzed sectors with the total emissions of CO_2 by agriculture in Czechia, and found out that the above branches make a great contribution to the total agricultural emission: approx. 77%; that is, only 23% of the CO_2 production originates from the remaining livestock production categories and plant production. However, comparing the contribution of the livestock production emissions to the overall CO_2 emissions in Czechia, the contribution is relatively very small, approx. 5.3% (and decreasing), which is approx. 3-7 times less than in most West European countries, since the estimate in those countries is 15-40% (DG Energy, 2013).

Based on the previous quantification of the amounts of greenhouse gases produced by the individual sectors of livestock production in Czechia, the following section makes a valuation of the public goods generated. At the same time, it valuates the attained agricultural production in the specified branches (see Table 5), making it ultimately possible to compare the value of the public goods with the value of the primary production and thus determine the mutual ratio, which attains surprising levels in many cases. The production valuation made (determined using normal weighted prices of agricultural production) indicates that whereas beef, chicken and eggs show a stagnating level over the study period, the value of the pork production decreases significantly and milk, on the other hand, increases, which is in line with the indicators obtained in other studies (e.g., MA CZ, Green Report, 2016).

The WTP method was then used to price the greenhouse gases generated, with methane values first; see Table 6.

The results permit us to conclude that the methane production shows the highest values (almost CZK 8.5 billion) in the milk sector, which is relatively closely followed by the beef sector (CZK 7.2 billion). Both the production and the price are significantly lower in the other sectors; the price is actually lower by an order of magnitude towards the end of the study period (CZK 3-18 million).

Figure 4 presents a very interesting comparison. The chart allows us to infer the mutual ratio between the value of production and methane emission generated; the rate of the emission exceed 6.5% in the beef sector, and attains nearly 3% of the priced production of milk. The gases produced by the other sectors are below 1%, meaning that their production is relatively negligible from the point of view of negative externality theory.

Year	Beef	Milk	Pork	Poultry	Eggs
2000	8523.40	20174.60	20291.53	6351.44	6036.08
2001	7041.86	21075.60	25018.73	8112.08	6061.00
2002	7533.12	22151.36	18726.11	6948.97	4630.98
2003	7339.44	20612.34	16908.95	6392.68	5000.16
2004	7015.87	20581.82	17476.94	6859.07	4775.40
2005	6783.54	21802.44	15457.38	6787.76	3575.04
2006	7050.33	21552.00	13896.55	6078.03	4506.32
2007	6587.50	23055.56	13084.80	6221.67	4611.04
2008	6954.00	23951.84	12921.12	7820.33	4632.25
2009	7084.34	21988.96	10955.70	6539.22	4211.92
2010	6657.03	20922.12	9790.50	5260.96	3442.50
2011	7137.01	22002.02	9623.70	4859.53	3100.53
2012	7907.88	21021.02	9843.92	5598.47	4462.97
2013	7352.41	23611.17	10161.97	5737.16	3822.38
2014	7846.84	26763.85	9992.67	5898.55	4116.85
Total	**108814.56**	**331266.70**	**214150.58**	**95465.93**	**66985.43**

Source: own calculation

Table 5: Production value (millions CZK).

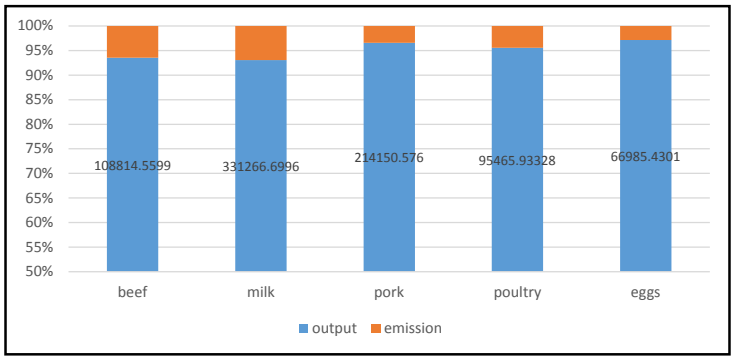
Year	Beef	Milk	Pork	Poultry	Eggs
2000	*898.23*	*1014.23*	*181.77*	*80.68*	*26.78*
2001	*870.34*	*965.44*	*169.53*	*82.58*	*25.49*
2002	*749.04*	*851.33*	*146.77*	*84.72*	*13.50*
2003	*740.17*	*870.84*	*148.21*	*75.12*	*14.37*
2004	*718.00*	*846.70*	*138.06*	*72.49*	*13.07*
2005	645.30	791.55	118.58	68.84	11.33
2006	453.98	556.40	83.76	49.22	8.62
2007	412.40	496.02	74.28	41.29	7.64
2008	413.13	496.70	63.49	47.12	7.62
2009	321.48	394.44	41.50	36.24	6.30
2010	341.66	415.56	43.00	36.05	6.48
2011	165.36	202.73	19.21	14.26	3.12
2012	157.88	190.96	16.34	13.64	2.56
2013	122.09	148.16	12.72	11.04	2.69
2014	178.72	219.22	18.78	14.68	3.63
Total	**7187.77**	**8460.29**	**1276.01**	**727.98**	**153.20**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)

Source: own calculation

Table 6: The value of CH_4 emissions (millions CZK).

Analogously to the above, the value of the nitrogen oxide emissions was quantified in Table 7 below. Unfortunately, these gases have many times stronger interaction with the ozone layer, so that their presence is a serious problem even with a seemingly small amount. The aforesaid fact is then reflected in the pricing, where the rate of the emission generated is very close to the priced agricultural production in the respective sectors, particularly at the start of the study period. From the perspective of absolute magnitude, the nitrogen oxide emission from the dairy sector attains unambiguously the highest value of approx. CZK 176 billion; this is an order of magnitude above those in the other sectors: CZK 27 billion for pork; CZK 5.7 billion for chicken; CZK 4.5 billion for eggs; and CZK 3.5 billion for beef.



Note: Different production value (inside the chart in millions CZK) is always considered 100%.
Source: own calculation

Figure 4: The share values of emissions CH4 and production value (%).

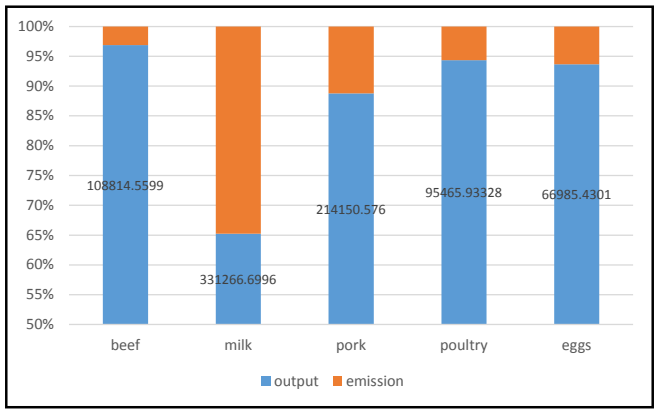
Year	Beef	Milk	Pork	Poultry	Eggs
2000	*468.27*	*20127.13*	*3429.85*	*627.22*	*638.20*
2001	*439.43*	*19405.85*	*3319.55*	*628.09*	*558.79*
2002	*410.25*	*17367.01*	*3077.63*	*606.43*	*468.13*
2003	*418.59*	*17904.92*	*3183.79*	*599.42*	*503.59*
2004	*374.91*	*18110.99*	*2922.34*	*616.33*	*463.57*
2005	293.39	16398.61	2459.46	599.36	419.46
2006	205.12	11536.41	1725.19	408.64	280.22
2007	182.87	10807.53	1571.54	346.37	228.61
2008	183.41	10569.32	1453.11	337.48	231.42
2009	142.43	8495.08	1052.42	262.21	194.24
2010	146.91	9237.99	1091.70	271.77	213.54
2011	69.57	4471.25	507.29	119.77	101.64
2012	59.74	4064.77	435.95	101.29	78.78
2013	45.67	3211.89	330.07	76.20	62.28
2014	66.85	4785.48	481.47	111.26	83.25
Total	**3507.42**	**176494.23**	**27041.39**	**5711.86**	**4525.72**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)
Source: own calculation

Table 7: The value of NO_x emissions (millions CZK).

The extreme value of nitrogen oxide emissions from the dairy industry is a major warning for authors of both agricultural and environmental policies, since, as shown in Figure 5, the ratio of this emission to the value of the production generated is almost 35%! Casey and Holden (2005), for example, obtained similar results. For pork, the ratio exceeds the significant 10% threshold, and the poultry sector too (in both the meat utility branch and eggs) exceeds 5%, a threshold considered to be the warning level that should indicate the setting of processes leading to a reduction of the emission.

The last gas analyzed is carbon dioxide; its emissions are priced in Table 8. The outcomes indicate that again the emission attains the highest rate in the dairy industry (approx. CZK 25 billion), followed by the very similar sectors of beef (approx. CZK 7.5 billion) and pork (approx. CZK 7.6 billion). The poultry meat sector generates emissions worth approx. CZK 4.4 billion, and the egg sector emits at approx. CZK 2 billion.



Note: Different production value (inside the chart in millions CZK) is always considered 100%.
Source: own calculation

Figure 5: The share values of emissions NO_x and production value (%).

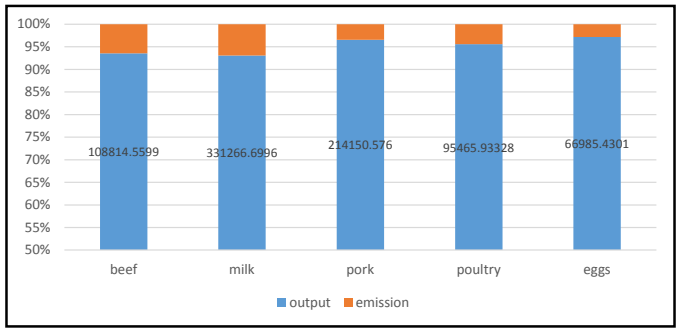
Year	Beef	Milk	Pork	Poultry	Eggs
2000	*1004.52*	*2813.47*	*968.10*	*485.04*	*276.56*
2001	*942.64*	*2712.65*	*936.97*	*485.70*	*242.14*
2002	*880.06*	*2427.65*	*868.69*	*468.96*	*202.86*
2003	*897.95*	*2502.84*	*898.65*	*463.54*	*218.22*
2004	*804.24*	*2531.64*	*824.85*	*476.62*	*200.88*
2005	629.37	2292.28	694.20	463.49	181.77
2006	440.01	1612.62	486.95	316.01	121.43
2007	392.29	1510.73	443.58	267.85	99.07
2008	393.45	1477.43	410.15	260.97	100.28
2009	305.54	1187.48	297.05	202.77	84.17
2010	315.15	1291.33	308.14	210.16	92.54
2011	149.25	625.01	143.19	92.62	44.04
2012	128.16	568.19	123.05	78.33	34.14
2013	97.96	448.97	93.17	58.93	26.99
2014	143.40	668.94	135.90	86.04	36.08
Total	**7523.99**	**24671.24**	**7632.65**	**4417.03**	**1961.16**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)
Source: own calculation

Table 8: The value of CO_2 emissions (millions CZK).

Looking at Figure 6, it can be concluded that the aforesaid warning threshold of 5% of share in the value of own production is exceeded by cattle breeding, in both the utility branches: milk and meat. The remaining branches of livestock production analyzed are below the set limit, even though the poultry meat production, for instance, comes relatively close to it. On the other hand, the development trends that can be inferred from Table 8 above indicate that all the sectors show a considerable decrease in both volume and emission rates, which can be recognized as a positive factor in the area of production of negative public goods.

The last analyzed area was the very interesting comparison of the value of the total emission in the agricultural production generated, as presented in Table 9. Thanks to the GWP conversion coefficients, the particular gas emissions can be expressed as the equivalent of the most voluminous gas, carbon dioxide, ultimately permitting a simple addition of the generated emissions and its valuation according to the method set. The results are shown in Table 9, which is divided into two parts, showing the total emission value as such and its



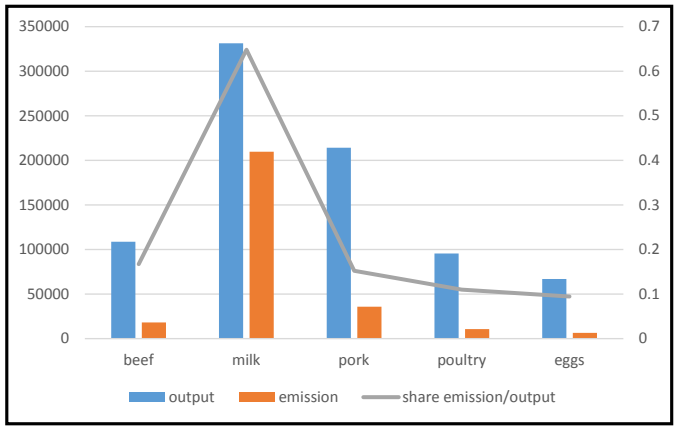
Note: Different production value (inside the chart in millions CZK) is always considered 100%.
Source: own calculation

Figure 6: The share values of emissions CO_2 and production value (%).

	Value GHG emissions (mil CZK)					Share emission values on the valuation of output				
Year	**Beef**	**Milk**	**Pork**	**Poultry**	**Eggs**	**Beef**	**Milk**	**Pork**	**Poultry**	**Eggs**
2000	*2371.03*	*23954.83*	*4579.73*	*1192.94*	*941.54*	*27.82%*	*118.74%*	*22.57%*	*18.78%*	*15.60%*
2001	*2252.41*	*23083.94*	*4426.06*	*1196.37*	*826.43*	*31.99%*	*109.53%*	*17.69%*	*14.75%*	*13.64%*
2002	*2039.35*	*20645.98*	*4093.09*	*1160.12*	*684.48*	*27.07%*	*93.20%*	*21.86%*	*16.69%*	*14.78%*
2003	*2056.72*	*21278.60*	*4230.65*	*1138.08*	*736.18*	*28.02%*	*103.23%*	*25.02%*	*17.80%*	*14.72%*
2004	*1897.14*	*21489.33*	*3885.25*	*1165.44*	*677.51*	*27.04%*	*104.41%*	*22.23%*	*16.99%*	*14.19%*
2005	1568.06	19482.44	3272.25	1131.70	612.56	23.12%	89.36%	21.17%	16.67%	17.13%
2006	1099.10	13705.43	2295.90	773.87	410.27	15.59%	63.59%	16.52%	12.73%	9.10%
2007	987.56	12814.28	2089.40	655.51	335.31	14.99%	55.58%	15.97%	10.54%	7.27%
2008	989.99	12543.45	1926.75	645.57	339.32	14.24%	52.37%	14.91%	8.25%	7.33%
2009	769.45	10077.00	1390.97	501.22	284.70	10.86%	45.83%	12.70%	7.66%	6.76%
2010	803.73	10944.89	1442.84	517.98	312.56	12.07%	52.31%	14.74%	9.85%	9.08%
2011	384.18	5298.99	669.68	226.65	148.81	5.38%	24.08%	6.96%	4.66%	4.80%
2012	345.78	4823.93	575.34	193.26	115.48	4.37%	22.95%	5.84%	3.45%	2.59%
2013	265.72	3809.02	435.97	146.17	91.96	3.61%	16.13%	4.29%	2.55%	2.41%
2014	388.96	5673.64	636.15	211.99	122.96	4.96%	21.20%	6.37%	3.59%	2.99%
Total	18219.18	209625.76	35950.04	10856.87	6640.07	Average **16.74%**	Average **64.83%**	Average **15.26%**	Average **11.00%**	Average **9.49%**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)
Source: own calculation

Table 9: The value SUM of GHG emissions and share on the valuation of output (%/mil CZK).



Source: own calculation

Figure 7: The value of sector output and SUM of GHG emissions (millions CZK) and share on the valuation of output (%).

contribution to the value of production generation in the respective livestock production branches in the CR.

The outcomes indicate warning signals based on the average values of the contributions of the priced emissions. The contributions exceed the 10% level in all the verticals analyzed (except eggs). However, the extreme rate for the dairy sector is absolutely unprecedented; the greenhouse gas emission makes up almost 65% of the value of the primary production. However, similarly high rates have been identified in other publications, such as Žáková-Kroupová et al (2016) and FAO (2010); moreover, they applied different methods (shadow price method), thus supporting our finding.

Figure 7 documents the situation outlines; it offers a direct comparison of the value of the total emission and the value of the production generated in the analyzed sectors while showing the relative contributions.

Conclusion

A number of partial conclusions can be made from the results presented. In the area of methane emissions, the beef cattle breeding sector is the biggest emitter - summing both the utility lines (milk and meat) has the almost 90% share of the methane emissions. The remaining livestock production categories make only a minor contribution, while the overall CH4 emission is decreasing. In the segment of nitrogen oxide emissions, the dairy sector is an extremely strong polluter; it generated over 82% of the total production on average over the study period. The second-biggest emitter is the pig breeding sector, but it only contributes about 11-12%. In this respect, it is highly desirable to pay an increased attention to the dairy sector, in terms of both the current and long-term overproduction of milk, and the destructive market mechanisms, which fully impact on domestic producers (the effect of the purchase price level and the zero profitability threshold), but also from the point of view of being the producer of an extremely dangerous greenhouse gas as proven by the analysis made. Unfortunately for Czechia, the nitrogen oxide emissions are decreasing very slowly. In addition, it can be concluded that the biggest emitter of greenhouse gases in the form of CO_2 from agriculture is again the cattle breeding sector, more specifically again the dairy production sector, which contributes more than one half to the livestock production emissions in Czechia. The second most important emitter is the pig breeding sector, but it only makes about 15% of the livestock emissions. Comparably pig is a major producer of CO_2 further breeding cow meat (with a slightly smaller contribution of approx. 11%). A very interesting finding is the development of greenhouse gas emissions and compared with the value in the EU. In 1990 was the proportion of greenhouse gases produced by EU 28 agriculture to total emissions 9.6 % and 9.9 % in 2014. In Czechia 1990 was the share of agriculture emissions to total 6.1% and 5.33% in 2014. (EUROSTAT, 2016). In terms of comparing the production of greenhouse gases among the EU-28, the share of the Czech Republic is about 2.87 %, Slovakia 0.92 %, Poland 8.64 %, Hungary 1.31 %, Germany 21.93 % (Germany is the biggest polluter). Warning finding is the fact, that only 7 of the EU-28 is a large producer of greenhouse gases than the Czech Republic – Germany, United Kingdom, France, Italy, Poland, Spain and Netherlands. (EEA, 2016)

Czechia has been managing to reduce its overall emission burden very fast. Last but not least, it can be concluded that the livestock production sectors analyzed in the Czech agriculture contribute 77% of the production of the most voluminous greenhouse gas – carbon dioxide, thus being an enormous producer of greenhouse gases, which deserves adequate attention both under the Czech Republic's Environmental Policy and when designing tools of the Common Agricultural Policy in the context of moral responsibility in production of necessary goods such as staple foods.

As part of the component assignment of pricing the greenhouse gas emissions generated, the research project has resulted in a number of serious findings. Whereas carbon dioxide is unambiguously the most voluminous of the gases emitted, the nitrogen oxide emissions are a major problem primarily from the point of view of gas valuation in the form of public goods connected with the conventional production. Thanks to its high reactive capacity, this gas is a hidden threat, which is fully identified when giving it a monetary value. The results show that nitrogen oxides are generated, for the greatest part, in the dairy sector, where they attain nearly 35% of the total value of the dairy production generated on average in the study period. Another major conclusion is the situation after conversion of all the gases to the CO_2 equivalent followed by a pricing and comparison with the value of the agricultural production. In this respect, the high ratio of the emission public goods produced to the value

of the livestock production is an alarming result. This ration exceeds 15% of the production value on average in the beef and pork sectors; it is at 11% of the production value on average in the poultry meat sector, but the greenhouse gas emissions from the dairy sector attain almost 65% of the value of the milk production, which is a very serious fact, which should be reflected by instruments of agricultural and environmental policies of the CR.

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Corresponding author:
Ing. Michal Malý, Ph.D.
Department of Economics, Faculty of Economics and Management,
Czech University of Life Sciences Prague, Kamýcká 129, Prague, 16521, Czech Republic
Phone: +420224382202, E-mail: maly@pef.czu.cz

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Assessment of the Agricultural Performance in Central and Eastern European Countries

T. Záhorský, J. Pokrivčák

Department of Economic Policy, Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Slovakia

Abstract

Based on selected individual data acquired from Farm Accountancy Data Network database the output efficiency of agriculture in Central and Eastern European countries at national level is evaluated. Moreover, the output oriented constant returns to scale Data Envelopment Analysis approach is applied in order of Malmquist productivity index calculation. Analysis includes two output variables and six input variables. The data were provided on request from Farm Accountancy Data Network for ten Central and Eastern European Countries and period 2004-2012 (in case of Bulgaria and Romania 2007-2012). Based on the results, the average Total Factor Productivity growth in Central and Eastern European region over the period 2004-2012 was 1.99%. Moreover, it can be concluded that the Total Factor Productivity growth was mainly the result of Technological Change.

Keywords

Central and Eastern European countries, Farm Accountancy Data Network, Data Envelopment Analysis, Malmquist productivity indices, total factor productivity.

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Introduction

Central and East European countries (CEEc) have undergone the process of transformation that affected their production structures (Ciaian, et al., 2009). Some CEEc are dominated by family farms (Poland, Slovenia) while in others there are prevalent transformed cooperatives (Slovakia, Czech Republic). Mixture of large transformed cooperatives and family farms can be observed in Hungary or Romania. There are also differences with respect to the application of the Common Agricultural Policy (CAP) at national levels as well as with the date of European Union (EU) accession, which had a tremendous impact on national economy in general and on agriculture in particular including the level of support (Pokrivcak et al., 2006). Gross Domestic Product (GDP) per capita and the level of development also differ between the countries, whereby Slovenia, the Czech Republic are among the most developed of CEECs and Romania or Bulgaria lag behind. The level of development is reflected in the functioning of land market as well as all other upstream and downstream markets.

All these differences between the countries might be reflected in the efficiency and productivity of agricultural sectors in different countries. The motivation to conduct this research was to calculate the productivity of agriculture in CEEc in order to find out, which countries use their limited resources in efficient way. We can find researches which took into account the analysis of one country (Coelli, 2006; Fogarasi, 2006) or the analysis of tens countries (Nowak et al., 2015; Domanska et al., 2014; Coelli and Rao, 2003). We took into account the countries situated in CEE region and the analysis was applied in a range of 9 years interval (2004 – 2012). The countries included are as follows: Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia and Slovenia. The novelty of the paper is reflected by the fact that our paper includes individual farm data, the analysis is performed for each country separately and the assessment of the performance of individual farms (58,929 observations in total) and their development during 9 years interval is analysed. Subsequently, the results are unified at country level.

To calculate the efficiency and productivity, different approaches have been used. In our paper, to express the efficiency, the Data Envelopment Analysis (DEA) and Malmquist productivity indices are used. Moreover, by applying Malmquist productivity indices, the change of the Total Factor Productivity (TFP) is decomposed into Technical and Technological efficiency change.

The objective of the paper is to examine the data acquired from Farm Accountancy Data Network (FADN) in order of asses the agricultural performance of CEE countries.

The paper consists of several parts. The following part consists of the literature review according to efficiency analysis and the determinants of efficiency. Data and methodology used are inherited by the second part of the paper. The third, and most important part of the paper, is the results and discussion, which consists of the efficiency analysis of the agricultural sector in selected countries. The last part deals with a summary of the results of previous sections.

There have been several papers which have measured the performance of agriculture in individual countries using indicators TE (technical efficiency) and TFP. Serrão (2003) examined the sources of productivity growth and the productivity differences among countries and regions over the period 1980-1998 covering 15 EU countries and 4 East European countries. The study was based on data collected from the Food and Agriculture Organisation (FAO) of the United Nations (UN). An approach based on DEA was used to provide the values of TE and to derive the Malmquist productivity indices. According to the author, average annual growth of TFP over that period reached 2.2%, where a major contributing factor was the technological change (TCH). Negative growth in technical efficiency change (TECH) was observed in a couple of years. France, Belgium and Luxembourg posted the most spectacular performance, with an average annual growth of 3.6% of TFP in case of France over the observed period. Turning to the performance of the five European regions defined in authors' research work, the Eastern European region (consisting of Romania, Bulgaria, Poland and Hungary) was the best performer, with an annual TFP growth of 2.6%.

Akande (2012) measured the TE and TFP growth of agricultural holdings in the EU-15 over the 11 years period by DEA approach. Author observed an average TE of 87% for the EU-15 region as a whole. The paper divided the EU-15 region into four regional groups. Western European Region was the most efficient with the highest average TE of 95% while Central European Region shared the same TE level of 85% with Southern European Region. Meanwhile, the Northern European region was the least technically efficient (84%). The annual average of 3% and 4% TFP growth rate was observed for all the regions in the EU-15. Study observed that TFP growth rate in the four regional groups were being driven by TCH and a decline in TECH particularly between the years 1999 and 2002. Subsequently up till 2005, the growth rate was driven by catch-up (TECH) while there seem to be technological regression.

Fogarasi (2006) analysed the efficiency and TFP in Hungarian sugar beet production. For the years 2004 and 2005, the TE and TFP were calculated by DEA and by a Malmquist index, respectively. Between 2004 and 2005 the average TE was very stable, around 0.80 for CRS efficiency and 0.87 for VRS efficiency. Between years TFP increased by 9%. The main reason for the observed TFP increase was TCH of 8%, while TECH efficiency played a limited role in improving the performance of sugar beet production.

Coelli et al. (2006) obtained detailed information on the TFP growth of arable farms in Belgium over a 16 years period (1987 – 2002). The TFP measures were calculated using a Malmquist indices and DEA approach. The results indicated an average annual rate of TFP change of 1% per year, with most of this being due to TCH. An inspection of the TFP change indices before and after the two CAP reforms (in 1992 and 2000) indicated that these reforms had had no discernible effect upon TFP trends.

Measurement of the TE of agricultural sector in the 27 European Union countries in 2010 was provided by Nowak et al. (2015). The research was conducted based on the output-oriented VRS DEA approach. Authors claimed that across the 27 EU Member States, the level of the TE of agricultural sector was diverse and the difference between the countries with the highest and the lowest efficiency was 40%. The countries situated in the western and southern part of the EU were identified as the countries with the thoroughly technically efficient agriculture. In turn, the least technically efficient agriculture was observed for the Central and North-East EU countries.

Domanska et al. (2014) measured the agricultural TFP change in 27 EU countries (2007-2011). The research was conducted based on Malmquist productivity index. The study demonstrated a small increase in agricultural TFP for the whole sample

of 27 EU countries over the examined period. The reason of this increase was mainly the changes in technical efficiency. An effect of TCH was in turn relatively low and of negative character.

Rizov et al. (2013) investigated the impact of the CAP subsidies on farm TFP in the 15 EU countries based on FADN data. Authors employed a structural semi-parametric estimation algorithm directly incorporating the effect of subsidies into a model of unobserved productivity. Authors found negative impact of subsidies on farm productivity in the period before the decoupling reform was implemented.

Based on the above mentioned researches, we can conclude the increase of the level of TFP in the EU region (Serrão, 2003; Akande, 2012; Fogarasi, 2006; Coelli et al., 2006; Domanska et al., 2014). This increase was mainly caused by the increase of technological change, while the impact of technical efficiency change had just marginal (Fogarasi, 2006; Akande 2012) or even negative impact (Serrão, 2003). In our research, the methodology of DEA and data applied by Akande (2012) has been used. The methodology of Malmquist index used by Domanska et al. (2014) has been employed in order to find the impact of TCH and TECH on TFP growth.

Materials and methods

Model works with two output variables – crop output (total value of output of crops and crop products [EUR], sales + farm use + farm house consumption) and animal output (the total value of output livestock and livestock products [EUR] livestock production + change in livestock value + animal products). These outputs are produced as a result of six inputs. Total labour in form of annual working units (AWU), the total utilized agricultural area (hectares), buildings (buildings and fixed equipment [EUR]), machinery (machines, tractors, cars and lorries, irrigation equipment [EUR]), cost of materials (total specific cost, total farming overheads, machinery and building current costs [EUR]) and total livestock units [livestock units, LU] are considered while calculating TE and TFP.

The data were provided on request from FADN for 10 CEEc and period 2004-2012 (in case of Bulgaria and Romania 2007-2012). The database was adjusted for the farms not appearing in each observed year and for negative outputs (the conventional DEA model is used, which doesn't work with negative data points). Monetary expressed data were deflated from nominal euro to constant euro based on a fixed base year using the Agricultural Price Index (API) obtained from the statistical office of the European Union (EUROSTAT) in order to eliminate the impact of inflation over time. Crop output adjustment is based on API crops, animal output adjustment is based on API animal and the adjustment of inputs is based on API total inputs with a base year 2005. It must be noted, that results represent efficiency scores for individual countries which are based on farm data. For the purposes of the calculation of Malmquist index the Stata 12.0 statistical program was used.

Technical efficiency

Efficiency can be simply defined as the ratio of output to input. More output per unit of input reflects relatively greater efficiency. If the greatest possible output per unit of input is achieved, a state of absolute or optimum efficiency has been achieved and it is not possible to become more efficient without new technology or other changes in the production process (Sherman and Zhu, 2006).

Technical efficiency is one of the three components of overall efficiency, while the others are allocative efficiency and economic efficiency (Farrell, 1957). Technical efficiency is related to the ability of the decision making unit (DMU) to produce maximum output from given inputs or the minimum feasible amounts of inputs to produce a given level of output. The first part of the definition refers to output-oriented TE, while the second refer to input-oriented TE (Watkins, 2013). The allocative efficiency refers to the ability to use the set of inputs in optimal proportions, given their pertinent prices (Farrell, 1957). Economic efficiency is then calculated as the ratio of the minimum possible costs and the actual observed costs for a DMU and is the reflection of both efficiencies.

Data Envelopment Analysis

The one of the most widely used technique to obtain technical efficiency is DEA. DEA is a linear programming non-parametric technique developed in the work of Charnes, Cooper and Rhodes (1978). The original idea behind DEA was to provide a methodology whereby, within a set of comparable decision making units (DMUs), those exhibiting best practice could be identified, and would form an efficient frontier[1]. Furthermore, the methodology enables one to measure the level of efficiency of non-frontier units, and to identify

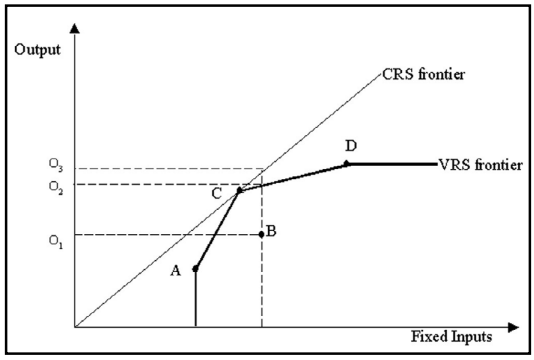
[1] An envelopment surface or efficient frontier is a frontier consisting of the "best practice" units (DMUs).

benchmarks against which such inefficient units can be compared (Cook and Seiford, 2009).

Returns to scale

The envelopment surface will differ depending on the scale assumptions that underpin the model. Two scale assumptions are generally employed: Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS). CRS reflects the fact that output will change by the same proportion as inputs are changed (e.g. a doubling of all inputs will double output); VRS reflects the fact that production technology may exhibit increasing, constant and decreasing returns to scale (Lestari, 2015).

The effect of the scale assumption on the measure of capacity utilization is demonstrated in Figure 1. Four data points (A, B, C, and D) are used to estimate the efficient frontier and the level of capacity utilization under both scale assumptions. Note that only fixed inputs are considered in Figure 1. The frontier defines the full capacity output given the level of fixed inputs. With constant returns to scale, the frontier is defined by point C for all points along the frontier, with all other points falling below the frontier (hence indicating capacity underutilization). With variable returns to scale, the frontier is defined by points A, C and D, and only point B lies below the frontier i.e. exhibits capacity underutilization. The capacity output corresponding to variable returns to scale is lower than the capacity output corresponding to constant returns to scale (Food and Agriculture Organization of the United Nations (FAO), 2003).



Source: FAO (2003)

Figure 1: The effect of the scale assumption on the measure of capacity utilization.

Input and output orientation

A range of DEA models have been developed to measure efficiency and capacity in different ways. These largely fall into the categories of being either input-oriented or output-oriented models (FAO, 2003).

Input-oriented models refer to the amount by which all inputs could be proportionally reduced without a reduction in output (e g. the input efficiency is 0.80 or 80%, which means that the selected DMU lags behind the best performer DMU, then the inputs should be reduced by 0.20 or 20% to become efficient) while output-oriented models answer the question by how much can be output quantities proportionally expanded without altering the input quantities (e g. the output efficiency is 1.30 or 130% compared to the best performer DMU, then the outputs should be proportionally expanded by 0.30 or 30% to become efficient) (Coelli, 1995). Uses of input or output oriented model provide similar values under constant return to scale but are unequal when variable return to scale is assumed.

In the case of efficiency we employ output-oriented model with CSR in form:

$$\begin{aligned} &max_{\varphi,\lambda\varphi} \\ &-\varphi y_i + Y\lambda \geq 0 \\ &x_i - X\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned} \quad (1)$$

Where φ is efficiency rate for each decision-making unit (DMU, CEE state in this case), λ refers to linear combination of inputs and outputs, Y is vector of outputs and X vector of inputs. The condition $\lambda \geq 0$ indicates CSR. For the further information about DEA please see the following materials: Cook and Seiford (2009), Sherman and Zhu (2006) or Cooper et al. (2011).

Malmquist productivity index

The Malmquist index measures the TFP change between two adjacent periods by calculating the ratio of the distance of each data point relative to a common technological frontier. The Malmquist index can be greater, equal to or less than 1 if productivity grows; is stagnant or declines between the two periods. It can be decomposed into TECH and TCH.

Malmquist productivity index is a geometric mean of two production functions based on the distance functions, as follows:

$$M_0(y_{t+1}x_{t+1}y_tx_t) = \left[\frac{d_0^t(y_{t+1},x_{t+1})}{d_0^t(y_t,x_t)} \times \frac{d_0^{t+1}(y_{t+1},x_{t+1})}{d_0^{t+1}(y_t,x_t)}\right]^{1/2} \quad (1)$$

$$M_0(y_{t+1}x_{t+1}y_tx_t) = \frac{d_0^{t+1}(y_{t+1},x_{t+1})}{d_0^t(y_t,x_t)}\left[\frac{d_0^t(y_{t+1},x_{t+1})}{d_0^{t+1}(y_{t+1},x_{t+1})} \times \frac{d_0^t(y_t,x_t)}{d_0^{t+1}(y_t,x_t)}\right]^{1/2} \quad (2)$$

Where the outputs and inputs are y_t, x_t in the basic period, y_{t+1}, x_{t+1} are output and output in the next period. Notation d_0^t and $d_0^{(t+1)}$ represents distance of the DMU in the basic and next period.

Technical efficiency change measures technical efficiency change between period t and $t+1$. If the value is greater than 1, the production unit moves closer to the frontier, in other words, the DMU is catching up to the production frontier by improving efficiency. A value of less than 1 indicates efficiency regress.

Technological change represents the shift in technology of selected DMU, which means that if the value is higher than 1, then the DMU experienced technology progress and, on the other hand, the value lower than 1 means that the country experienced technological regress.

Technical efficiency change and technological change can be expressed also in percentage, where the positive value means progress, while the negative value means regress.

Whenever the M_0>1 it signalizes the enhanced productivity.

Results and discussion

After the database have been obtained, the data were cleaned by the DMUs not appearing in whole period and by DMUs with negative output values as one of the constraint of conventional At the end of the process, the clean database contained 58,929 observations. Table 1 describes the descriptive statistics of the individual farms. The vast variation of variables between the countries was found. As you can see, the highest average and median values of the variables can be observed in case of Czech Republic and Slovakia as a consequence of the highest values of farm size according to Total UAA in ha and to Economic size in ESU. On the other hand, the lowest average and median values of the variables can be observed in case of Poland and Slovenia, where the agricultural sector is dominated by small family farms. The most data points can be observed for Poland while the least for Lithuania.

Technical efficiency

Output-oriented DEA models answer the question by how much can be output quantities proportionally expanded without altering the input quantities (e. g. the output efficiency is 1.30 compared to the best performer DMU, then the outputs should be proportionally expanded by 0.30 (or 30%) to become efficient). The output TE scores for the period under consideration (2004-2012, in case of Bulgaria and Romania (2007-2012)) are presented in Table 2. The average farm´s output TE suggests that CEEc should augment the outputs in average by more than 52 % (1.5267) without changing the input quantities to become efficient. The efficiency scores were ranging from 1.09 in case of Lithuanian farms to 2.28 in Polish farms. The most efficient country was Lithuania in 2005, while the least efficient country was Romania in 2007. The CEE region as a whole performed the best in 2006, where the output TE score was 1.40.

As we mentioned above, Lithuania attained efficiency in terms of farm outputs in 2005 and was close to efficiency frontier over the whole observed period. These results support the findings of Bojnec et al. (2012), who studied TE in new member states of EU over the time period 2001-2006 and concluded that there are opportunities for better use of agricultural resources, since all countries achieved input TE scores lower than 1. Lithuania was valued first in terms gross value added agricultural performance also according to authors Csaki and Jambor (2015), who ranked agricultural performance of newly entered member states of EU. On the other hand, the same authors ranked Poland as the first regarding the benefits of accession to EU, but our results suggest that Poland exhibit the worst farm performance. The reason is that there are many small, non-commercial family farms in Poland.

Over the observed period 2007-2012, the average TE score for Bulgaria was 1.93 and 1.85 for Romania. Both countries have the highest share of agriculture on GDP compared to the rest of CEEc; Bulgaria 5.36% and Romania 7.10% (Csaki and Jambor, 2013). Thus, high TE scores are the result of inefficiency in inputs use. Bulgaria and Romania have more labor units employed on farms compared to other CEEc, signalizing the lower level of economic development and farm fragmentation as a result of land reform (Bojnec et al., 2012).

Total factor productivity index and its components in CEEc

The components of Malmquist index; TECH and TCH are presented in Table 3 and 4, while the TFP change from one year to another is presented in Table 5.

The TFP over the period 2004-2012 increased in all CEEc, except Bulgaria and Romania, thus the components of TFP contributed to TFP

Country	Obs.	Stat. var.	Crop output [EUR]	Animal output [EUR]	Total labour input [AWU]	Total UAA [ha]	Buildings [EUR]	Machinery [EUR]	Consumption of materials [EUR]	Livestock unit [LU]	Total subsidies (excl. on investment) [EUR]	Economic size [EUR]
		Average	128417.27	109491.18	14.14	337.95	56399.28	99967.26	173568.13	140.03	48022.43	269.48
		Median	16142.30	0.00	4.62	35.95	5456.93	9682.87	27791.31	0.00	7562.12	63.25
BGR	**3426**	St. dev.	255040.39	605805.91	33.82	604.06	213655.44	241508.02	502600.82	681.45	86744.07	707.75
		Skewness	3.32	9.83	12.40	2.46	8.21	5.22	8.46	9.02	2.86	8.73
		Kurtosis	13.70	114.61	253.69	6.47	82.10	38.57	95.93	101.91	10.72	104.83
		Average	359111.55	393753.48	24.26	756.87	821594.46	575877.66	702388.06	370.72	194347.21	770.81
		Median	158742.06	96425.73	9.02	463.48	212497.92	251814.52	323301.76	111.76	109360.03	357.63
CZE	**2718**	St. dev.	447046.19	534281.02	28.39	797.53	1243979.25	742182.95	835875.70	474.98	207257.64	884.75
		Skewness	1.71	1.58	1.31	1.09	2.75	2.32	1.49	1.62	1.15	1.30
		Kurtosis	3.30	2.06	1.14	0.44	12.60	8.27	2.29	2.72	0.65	1.25
		Average	61560.27	80951.61	4.36	251.56	108516.83	103976.28	117782.75	82.70	33693.82	143.98
		Median	24468.08	12038.70	2.00	137.00	25585.87	49482.21	50113.85	20.37	17980.70	65.54
EST	**2457**	St. dev.	104151.38	234466.42	8.56	325.53	314495.92	153500.67	228532.26	233.33	46796.20	264.71
		Skewness	3.55	5.40	5.96	2.82	6.11	2.88	4.65	6.11	3.36	4.54
		Kurtosis	15.09	35.14	46.04	8.81	44.99	10.06	26.44	48.42	14.19	24.98
		Average	120744.83	49410.01	6.77	323.63	94733.05	85532.67	149694.41	53.70	63831.75	194.80
		Median	33335.73	0.00	1.68	122.01	10566.64	15742.14	40442.49	0.00	20838.66	58.25
HUN	**855**	St. dev.	229684.25	263475.80	16.57	597.70	214352.20	187337.02	367237.27	221.32	149065.05	428.63
		Skewness	3.28	8.15	4.57	3.26	3.72	3.83	5.48	5.47	5.19	4.36
		Kurtosis	12.67	71.64	22.76	11.31	16.34	17.40	36.82	30.13	32.58	20.59
		Average	184194.45	37362.00	5.76	334.85	56459.07	213061.53	137608.13	41.02	37910.14	182.61
		Median	96697.88	0.00	3.39	233.07	12422.60	112396.46	95926.69	0.00	27736.50	135.92
LTU	**432**	St. dev.	222137.49	89950.56	8.85	311.83	124548.34	248945.38	138180.34	96.18	33933.02	167.69
		Skewness	1.82	3.24	4.55	1.13	3.70	1.87	1.54	3.25	1.16	1.36
		Kurtosis	3.11	11.00	23.73	0.39	14.38	4.06	2.20	11.27	0.90	1.65
		Average	80894.08	79859.31	8.06	291.17	60496.69	100356.37	139910.01	98.06	45958.27	141.75
		Median	18327.21	11179.18	2.44	118.40	4842.80	28743.14	45978.74	19.59	18278.68	52.90
LVA	**3123**	St. dev.	193696.05	216933.59	16.11	476.03	268624.82	199609.01	264882.87	259.83	83173.36	262.41
		Skewness	7.14	6.92	4.00	4.20	10.21	4.71	4.03	8.42	6.68	5.02
		Kurtosis	74.96	77.09	18.25	27.57	131.33	30.56	20.75	116.56	102.15	40.27
		Average	18601.09	24111.68	2.09	33.28	43837.61	33615.63	29142.60	30.96	7130.02	45.10
		Median	8854.34	11378.88	1.88	21.67	29189.98	18741.63	16725.06	17.83	4457.87	29.15
POL	**42291**	St. dev.	38776.42	53222.08	1.63	48.99	57951.65	48048.56	49379.28	61.40	10666.97	67.30
		Skewness	13.68	10.58	13.73	12.16	7.73	5.89	9.76	15.33	11.12	12.79
		Kurtosis	366.66	186.80	317.87	266.38	114.96	80.26	161.74	463.14	249.98	327.53
		Average	208000.97	108591.68	13.87	607.39	79154.02	190239.12	241767.59	197.80	108068.63	407.04
		Median	27278.43	0.00	5.40	39.00	7322.85	18114.55	40395.02	0.00	10459.19	83.57
ROU	**1248**	St. dev.	441896.23	500787.24	24.46	1193.16	239837.64	391293.64	558597.31	872.67	214325.70	903.37
		Skewness	6.06	7.96	5.90	4.50	5.82	3.92	6.31	6.10	4.95	5.64
		Kurtosis	55.29	83.75	58.61	30.42	44.73	20.84	54.59	42.50	39.88	41.59
		Average	330040.03	346304.73	32.23	1026.67	1025651.89	220923.89	690387.81	379.97	236664.22	618.37
		Median	149519.32	87771.07	20.21	711.57	156159.72	110149.94	402571.40	209.65	140022.69	345.98
SVK	**1224**	St. dev.	422703.97	536479.02	36.92	1044.92	2029346.12	294048.28	844139.14	534.13	275801.07	749.05
		Skewness	2.38	2.39	1.49	1.50	3.13	2.65	1.91	2.56	2.00	2.06
		Kurtosis	7.40	7.15	1.97	2.45	12.20	9.76	3.77	9.30	6.14	5.01
		Average	17744.25	31682.04	2.49	23.50	95279.74	48975.39	37012.19	33.54	12952.80	54.99
		Median	9287.91	19663.71	2.16	18.40	63207.36	34697.22	26290.80	23.79	8897.13	39.34
SVN	**1161**	St. dev.	31467.48	42536.56	2.95	18.68	106350.82	62387.45	36900.63	40.28	13907.58	54.53
		Skewness	5.11	4.32	11.31	3.27	2.43	7.93	2.87	4.81	3.91	3.05
		Kurtosis	35.48	32.09	149.44	15.41	7.95	129.28	11.74	35.48	20.53	14.89

Source: own processing based on FADN data

Table 1: Descriptive statistics of the data in CEEc.

Index	out_DEA (CRS)									
Year/Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	geomean
Bulgaria	:	:	:	1.8919	2.0475	2.3330	2.0694	1.7028	1.6161	*1.9287*
Czech Republic	1.3648	1.3905	1.2594	1.3333	1.3323	1.4605	1.4033	1.3103	1.3269	*1.3524*
Estonia	1.2990	1.3253	1.2547	1.2242	1.3467	1.4739	1.3649	1.3635	1.4171	*1.3391*
Hungary	1.3393	1.6709	1.4099	1.6084	2.0803	1.4968	1.6442	1.3848	1.4741	*1.5546*
Lithuania	1.0720	1.0000	1.1307	1.1208	1.1454	1.0584	1.0703	1.1146	1.0765	*1.0868*
Latvia	1.4283	1.3618	1.3307	1.2924	1.3999	1.3177	1.3037	1.3068	1.3097	*1.3383*
Poland	2.1165	2.2807	2.0833	2.3922	2.0817	2.2976	2.3518	2.3172	2.6558	*2.2800*
Romania	:	:	:	2.4663	1.9677	1.7047	1.9715	1.5677	1.5829	*1.8529*
Slovakia	1.3908	1.4188	1.3713	1.3671	1.3324	1.6041	1.3964	1.4323	1.2886	*1.3978*
Slovenia	1.4719	1.4324	1.3882	1.6196	1.2785	1.4379	1.4210	1.2772	1.3205	*1.4017*
Avg. CEE	*1.4353*	*1.4850*	*1.4035*	*1.6316*	*1.6012*	*1.6185*	*1.5996*	*1.4777*	*1.5068*	*1.5267*

Note: : - not available, median values
Source: own processing based on FADN data

Table 2: Technical efficiency scores for CEEc over 2004-2012.

Index	Efficiency change									
Year/Country	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Avg.	Total
Bulgaria	:	:	:	1.30	12.41	-6.03	-14.50	-3.71	*-2.11*	*-10.53*
Czech Republic	0.00	6.32	-3.35	0.00	-6.68	1.33	3.08	-1.03	*-0.04*	*-0.32*
Estonia	0.00	0.00	0.00	-3.17	-0.57	1.67	0.00	0.00	*-0.26*	*-2.08*
Hungary	-11.92	14.85	-9.12	-5.94	36.41	0.00	12.76	-1.49	*4.44*	*35.55*
Lithuania	0.00	0.00	0.00	0.00	6.73	0.00	0.00	0.00	*0.84*	*6.73*
Latvia	0.78	0.00	1.80	-3.55	0.57	0.00	0.00	0.00	*-0.05*	*-0.40*
Poland	-7.45	10.07	-12.73	15.18	-9.26	-3.13	2.45	-11.25	*-2.02*	*-16.13*
Romania	:	:	:	-13.97	-9.21	7.78	-11.16	0.00	*-5.31*	*-26.55*
Slovakia	0.00	2.91	0.00	2.31	-5.59	1.33	0.00	4.64	*0.70*	*5.59*
Slovenia	0.00	0.00	-10.27	20.15	-0.40	0.00	4.45	0.00	*1.74*	*13.94*
Avg. CEE	*-2.32*	*4.27*	*-4.21*	*1.23*	*2.44*	*0.30*	*-0.29*	*-1.28*	*0.02*	*0.13*

Note: : - not available, median values, percentage change
Source: own processing based on FADN data

Table 3: Technical efficiency change for CEEc.

growth. The results shows that TFP growth caused by TECH or process of catching up can be observed in case of Hungary by 4.44%, Lithuania by 0.84%, Slovakia 0.70% and Slovenia by 1.74%. The rest of the countries experienced the deterioration of TECH. Bulgaria reported a decrease in TECH by 2.11%, whereby the TECH increase can be seen between years 2007-2008 and 2008-2009. Romania exhibited the average decrease in TECH by 5.31%, caused by decreased TECH over the observed period, except to the year 2010. It must be noted that there are data gap for Bulgaria and Romania over the period 2004-2006. The total technical efficiency change in CEE region as a whole in period 2004-2012 attained the positive value of 0.13 %, while the best performer country in the process of catching up was Hungary, while, on the other hand, the least performer country in CEE region over the observed period was Romania, where the contribution of technical efficiency change to TFP growth was – 26.55%. These results were supported by the fact that in case of Poland only 1.66% of farm attained output TE score equal to one (the most efficient), while the share of farms which attained the output TE score higher than 2 (the least efficient) was 65.09%. On the other hand, our analysis revealed that in case of Lithuania 41.90% of farm attained output TE score equal to one (the most efficient), while the share of farms which attained the output TE score higher than 2 was only 3.24%.

The average growth in TFP due to the TCH can be observed in all countries except Estonia, Romania and Slovakia (Table 4). The highest average technological progress was in case of Poland, by 5.06%, while, on the other hand, the least performer was considered as Romania (-1.29).

Index	Efficiency change									
Year/Country	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Avg.	Total
Bulgaria	:	:	:	8.60	24.98	-1.93	-14.41	-7.36	*1.97*	*9.87*
Czech Republic	6.63	-9.26	11.87	-2.85	13.84	0.70	0.44	-0.80	*2.57*	*20.56*
Estonia	-4.82	-6.92	1.57	-2.59	16.15	-12.86	0.66	8.44	*-0.05*	*-0.38*
Hungary	17.22	-21.80	7.82	79.38	-35.75	10.45	3.55	-2.19	*7.33*	*58.66*
Lithuania	0.05	-17.89	27.31	14.77	-23.60	4.44	1.86	14.88	*2.73*	*21.83*
Latvia	1.88	-7.46	-0.40	10.46	-3.71	-1.89	1.25	4.84	*0.62*	*4.97*
Poland	5.60	-9.75	15.04	-10.94	8.00	15.13	-0.12	17.55	*5.06*	*40.50*
Romania	:	:	:	-3.21	-19.51	35.90	-13.75	-5.87	*-1.29*	*-6.44*
Slovakia	-2.12	3.85	10.45	-16.53	8.41	-2.28	1.28	-10.43	*-0.92*	*-7.38*
Slovenia	3.27	-5.64	21.66	-15.97	9.50	-4.34	0.56	-2.42	*0.83*	*6.63*
Avg. CEE	*3.47*	*-9.36*	*11.91*	*6.11*	*-0.17*	*4.33*	*-1.87*	*1.66*	*2.01*	*16.09*

Note: : - not available, median values, percentage change
Source: own processing based on FADN data

Table 4: Technological change for CEEc.

Index	Efficiency change									
Year/Country	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Avg.	Total
Bulgaria	:	:	:	12.27	37.79	-12.20	-29.21	-11.97	*-0.66*	*-3.32*
Czech Republic	6.06	-0.36	7.28	-0.61	4.27	4.23	5.37	-3.58	*2.83*	*22.66*
Estonia	-0.02	-5.49	5.78	-7.80	13.00	-9.18	2.56	5.21	*0.51*	*4.06*
Hungary	-0.36	-7.01	-4.31	45.48	-9.90	-1.19	26.26	-10.98	*4.75*	*38.00*
Lithuania	0.37	-16.79	29.36	9.20	-11.57	0.05	10.34	17.41	*4.80*	*38.39*
Latvia	6.22	-6.58	3.42	1.71	1.91	0.64	7.58	6.51	*2.68*	*21.42*
Poland	-1.03	-0.45	-0.48	3.53	-3.49	9.53	3.20	4.16	*1.87*	*14.96*
Romania	:	:	:	-25.62	-23.53	52.36	-28.68	-10.44	*-7.18*	*-35.91*
Slovakia	-3.56	12.41	9.36	-11.03	-4.34	10.44	5.53	-4.43	*1.80*	*14.38*
Slovenia	8.56	-0.75	9.56	2.78	2.81	0.30	13.16	-5.02	*3.92*	*31.39*
Avg. CEE	*2.03*	*-3.13*	*7.50*	*2.99*	*0.70*	*5.50*	*1.61*	*-1.31*	*1.99*	*15.88*

Note: : - not available, median values, percentage change
Source: own processing based on FADN data

Table 5: TFP change for CEEc.

The highest technological change in CEE region was observed between years 2006 and 2007, where the technological progress changed by 11.91%. Based on Table 3 and 4, we can conclude that the TFP growth was mainly driven by TCH in CEEc, because of the fact that contribution of TECH to TFP was in average 0.02% (0.13% in total), while the contribution of TCH to TFP was in average 2.01% (16.09% in total). Our results are supported by the findings of the authors mentioned in the literature review (Serrão, 2003; Akande, 2012; Fogarasi, 2006; Coelli et al., 2006; Domanska et al., 2014).

The average decrease of TFP over the period 2007-2012 can be observed in case of Bulgaria (by 0.66%) and Romania (by 7.18%) (Table 5). The CEE region as a whole performed the best between years 2006 and 2007, where the increase in TFP was 7.50% in average. The best performer country was Lithuania, where the average growth of TFP attains 4.80% (38.39% in total during the 9 years period). The average TFP growth for CEEc over the period 2004-2012 was 1.99 % mainly due to the TCH. Domanska et al. (2014) studied the TFP of agricultural sector in EU states over the period of 2007-2011, finding the increase by 2.4%. Our results suggest that in CEEc which joined the EU after 2004, the TFP growth was caused by TCH, because of the changes of the structure in the agriculture after the accession. The results can be used for the comparison of the trend in individual economies. The analysis was provided individually for each country, so the data from different countries have not been considered as they have they own different and specific frontier.

Based on other authors' findings, we can explain the differences between efficiency and technology in CEEc by natural agricultural factor endowments, average farm size, farm specialization, institutional developments (Bojnec, et al., 2010), imperfections on the credit and land markets (Latruffe, et al., 2008) severe lack of financing in the agricultural sector (Swinnen and Gow, 1999). Further studies are required to tackle the issue, how to explain the differences in the gap between the countries and how to ensure the sustainable growth of efficiency in the CEEc.

Conclusion

We investigated the farms output Technical Efficiency in ten Central and Eastern European countries, as well as the Total Factor Productivity development over the period 2004-2012 (2007-2012 in case of Bulgaria and Romania).

We found, that none of the countries were efficient in terms of farm performance over the observed period, although Lithuania was close to score 1 throughout the studied years. The least efficient country over the observed period was Poland.

The results showed that Total Factor Productivity growth caused by process of catching up can be observed in case of Hungary by 4.4%, Lithuania by 0.8%, Slovakia 0.7% and Slovenia by 1.7%. The rest of the countries experienced the deterioration of Technical Efficiency. On the other hand the average growth in Total Factor Productivity due to the Technical Change was observed in all countries except to Estonia, Romania and Slovakia. The highest Technical Change was observed in case of Poland, by 5.1%. Based on the results, we can conclude that the TFP growth was mainly driven by TCH in CEEc, because of the fact that contribution of TECH to TFP was in average 0.02% (0.13% in total), while the contribution of TCH to TFP was in average 2.01% (16.09% in total). The average Total Factor Productivity growth in Central and Eastern European countries over the period 2004-2012 was 1.99%.

Even though the policy regimes have changed and shifted toward market economy, it seems the sector of agriculture in Central and Eastern European countries cannot break the issue of inefficient input use. This can be partly attributed to the remainings of former regimes, but also to failure in adapting the efficient policy and support systems in agriculture. Thus, it would be beneficial for Central and Eastern European countries to model the proper supporting scheme considering the full impact on agricultural performance of individual farms.

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Corresponding author:
Ing. Tomáš Záhorský
Department of Economic Policy, Faculty of Economics and Management,
Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia
Phone: +421 907 486 203, E-mail: xzahorsky@is.uniag.sk

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