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Analysis of Selected Profitability Ratios in the Agricultural Sector

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Abstract

The paper deals with the analysis of selected profitability indicators of Czech agricultural businesses of legal entities and their subcomponents, based on DuPont analysis. The effect of asset turnover ratio, net profit margin ratio and equity multiplier on the value of return on equity (ROE) and return on assets (ROA) is studied in relation to the legal form and size group. The analysis of the effect of sub-indicators is performed by way of a correlation analysis. Furthermore, the assumption about the influence of sub-components indicators on synthetic profitability ratios is verified.

The panel data set we used was obtained from the Amadeus database. The analytical section is based upon accounting statements of agricultural businesses of legal entities in the Czech Republic within the period of 2011 – 2015. The analysis is based on the calculated values of ROA and ROE, including partial values of the sub-components indicator, by using DuPont analysis. The differences between the groups of businesses are tested through correlation analysis and subsequently evaluated with respect to the specifics of each group. The object of examination was more than 3000 companies annually, on average. The evaluated companies were divided, in terms of legal form, into joint-stock companies, cooperatives and limited liability companies, and in terms of size structure into small, medium and large businesses.

Keywords

Return on assets, return on equity, DuPont analysis, agricultural enterprise, company size, legal form, correlation analysis.

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Introduction

The evaluation of the efficiency and profitability of a business, regardless of its field of activity, comprises a significant part of managerial decision-making in terms of operational and strategic management. On the basis of such an evaluation, one can judge as to the overall performance of a business, of which the definition and methods of measurement have been an object of interest of many expert studies and authors (Král, Wagner and Stránský, 2006; Kaplan and Norton, 2007; Sardana, 2008; Antony and Bhattacharyya, 2010; Wagner, 2011; Schader et al., 2016; Vastola et al., 2017; Ssebunya et al., 2019) for several years now.

The performance of a business is an important gauge not only for the management of the business itself, but also for external entities that come into contact with the business, and this is precisely why it can be interpreted and comprehended in various ways. However, in recent years, there has been a noticeable trend in the measurement of performance toward the use of indicators that prefer the market value of a business and take into consideration criteria of economic and environmental sustainability, as opposed to traditional indicators whose foundations are based upon accounting. Nevertheless, in practice, emphasis is still placed specifically upon measuring the financial performance of businesses, a very important gauge for both internal and external users. In this regard, rate of return indicators in particular are thus of vital significance, as the overall efficiency of a business can be evaluated on the basis of them, and the causes of trends in the achieved economic results can also be revealed through their analysis.

An analysis of profitability can be based, for example, upon a detailed examination of rate of return indicators by using DuPont analysis and evaluating the impact of factors that influence the given synthetic indicator. Such an approach, which is also the basis for this article, can be seen in the publications of authors within a worldwide context. As shown in publications by, for example, (Bumbescu, 2015; Soliman, 2003, 2008; Liesz, 2004; Mishra et al., 2012; Sheela and Karthikeyan, 2012; Burja and Mărginean, 2014; Chang, Chichernea and HassabElnaby, 2014; Doorasamy, 2016; Reiff et al., 2016), analysis of rate of return indicators using DuPont analysis is truly a globally recognized methodological approach. However, such a concept is also used by Czech authors. Its significance and utilization in the area of agricultural and food-processing businesses is apparent, for example, in the following publications: Machek and Špička, (2014), Vítková and Semenova (2015), Novotná and Svoboda (2010), Střeleček and Zdeněk (2018), and Kocisova et al. (2018).

An analysis of synthetic rate of return indicators can be successfully based upon a DuPont analysis. However, the key task within the entire analysis should be to ascertain the influence of sub-indicators upon the synthetic indicator. Identifying the main factors influencing the ROE, ROA or ROS indicators and explaining their influence upon profitability and the formation of the value of a business can be done, for example, by utilizing correlation analysis and regression analysis. The impact of selected factors upon the economic results of businesses operating within the Czech agri-food market is addressed, for example, in the following publications: Náglová and Horáková (2016), Aulová, Rumánková and Ulman (2013), Lososová and Zdeněk (2014), Novotná and Svoboda (2010), Novotná and Volek (2015), and Brožová and Beranová (2017).

Materials and methods

The objective of this article is to verify the assumption that there exist significant differences in the impact of ratio sub-indicators upon the synthetic indicator of return on assets (ROA) and return on equity (ROE) among individual groups of agricultural businesses of legal entities in the Czech Republic, in terms of both legal form and their size. The main objective is fulfilled by way of the following sub-objectives:

- definition of synthetic indicators for the DuPont analysis;
- specification of analytical sub-determinants of return on assets and return on equity on the basis of the DuPont analysis;
- evaluation of the strength of correlation of the synthetic indicator in regard to analytical indicators, within both individual size groups and legal forms of agricultural businesses, within the years being assessed.

The analytical section is based upon longitudinal data obtained from the Amadeus database. Specifically, financial statements of agricultural businesses of legal entities in the Czech Republic for the period of 2011-2015 have been used. Agricultural businesses of legal entities are divided according to legal form into joint stock companies (JSC), cooperatives (COOP) and limited liability companies (LLC) with their predominant activity being agriculture, namely category 01 according to the CZ-NACE classification. The authors consider non-included activities from category 01 CZ-NACE to be irrelevant, in view of the object of evaluation and its proportion in the income of agricultural businesses.

Size groups of businesses are defined on the basis of the AMADEUS database methodology as large (L), medium (M) and small (S) businesses.

Large Companies:

- Operating revenue ≥ 10 million EUR
- Total assets ≥ 20 million EUR
- Employees ≥ 1 000

Medium - sized Companies:

- Operating revenue ≥ 1 million EUR
- Total assets ≥ 2 million EUR
- Employees ≥ 15

Small Companies

- all companies not included into the above categories

The structure of analyzed companies and its difference between years 2011 and 2015 can be seen in Table 1.

Decrease of the number of the enterprises in analyzed period is obvious; from viewpoint of the type of the company as well as its size. It can be stated that the number of LLC exceeds the number of JSC and COOPs. Also, the smallest share of large companies among all analyzed companies is obvious. However, the structure of each type of the company can be considered as stable in the analyzed period.

The variability of ROA and ROE is closely related to the negative value of these indicators. Negative values of ROE were detected especially in group of small cooperatives while negative values of ROA are characteristic for groups of all small enterprises. The negative value of ROA is connected to the loss while the negative value of ROE is based not only on the loss but also on the negative value of equity; that is common for small companies and is usually

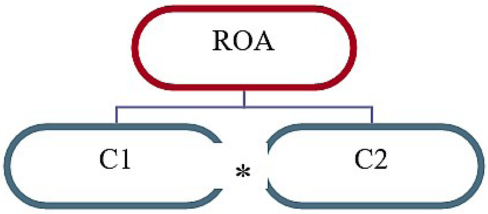
Company	JSC		LLC		COOP	
Period	**2011**	**2015**	**2011**	**2015**	**2011**	**2015**
Small	105	75	1468	1359	120	79
Medium	462	374	747	578	389	330
Large	87	79	18	15	41	40

Source: own processing

Table 1: Number of companies.

produced by cumulative losses of the previous periods.

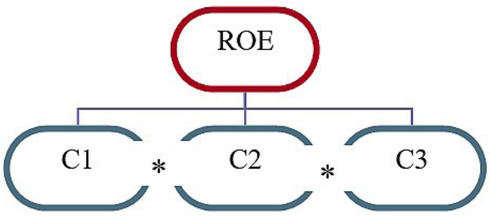
In order to define the relations between synthetic indicators (ROA, ROE) and analytical indicators, the DuPont model has been used. The model is based upon the basic indicator of return on assets, which is given as the result of the multiplier effect of the profit margin and sales turnover, with a subsequent modification, or extended in view of the impact of financial leverage (Sheela and Karthikeyan, 2012). A basic diagram of this analysis can be shown to have the following structure:



Source: own processing, according Sheela and Karthikeyan (2012)

Figure 1: Return on assets.

ROA = Net Profit/Assets
C1 = Return on Sales = Net Profit/Sales
C2 = Assets Turnover = Sales/Total Assets



Source: own processing, according Sheela and Karthikeyan (2012)

Figure 2: Return on equity.

ROE = Net Profit /Equity
C1 = Return on Sales = Net Profit/Sales
C2 = Assets Turnover = Sales/Total Assets
C3 = Financial Leverage = Total Assets/Equity

The relationship between individual sub-indicators and the aggregate indicator (ROE, ROA) has been examined by way of correlation analysis, specifically by utilizing the Pearson correlation coefficient. The correlation coefficient (r) can be calculated on the basis of the following relationship[1]:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}},$$

where x and y are random variables with a common normal distribution. The values of the correlation coefficient are within the interval of <-1;1>. Results of correlation coefficients nearing the value of |1| show the aggregate indicator to have a strong correlation to the given sub-indicator. Positive values show a positive correlation, while negative values show a negative relationship between the indicators being examined. A value of the correlation coefficient equal to 0 says that the variables being examined are not correlated.

In individual years, correlation coefficients were calculated for individual sub-determinants of the synthetic indicators ROA and ROE. The decisive sub-determinants in terms of the strength of the correlation of the synthetic indicator were thus always selected so as to be those that showed the highest value of the correlation coefficient. Moreover, the significance of the correlation coefficients was verified using t-test. In conclusion, given coefficients were mostly statistically significant on the significance level $\alpha = 0.05$ or $\alpha = 0.10$, respectively. In terms of the classification of businesses, this was conducted according to both legal form and size group.

[1] The DuPont analysis in combination with correlation analysis is used, for example, by Bumbescu (2015) and Focsan et al. (2015)

Results and discussion

Results of the analysis of return on assets

On the basis of the conducted correlation analysis, it is possible to state that significant differences exist in the impact of individual analytical sub-indicators on the synthetic indicator ROA, in terms of both legal form and size of the business (Table 2).

Small Businesses – ROA

Profit margin (or return on sales) and, to a lesser degree and only in some years, assets turnover, can be considered significant determinants impacting the value of the ROA for SMALL businesses of various legal forms. Whereas for small joint stock companies and cooperatives there is a predominating correlation proximity between ROA and return on sales within the five-year period under consideration, for limited liability companies the main determinant was seen to be assets turnover. All of the analyzed correlation proximities can, in the case of small businesses, be considered direct linear correlations for the determinant of return on sales. On the other hand, the correlation proximity between return on total capital and assets turnover was evaluated as negative. This means that while growth in return on sales leads to growth in return on total capital, growth in the speed of assets turnover leads to a decline in the main indicator being analyzed (ROA).

In the case of small joint stock companies, a moderate rate of direct linear correlation between ROA and return on sales was proven on the basis of the Pearson correlation coefficient. The proven correlation can be considered statistically significant at a significance level of $\alpha = 0{,}05$. The effect of the second of the sub-determinants, i.e. assets turnover, can be considered statistically significant within only one year (2014), where an indirect linear correlation between the indicators being assessed was proven. This means that growth in assets turnover led to a decrease in the value of ROA. In the case of small limited liability companies, a low to moderate strength of correlation proximity between ROA and assets turnover was proven. Within the entire period being assessed, this was an indirect correlation, and therefore growth in the value of assets turnover brought about a decrease in the return on total assets. In the case of small cooperatives, the relationship between return on sales and ROA was shown to be more significant; the rate of correlation proximity reached a correlation coefficient value of up to 0.3, and the direction of the effect of return on sales on ROA is a positive one. In one of the assessed periods (the year 2011), assets turnover had a negative effect on ROA, with a mild to moderate degree of correlation.

Medium Businesses – ROA

For MEDIUM-sized businesses, the conducted analysis of relation between return on total capital and its main determinants indicates a predominating correlation proximity between return on total assets and return on sales. This is a direct linear correlation that is reflected in instances of a growing profit margin through a growing return on total capital. The effect of such growth can, in isolated cases, be offset by a negative correlation proximity between ROA and assets turnover (as occurs, for example, in the case of medium joint stock companies in 2011 or medium limited liability companies in 2014). On the other hand, in the case of medium cooperatives, one can find a positive rate of correlation proximity between assets turnover and return on total capital.

In the case of medium-sized joint stock companies, significant differing values of correlation coefficients were identified in the course of the period being assessed. Whereas in the years 2011, 2014 and 2015, the strength of correlation proximity between ROA and return on sales was low, in the years 2012 and 2013 it can be assessed as medium. Within the entire period being assessed, such correlation can be considered positive, i.e., direct (growth of one variable will lead to the growth of the other variable and vice versa). In the years 2011 and 2012, assets turnover can be considered a statistically significant sub-determinant, with a moderate to medium

ROA	Small	Medium	Large	Intervals of correlation coefficient
JSC	C1*	C1	C1*	0-0.39
LLC	C2	C1	C1	0.4-0.69
COOP	C1	C1	C1	0.7-1.0

Note: *cannot be unequivocally determined (i.e., there are not at least 3 equal values)
Source: own processing

Table 2: Results of Return on Assets.

strength of correlation proximity. However, the achieved results do not unequivocally confirm a direct correlation between the variables being assessed. In the case of medium limited liability companies, it cannot be clearly proven that assets turnover has as indirect effect on the value of ROA. Within three of the five years being assessed, the correlation proximity between ROA and return on sales was assessed as being low, with a direct correlation.

In the case of medium-sized cooperatives, a positive effect of return on sales predominates within the three years being assessed (2011, 2012, 2013), which is before assets turnover at the conclusion of the period being assessed (the years 2014 and 2015), while the rate of correlation proximity greatly differs (on the timeline, it is seen to be mild, medium to high for return on sales, and low to medium for assets turnover).

Large Businesses – ROA

Unequivocal conclusions arose from the analysis of sub-determinants of ROA in the case of large companies of all legal forms. According to the results, it is typical for large businesses that return on equity is determined, on a long-term basis, by return on sales, which is classified as having a medium-to-high rate of correlation proximity.

For large joint stock companies, it can be unequivocally stated that the analytical sub-indicator of return on sales shows a strong rate of correlation proximity in relation to ROA, with the exception of one of the assessed periods. A very high degree of correlation was also found between ROA and return on sales within all of the assessed periods for large limited liability companies. This was a direct correlation. On the timeline of the period being assessed, large cooperatives show identical results, which indicates a very high rate of correlation proximity between return on sales and return on total capital.

Results of the analysis of return on equity

The results of the analysis of return on equity are summarized in Table 3.

Small Businesses – ROE

The results of an assessment of the relationship between return on equity and its sub-determinants within the agriculture, forestry and fishing sectors indicate the significance of financial leverage, primarily in the case of SMALL companies having the legal form of joint stock company and limited liability company. The effect of financial leverage impacts negatively upon return on equity. In the case of small joint stock companies, the indicator of financial leverage with a medium-to-high rate of correlation proximity was defined when analyzing the decisive determinants affecting the size of ROE. Statistically, an indirect effect of such a variable on the synthetic indicator was confirmed. For small limited liability companies, financial leverage was also unequivocally determined as the dominant analytical indicator, with an indirect effect on the evolution of ROE. The rate of correlation proximity was evaluated within the years being assessed as low. In the case of small cooperatives, unequivocal conclusions cannot be determined in terms of the effect of sub-determinants on the synthetic indicator. Within the period being assessed, a significant dissimilarity is apparent in terms of the direction and rate of correlation proximity between the indicators being analyzed. A medium and high rate of correlation proximity between financial leverage and ROE was identified in the years 2011 and 2014, but in the years 2012 and 2015 the correlation between return on sales and ROE is shown to be of medium strength. However, in all cases, the effect of sub-determinants on the indicator as a whole has an alternating positive and negative direction. In one of the periods being assessed, the indicator of assets turnover also appeared to be the most significant, but with a moderate positive degree of correlation between the variables being analyzed.

Medium Businesses – ROE

Just as in the case of small joint stock companies and limited liability companies, MEDIUM joint stock companies and limited liability companies

ROA	Small	Medium	Large	Intervals of correlation coefficient
JSC	C3	C3	C3	0-0.39
LLC	C3	C3	C1	0.4-0.69
COOP	C3	C3	C1	0.7-1.0

Source: own processing

Table 3: Results of the Analysis of Return on Equity.

also show a provable rate of correlation proximity between ROE and financial leverage. For medium joint stock companies, the indicator of financial leverage was also identified as a statistically significant determinant affecting the value of ROE. However, for medium joint stock companies, an indirect effect on the value of return on equity cannot be unequivocally proven, as is the case for the group of small joint stock companies. For medium joint stock companies, it can be unequivocally stated that the analytical sub-indicator of return on sales shows a strong rate of correlation proximity in relation to ROA, with the exception of one of the periods being assessed. A moderate rate of correlation proximity was also proven for return on sales and assets turnover, generally with a predominating positive effect on the synthetic indicator. Limited liability companies can be characterized as having a rather predominating indirect effect between financial leverage and ROE. In the case of medium cooperatives, the results of correlation analysis are significantly heterogeneous. Within two of the periods being assessed (2012, 2015), financial leverage has a predominating effect, while its effect in the year 2015 is negative, with a medium rate of correlation proximity between the variables. In the years 2013 and 2014, variable C2 shows a moderate degree of correlation proximity, i.e. assets turnover with a direct correlation. In 2011, a positive effect of return on sales with a low rate of correlation proximity predominates for medium cooperatives.

Large Businesses – ROE

In the case of LARGE businesses, differences were identified between individual legal forms. For large joint stock companies, one can find (similarly to small joint stock companies) a statistically significant medium-to-high rate of correlation proximity, with a negative impact for the financial leverage variable. Different results can be seen for large limited liability companies, where the decisive factor for the evolution of ROE was identified as being return on sales, with a high degree of correlation and a direct effect. A medium rate of correlation proximity can also be proven in regard to financial leverage, with a direct effect, which is the opposite result compared to the other size groups for limited liability companies. Large cooperatives within the period of 2011 to 2014 show a high rate of correlation proximity between return on sales and return on equity, with a positive direction of the effect.

The achieved results of the correlation analysis show a differing effect of the sub-determinants on the value of the synthetic indicator ROA for the individual size groups and legal forms within the years being assessed.

While a stronger impact of assets turnover on the value of ROA was proven in the case of small limited liability companies, in the case of small joint stock companies (as well as small cooperatives) return on sales was shown to be decisive. It is thus apparent that for small companies, the ability to effectively utilize invested assets has a large impact upon the achieved rate of return.

In the case of both medium and large businesses of all legal forms, it was clearly proven that return on sales has the strongest impact on the value of the indicator of ROA. For these companies, it can thus be presumed that profit margin is the decisive factor in a business's performance within a given year. The average realization price is thus a decisive factor for performance in the case of businesses that are stable in terms of assets. The profit margin enables an evaluation of the ability of businesses to achieve profit at a given level of sales, and reflects the price strategy of the company and its ability to manage operating costs. In terms of achieved results, these are thus in accordance with the results of Chang, Chichernea and HassabElnaby (2014), who specifically define profit margin as the most important indicator of the future evolution of rate of return. On the contrary, this result is not in accordance with the conclusions of Fairfield and Yohn (2001), who consider a more important factor in terms of the evolution of profitability to be the assets turnover rate. However, it is necessary to realize that the agriculture sector has its specifics, which can be reflected specifically in profitability results (e.g., seasonality, the biological nature of production, duality of the structure of agricultural businesses, and other factors).

For all legal forms of medium and small businesses, the influence of financial leverage on the value of the indicator ROE was proven. In the case of large businesses, financial leverage was decisive for the evolution of ROE in the case of joint stock companies. Current specialized studies indicate that small and medium businesses have more limited access to external financing resources and are thus more dependent upon generated internal resources/profit (Uyar and Guzelyurt, 2015; Anuar and Chin, 2016). Large businesses usually have lower bankruptcy costs and are more diversified, and that positively affects their access to third-party capital (Rajan and Zingales, 1995;

Chen, 2004; Weill, 2004; Song, 2005; Delcoure, 2007). In the case of large limited liability companies and cooperatives, return on sales had a decisive influence on the value of ROE, which can be explained as cited above. They state in their study that the evolution of individual parameters of profitability indicators has a much greater significance for estimating the future evolution of a business's profitability than does their value. Soliman (2008) then confirms that changes in the assets turnover rate explain changes in the future evolution of the profitability being achieved by a business. At the same time, Soliman also states that changes in individual sub-determinants of rates of return provide useful information regarding the operating characteristics of companies and can influence both the market value of a company as well as the prognosis for the business on the part of analysts.

As considered Czech agricultural businesses, profitability indicators are analyzed mainly as time series development or relating selected performance indicators (Machek and Špička, 2014; Lososová and Zdeněk, 2014; Náglová and Horáková, 2016). Based on the Du Pont model, Mishra et al. (2012) identified the profitability key drivers in US farms. As key factors affecting profitability are defined specialization and receiving government payments.

Conclusion

The aim of the paper was to verify the assumption that there exist significant differences in the impact of ratio sub-indicators upon the synthetic indicator of return on assets (ROA) and return on equity (ROE) among individual groups of agricultural businesses of legal entities in the Czech Republic, in terms of both legal form and their size. The analysis was based on longitudinal data obtained from the Amadeus database, concretely financial statements of agricultural businesses of legal entities in the Czech Republic for the period 2011 – 2015. The relationship between individual sub-indicators and the aggregate indicator (ROE, ROA) was examined by way of correlation analysis, specifically by utilizing the Pearson correlation coefficient. Moreover, the impact of individual sub-indicators was compared among different size-groups businesses (small, medium and large) as well as different legal-form businesses (JSC, LLC, COOP).

It is obvious, that the profitability indicators are influenced by several factors and the intensity of their influence differs. The development of the profitability can not be considered as identic for all analyzes size-groups businesses as well as the legal-form businesses. The values of ROA and ROE can be influenced by cost management or management of production expenses. Due to the position of agriculture in the national economy, with no power to state the market prices; the cost management can be considered as an appropriate way to control and manage the profitability.

The cost management may employ target inputs application connected to the application of fertilizers, seeds or chemical preservation. Also the diversification and specialization of business activities can be employed effectively. Thus, several ways are in compliance with CAP and target support of e.g. investments in the framework of precision agriculture, fixed assets modernization, or a diversification.

On the basis of the conducted analysis of indicators of rate of return, based upon the DuPont analysis, it is possible to state that significant differences do exist in the impact of individual ratio indicators on the synthetic indicator, in terms of both legal form and size of the business.

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References

[1] Antony, J. P. and Bhattacharyya, S. (2010) "Measuring organizational performance and organizational excellence of SMEs – Part 1: A conceptual framework", *Measuring Business Excellence*, Vol. 14, No. 2, pp. 3-11. ISSN 1368-3047. DOI 10.1108/13683041011047812.

[2] Anuar, H. and Chin, O. (2016) "The Development of Debt to Equity Ratio in Capital Structure Model: A Case of Micro Franchising", *Procedia Economics and Finance*, Vol. 35, pp. 274-280. ISSN 2212-5671. DOI 10.1016/s2212-5671(16)00034-4.

[3] Aulová, R., Rumánková, L. and Ulman, M. (2013) "Determinants of the result of economic activity of agricultural businesses of legal entities in the Czech Republic", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 61, No. 4, pp. 849-859. E-ISSN 2464-8310, ISSN 1211-8516. DOI 10.11118/actaun201361040849.

[4] Brožová, I. and Beranová, M. (2017) "A comparative analysis of organic and conventional farming profitability", *Agris On-line Papers in Economics and Informatics*, Vol. 9, No. 1, pp. 3-15. ISSN 1804-1930. DOI 10.7160/aol.2017.090101.

[5] Bumbescu, S. S. (2015) "Performance analysis in agriculture using Du Pont model", *Alma Mater University journal*, Alma Mater University Jornal of Sibiu, Vol. 8, No. 2, pp. 41-47.

[6] Burja, V. and Mărginean, R. (2014) "The Study of Factors that may Influence the Performance by the Dupont Analysis in the Furniture Industry", *Procedia Economics and Finance*, Vol. 16, pp. 213–223. ISSN 2212-5671. DOI 10.1016/S2212-5671(14)00794-1.

[7] Chang, K. J., Chichernea, D. C. and HassabElnaby, H. R. (2014) "On the DuPont analysis in the health care industry", *Journal of Accounting and Public Policy*, Vol. 33, No. 1, pp. 83-103. ISSN 0278-4254. DOI 10.1016/j.jaccpubpol.2013.10.002.

[8] Chen, J. J. (2004) "Determinants of capital structure of Chinese-listed companies", *Journal of Business Research*, Vol. 57, No. 12, pp. 1341-1351. ISSN 0148-2963. DOI 10.1016/S0148-2963(03)00070-5.

[9] Delcoure, N. (2007) "The determinants of capital structure in transitional economies", *International Review of Economics and Finance*, Vol. 16, No. 3, pp. 400-415. ISSN 1059-0560. DOI 10.1016/j.iref.2005.03.005.

[10] Doorasamy, M. (2016) "Using DuPont analysis to assess the financial performance of the top 3 JSE listed companies in the food industry", *Investment Management and Financial Innovations*, Vol. 13, No. 2, pp. 29-44. E-ISSN 1812-9358, ISSN 1810-4967. DOI 10.21511/imfi.13(2).2016.04.

[11] Fairfield, P. M. and Yohn, T. L. (2001) "Using asset turnover and profit margin to forecast changes in profitability", *Review of Accounting Studies,* Vol. 6, No. 4, pp. 371-385. E-ISSN 1573-7136, ISSN 1380-6653. DOI 10.1023/A:1012430513430.

[12] Focsan, I. E., Miron, V. C. I. and Jeler (Popa), I. (2015) "Du Pont Analysis In The Production And Preservation Of Meat", *Annals - Economy Series,* Vol. 1, pp. 140-146.

[13] Kaplan, R. S. and Norton, D. P. (2007) "Using the balanced scorecard as a strategic management system*", Harvard Business Review*. [Online]. Available: https://hbr.org/2007/07/using-the-balanced-scorecard-as-a-strategic-management-system [Accessed: 25 July 2019].

[14] Kocisova, K., Gavurova, B. and Kotaskova, A. (2018) "A slack-based measure of agricultural efficiency in the European Union countries, *Journal of International Studies*, Vol. 11, No. 1, pp. 189-200. E-ISSN 2306-3483, ISSN 2071-8330. DOI 10.14254/2071-8330.2018/11-1/14.

[15] Král, B., Wagner, J. and Stránský, J. (2006) "Vývojové tendence v systémech řízení výkonnosti" (In Czech), *Český finanční a účetní časopis*, Vol. 1, No. 3, pp. 33-42. ISSN 1802-2200. DOI 10.18267/j.cfuc.176.

[16] Liesz, T. J. (2004) "Really Modified DuPont Analysis: Five Ways to Improve Return on Equity", *The Economics Review*. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.610.5026&rep=rep1&type=pdf [Accessed: 22 July 2019].

[17] Lososová, J. and Zdeněk, R. (2014) "Key factors affecting the profitability of farms in the Czech Republic", *Agris On-line Papers in Economics and Informatics*, Vol. 6, No. 1, pp. 1-16. ISSN 1804-1930.

[18] Machek, O. and Špička, J. (2014) "Productivity and profitability of the Czech agricultural sector after the economic crisis", *WSEAS Transactions on Business and Economics*. [Online]. Available: http://www.wseas.org/multimedia/journals/economics/2014/a265707-083.pdf [Accessed: 20 July 2019].

[19] Mishra, A. K., Harris, J. M., Erickson, K. W. Hallahan, Ch. and Detre, J. D. (2012) "Drivers of agricultural profitability in the USA: An application of the Du Pont expansion method", *Agricultural Finance Review*. Vol. 72 No. 3, pp. 325-340. ISSN 0002-1466. DOI 10.1108/00021461211277213.

[20] Náglová, Z. and Horáková, T. (2016) "Influence of Qualitative Factors on Quantitative Determinants in the Czech Meat Industry Economy", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 4, pp. 111-123. ISSN 1804-1930. DOI 10.7160/aol.2016.080410.

[21] Novotná, M. and Svoboda, J. (2010) "Application of a system of indices to an analysis of agricultural holdings economy in the LFA regions", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 58, No. 3, pp. 165-174. E-ISSN 2464-8310, ISSN 1211-8516. DOI 10.11118/actaun201058030165.

[22] Novotná, M. and Volek, T. (2015) "Efficiency of Production Factors and Financial Performance of Agricultural Enterprises", *AGRIS on-line Papers in Economics and Informatics*, Vol. 7, No. 4, pp. 91 - 99. ISSN 1804-1930.

[23] Rajan, R. G. and Zingales, L. (1995) "What Do We Know about Capital Structure? Some Evidence from International Data", *The Journal of Finance,* Vol. 50, No. 1, pp. 1421-1460. E-ISSN 1540-6261. DOI 10.1111/j.1540-6261.1995.tb05184.x.

[24] Reiff, M., Surmanová, K., Balcerzak, A. P. and Pietrzak, M. B. (2016) "Multiple Criteria Analysis of European Union Agriculture", *Journal of International Studies*, Vol. 9, No. 3, pp. 62-74. E-ISSN 2306-3483, ISSN 2071-8330. DOI 10.14254/2071-8330.2016/9-3/5

[25] Sardana, G. D. (2008) "Measuring business performance: A conceptual framework with focus on improvement", *Performance Improvement*, Vol. 47, No. 7, pp. 31-40. E-ISSN 1930-8272. DOI 10.1002/pfi.20014.

[26] Schader, C., Baumgart, L, Landert, J., Muller, A., Ssebunya, B., Blockeel, J., Weisshaidinger, R., Petrasek, R., Mészáros, D., Padel, S., Gerrad, C. Smith, L. Lindenthal, T., Niggli, U. and Stolze, M. (2016) "Using the Sustainability Monitoring and Assessment Routine (SMART) for the systematic analysis of trade-offs and synergies between sustainability dimensions and themes at farm level", *Sustainability*, Vol. 8, No. 3, pp. 274. ISSN 2071-1050. DOI 10.3390/su8030274.

[27] Sheela, S. C. and Karthikeyan, K. (2012) "Financial Performance of Pharmaceutical Industry in India using DuPont Analysis", *European Journal of Business and Management, Vol. 4, No. 14*. E-ISSN 2222-2839, ISSN 2222-1905.

[28] Soliman, M. T. (2003) "Using Industry-Adjusted DuPont Analysis to Predict Future Profitability, *SSRN Electronic Journal*. 48 p. ISSN 1556-5068. DOI 10.2139/ssrn.456700.

[29] Soliman, M. T. (2008) "The Use of DuPont Analysis by Market Participants", *The Accounting Review*, Vol. 83, No. 3, pp. 823-853. E-ISSN 1558-7967, ISSN 0001-4826. DOI 10.2308/accr.2008.83.3.823.

[30] Song, H. (2005) "*Capital structure determinants An empirical study of Swedish companies*", CESIS Working Paper Series in Economics and Institutions of Innovation, [Online]. Available: http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A565199&dswid=-6302 [Accessed: 20 July 2019]. 25 p.

[31] Ssebunya, B. R. Schader, Ch., Baumgart, L., Landert, J., Altenbuchner, Ch., Schmid, E. and Stolze, Matthias (2019) "Sustainability Performance of Certified and Non-certified Smallholder Coffee Farms in Uganda", *Ecological Economics*. Vol. 156, pp. 35-47. ISSN 0921-8009. DOI 10.1016/j.ecolecon.2018.09.004.

[32] Střeleček, F. and Zdeněk, R. (2018) "Importance of objective and formal adequacy for the indicators of enterprise financial health", *Agricultural Economics - Czech*, Vol. 50, pp. 543-551. DOI 10.17221/5246-agricecon.

[33] Uyar, A. and Guzelyurt, M. K. (2015) "Impact of firm characteristics on capital structure choice of Turkish SMEs", *Managerial Finance*, Vol. 41, No. 3, pp. 286-300. ISSN 0307-4358. DOI 10.1108/MF-01-2014-0016.

[34] Vastola, A., Zdruli, P., D´Amico, M., Pasppalardo, G., Viccaro, M., DiNapoli F., Cozzi, M. and Romano, S. (2017) "A comparative multidimensional evaluation of conservation agriculture systems: A case study from a Mediterranean area of Southern Italy", *Land Use Policy*. Vol. 68, pp. 326-333. ISSN 0264-8377. DOI 10.1016/j.landusepol.2017.07.034.

[35] Vítková, E. and Semenova, T. (2015) "The Impact of Key Parameters Change on Economic Development of the Company", *Procedia Computer Science,* Vol. 6, pp. 744-749. ISSN 1877-0509. DOI 10.1016/j.procs.2015.08.605.

[36] Wagner, J. (2011) "Měření výkonnosti - vývojové tendence 2. poloviny 20. století" (Performance Measurement - Developing Tendencies of the Second Half of the 20th Century) (In Czech), *Politická ekonomie*, Vol. 2011, No. 6, pp. 775-793. E-ISSN 2336-8225, ISSN 0032-3233. DOI 10.18267/j.polek.821.

[37] Weill, L. (2004) "What determines leverage in transition countries?", *Czech Journal of Economics and Finance (Finance a uver)*, Vol. 54, No. 5-6, pages 234-242. ISSN 0015-1920.

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The Position of Agriculture and Food Sector in V4 Countries

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Abstract

Input-output tables are a simple tool, used for studying the structure of economies or sectors' demand and supply linkages. The aim of this paper is to present and compare the main characteristics of 2 selected sectors in V4 countries, namely the agriculture and food sectors. The analysis is based on the input output coefficients and multipliers, used for studying input, output and import relationships. These analyses can reveal ongoing structural changes what represents an interesting topic especially for former transition economies. The objective is to verify the similarities in the position and the development of these sectors, to examine backward and forward linkages and their strength in order to identify key sectors and to measure possible concentrations of their impacts. With accordance to the previous research and general trends, we expected certain decline of importance over the period 2000-2014, especially in terms of production, employment but also in overall effects on the whole economy. This was mostly confirmed with the exception of Polish data that point out to relatively stronger domestic position of both sectors. The presented results were obtained within the Research Project VEGA/1/0961/16

Keywords

IO analysis, linkages, agriculture, food sector, demand, supply, V4 countries

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Introduction

Input-output analyses are based on the model presented by Leontief (1953). Input output (IO) data cover all transactions between all sectors in a particular economy. This way it is possible to study sectorial flows, existing interdependencies or linkages between sectors as well as their strength. We can also see how certain sectors are impacted if other sectors change.

This paper focuses on the agriculture and food sectors, sectors that were, in many countries, experiencing a generally decreasing trend over previous decades. The aim of the analysis is to compare and evaluate positions and the development of these sectors in V4 countries; i.e. Slovakia (SK), Czech Republic (CZ), Hungary (HU) and Poland (PL) over the period of 2000-2014. The analysis should permit to study whether the possible similarities exist, to verify the strength of sectors' demand and supply linkages, the importance of their positions in national economies (key sector point of view) and to measure possible concentrations of their effects on the whole economy.

Literature review

The agriculture and food sector represent essential sectors to each national economy. Nevertheless, their economic importance has been declining over the last decades. According to the European Environment Agency, even though Europe is still one of the most intensively exploited continents in the world, the total area of agricultural land in the European Union (EU) decreases in time in favour of construction and other areas, and partly even forest. This can be seen as a sign of a lessening importance in this domain (Gebeltová, 2017).

This trend, observed in many EU countries, has been even more pronounced in countries that shifted from centrally planned economy to market systems (Central European, Baltic or Balkan countries). This transformation can be linked to the growth of innovations and the use of new technologies that increased the productivity and effectiveness in the agricultural sector as a whole. (Bednaříková, 2012; Benešová et al., 2016) The transition from one system to other significantly impacted various areas of economic life of countries, the agriculture and food sectors included. (Záhorský and Pokrivčák, 2017) In case of the 2 sectors, the transformation process brought many changes (the structure, property rights, cheap imported products or machinery renovation), necessary for assuring higher similarity of economic structures of so-called "old" and "new" EU members (Turčeková et al., 2015). With transition, these countries lost many traditional markets but new markets of other EU countries, together with new financial resources, were opened to them with the accession in 2004 (Lauri, 2012; Néméthová and Civáň, 2017)

In general, position and importance of any sector can be described by various basic indicators. One of the simplest are e.g. the sector's share on overall output, employment, value added, imports or exports. More detailed analyses, such as IO, represent another approach for studying the particular sector, its place in economy or its linkages with other sectors. This way we can verify to what extent the positions and impacts of agriculture and food sector correspond to their shares on the whole territory.

Despite IO analysis being an "old" method, there are not many studies present to document the position and evolution of the studied sectors, neither in V4, nor for EU countries in general. The authors focus mainly on overall structure of economy and key sectors (e.g. Kanemitsu, Ohnishi, 1989 - Japan; Cuello et al., 1992 - Washington; Sonis et al., 1995 - Brazil; Drejer, 2002 - Denmark, Tounsi, 2012 - Morocco; Temursho, 2016 - Kazahstan) or manufacturing sectors (e.g. Hečková, Chapčáková, 2011, Kubala, 2015 or Lábaj, 2014 - Slovak automotive sector). The analyses studying especially agriculture or food sectors are quite scarce and are done mainly on the regional level (e.g. Bednaříková, 2012 – Czech Republic or Heringa et al., 2013 – Netherlands). These works concluded that even though agriculture is not a key sector, it has strong linkages, especially towards food sector. Its impacts vary depending on the region but usually are important in the domain of employment and the income.

Materials and methods

As mentioned before, IO models are based on the Leontief's theory (Leontief, 1953). He was the first to use an IO model on a national level in order to study structural changes. Models can be constructed as basic (national IO data) or as more detailed models (relationships with the rest of the world, world IO data). In general, IO tables (IOT) supply information about activities of all sectors in each economy, from the point of view of producers of inputs, and also from the point of view of buyers of inputs, within the whole production process (Dujava et al., 2011). These monetary transactions cover a 1 year period and are recorded as both intra and intersectorial flows (Miller, Blair, 2009). This type of data can be viewed as useful also when evaluating overall macroeconomic impacts of the changing demand in various sectors (D'Hernoncourt et al., 2011). According to Timmer (2012), the use of the IO framework and multipliers for impact analysis, due to changing final demands, constitutes one of the most frequent uses of the model.

IOT approach evaluates 2 kinds of economic linkages between sectors, i.e. backward and forward linkages (demand/supply side) and enables calculating of various types of multipliers: output, input, import, value added, income or employment multipliers (Lábaj, 2014). They can be viewed as summary measures for estimating likely effects of economic changes or impacts generated by a particular sector on all industries in the national economy. IO multipliers can be calculated either as simple or total multipliers (Habrman, 2013). The calculation of simple multipliers assumes that there is no feedback between the household sector and the other sectors (open model). When the households are included, the model becomes total or closed with respect to households (Pissarenko, 2003).

Assume that each national economy can be divided into "n" sectors, interlinked by various flows, representing demand and supply relationships (linkages). The structure of each economy can be presented as follows (Miller, Blair, 2009):

$$\begin{aligned} X_1 &= Z_{11} + Z_{12} + \ldots + Z_{1j} + \ldots + Z_{1n} + Y_1 \\ X_2 &= Z_{21} + Z_{22} + \ldots + Z_{2j} + \ldots + Z_{2n} + Y_2 \\ &\ldots \\ X_i &= Z_{i1} + Z_{i2} + \ldots + Z_{ij} + \ldots + Z_{in} + Y_i \\ &\ldots \\ X_n &= Z_{n1} + Z_{n2} + \ldots + Z_{nj} + \ldots + Z_{nn} + Y_n \end{aligned} \quad (1)$$

where X_i stands for total sector output for sector i, Y_i the final demand for the sector production and Z_{ij} the intersectorial flows. The production of each sector can further serve as the intermediate consumption (inputs for other productions) or can be used directly in various sectors (final consumption) (Habrman, 2013; Duvajová, 2014). When the input flows from sector i to the sector j are divided by total sector outputs X_i, we can obtain technical coefficients (tc) that reflect the cost structure of each industry:

$$a_{ij} = \frac{z_{ij}}{x_j} \quad (2)$$

Technical coefficients matrix (A) allows to determine the structure and volume of direct inputs (intermediate consumption) of different commodities to produce 1 unit of output in the sector. The set of equations (1) can be rewritten and expressed in matrix notation: $X = AX + Y$. We obtain $X = Y(I\text{-}A)^{-1}$ where the inverse matrix $(I\text{-}A)^{-1}$ is referred to as Leontief inverse matrix L (e.g. Lábaj, 2017):

$$L = (I\text{-}A)^{-1} \quad (3)$$

The L matrix helps to understand the total direct and indirect effects of any increase in the final demand for production in each sector. It represents the base for the IO analysis. By adding up each column vector of L, we obtain simple output multipliers (som) or backward linkages of the sector (Reis and Rua, 2006). Assessing impacts of changing demand in domestic sectors on imported inputs can be calculated via import multipliers (*simp*). The calculations require knowing the vector of import coefficients "*im*", then calculating the matrix $im(I\text{-}A)^{-1}$, and lastly adding up column vector of this matrix (Trinh et al., 2009). The values of import coefficients (*ic*) are obtained by dividing sector import flows by total sector outputs X_i.

In addition to demand side, IOT allow studying the supply side perspective. This analysis works with allocations coefficients (*ac*) and simple input multipliers (*sim*), reflecting sector forward linkages. Here the vertical (column) view of the model (used for finding som values) is transposed to a horizontal (row) one. Firstly the coefficients (*ac*) need to be determined by dividing particular sector values by total sector outputs (by rows, matrix B). *Ac* represent the distribution of sector's outputs across other sectors of economy that purchase its inputs. Sim for each sector is determined by adding up row vector of the matrix $L = (I\text{-}B^T)^{-1}$. These values show the total new sector intermediate sales to all sectors (Miller and Blair, 2009).

IO approach is also focused on the analyses of the strength of demand and supply linkages between various sectors (back and forward linkages, $som = BL$ and $sim = FL$). Their strength points out to the most important sectors. In this case the analysis works with the normalised values of *som* and *sim*. Strong backward linkages ($nBL_j > 1$) point out to the backward oriented sector while strong forward linkages ($nFL_i > 1$) mean forward orientation. If both *nBL* and *nFL* are strong, such sectors represent key sectors. *nBL* and *nFL* also help to determine to what extent a particular sector impacts all other sectors of economy, i.e. the concentration of the impacts (Reis and Rua, 2006).

One of the most important advantages of IO analyses is that the values of multipliers remain relatively stable even for longer periods of time, so even older values can be used for e.g. the assessment of the current situation or predicting future impacts of changing demand. The stability of multipliers is linked to the structure of the economy and can be explained by the frequency of the occurrence of technological changes (McLennan, 1995).

Results and discussion

With regards to the limited extent, this paper presents only selected results of the research. More detailed results can be provided upon request. The focus of the presented analysis is narrowed to the evolution of Agriculture and Food sector - A01 and C10-12 according to the International Industrial Classification, revision 4 (ISIC Rev. 4). The research was based on data from the WIOD Database for 2000- 2014 (WIOD, 2018; UN, 2017). The latest WIOD update was published in 2016 and covers the period up until 2014. The choice of sectors can be linked to the certain trend of decline of domestic production in these sectors even though they can still be considered as important in each economy. We would like to verify their current positions, similarities in their evolution and to compare possible changes in their positions during 2000-2014.

According to the most recent EU data on agriculture (Eurostat, 2016), namely the agricultural census of Eurostat in 2016, the utilised agricultural area (UAA) represented 1.9 million hectares in SK, 3.5 mil. ha in CZ, 4.7 mil. ha in HU and 14.4 mil. ha in PL. When compared to the "biggest" European agriculturers such as France (16 % of European UAA) or Spain (14 %), the shares of V4 countries might not seem very significant. However, from the national point of view, it corresponded to 39 % of the total area in SK, 44 % in CZ, 57 % in HU and 46 % in PL (Eurostat, 2018).

One of the latest trends in agriculture in EU is a gradual increase of interest in organic farming, especially after 2000 (increase by 18.7 % in 2012-2016). Organic farming can be described as an agricultural production which uses organic production methods and places the highest emphasis on environmental and wildlife protection (European Commision, 2018). Over 2000-2016, the UAA under organic farming was slowly increasing in all EU countries. The size of the organic area differs considerably from one EU country to another. In 2016, the highest shares could have been attributed to the largest EU economies, i.e. Spain (17 %), Italy (15 %), France (13 %) and Germany (10 %), together making up 54 % of the total EU-28 organic area. In V4 countries, the conversion of UAA organic areas was following a slower pace: from relatively low shares around 2-5 % in 2000 to almost 10 % (SK) or 14 % (CZ) in 2016. The shares of HU and PL remained quite low (4 %). This may seem a bit of a paradox, as these countries are important agriculturals. The potential growth in the organic sector can be measured by the area under conversion. In this case, HU accounts for one of the largest shares, i.e. 51 % (European Commission, 2018; Eurostat, 2018).

As mentioned before, the importance or the position of any sector can be described by basic indicators, such as the sector's share on total output, employment, value added (VA), exports or imports. When we compare the characteristics of V4 countries, out of 56 sectors, there are only few sectors with average sector shares exceeding 5 % of total values for the whole economy. It was confirmed for all of observed indicators, i.e. average production share on total country's production (SK-4 sectors, CZ-3 sectors, HU-5 sectors, PL-4 sectors), average employment share (SK-6, CZ-5, HU-6, PL-6), average export share (SK-5, CZ-5, HU-3, PL-2), average import share (SK-6, CZ-4, HU-3, PL-4) and average value added share (SK-5, CZ-0, HU-3, PL-6). Based on this comparison, the most important producers were the sectors of motor vehicles manufacturing (SK, HU), construction (CZ, PL); the most important employers the sectors of education (SK), construction (CZ), retail trade (HU) and agriculture (PL). As for the foreign trade, the highest average shares were in the manufacture of motor vehicles (export-V4, import-SK, CZ), manufacture of computer, electronic and optical products (import-HU) and construction (import-PL). The highest share of VA on total VA was created in construction (SK), retail trade (PL) and public administration and defence (HU). In CZ, there was no sector with the VA exceeding 5 %. From this point of view we could state that there are certain similar traits in the structure of V4 countries. Especially the domain of foreign trade seems to be rather similar.

Tables 1 and 2 show average shares of observed indicators for agriculture and food sectors together with their trend during 2000-2014. It can be seen that countries experienced declines in both production and employment shares vis-à-vis the total production and employment. The most significant reductions (more than 50 %) appeared in SK in case of c1012 (production) and a01 (employment). The shares increased mainly on the export side (e.g. a01 in SK, HU, PL or c1012 in CZ, HU, PL). Overall, the evolution in Polish c1012 can be described as the most favourable one with the increases for all 5 observed indicators.

The next part of the analysis was based on the IOT representing intersectorial relationships. Firstly, the basic IO coefficients were calculated, i.e. technical, allocation and import coefficients

	out	Δ%	emp	Δ%	exp	Δ%	imp	Δ%	VA	Δ%
SK a01	2.75	-34	3.09	-54	1.49	68	2.04	-40	3.13	-8
CZ a01	1.85	-23	2.98	-27	1.02	-2	1.30	13	0.75	-61
HU a01	4.50	-26	7.96	-49	2.37	53	2.44	-17	4.23	28
PL a01	3.46	-25	15.07	-47	1.50	-22	3.09	-34	2.82	-7

Source: own calculation, WIOD data

Table 1: Agriculture sector – average output, employment, export, import and value added shares on total values (2000-2014).

	out	Δ%	emp	Δ%	exp	Δ%	imp	Δ%	VA	Δ%
SK c1012	3.09	-51	2.72	-39	1.59	-31	2.55	-47	2.06	-50
CZ c1012	4.16	-37	2.76	-22	3.22	60	2.29	-32	1.11	33
HU c1012	5.15	-26	3.15	-24	4.42	20	3.27	-17	2.68	-27
PL c1012	6.45	6	3.24	11	6.54	47	3.09	25	3.32	1

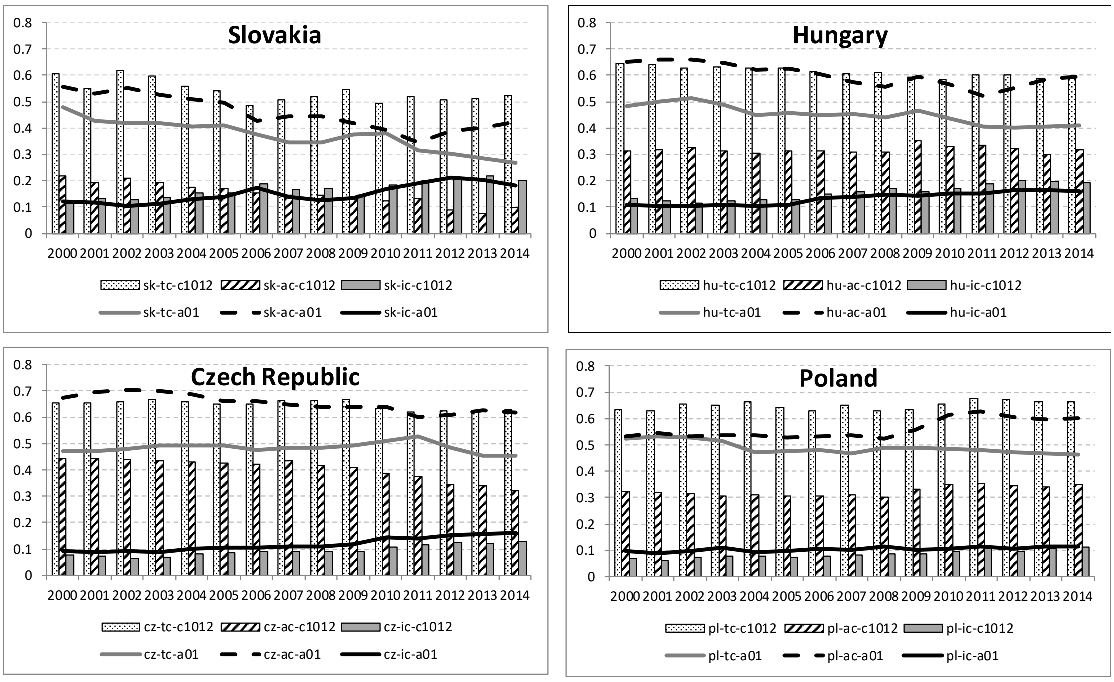
Source: own calculation, WIOD data

Table 2: Food sector – average output, employment, export, import and value added shares on total values (2000-2014).

(*tc, ac, ic*). These coefficients were then used to calculate simple output, input and import multipliers (som, sim, simp). And lastly, the analysis proceeded to verify the importance of both industries by studying the strength of demand and supply linkages (nBL, nFL) as well as concentration of their impacts.

The study of IO coefficients showed (Figure 1) that they were marked by steady declines (SK, CZ, HU) with the exceptions of Polish sectors' values. On the other hand, ic were showing the opposite trend (gradual increases), confirming growing significance of the imported inputs for both sectors and both countries. It can be also interpreted as an increasing share of domestic inputs that are being replaced by the imported ones.

Table 3 and 4 show multiplier values at the beginning and the end of the period, as well as average and median values (av, med). In most cases *som* and *sim* values were following the decreasing trend. The only exceptions are Polish values. As for the *simp*, the values were slowly increasing. When we compare multipliers for 2 sectors, it is obvious that on the demand side (*som*) the food sectors impact national economies more significantly than the agriculture sectors: average values of multipliers from the range (1.617 - 1.957) for a01 compared to c1012 values from the range (1.931 – 2.308). A closer look at the results shows that higher average demand impacts (som) appear in case of c1012. While in SK each 1€ of demand increase in agriculture would generate 1.62€, in case of CZ agriculture, the impact would be almost 1.97€. Same can be said for c1012, the lowest impact was in case of SK (1.93€ for +1€) and the highest in case of CZ (2.25€ for +1€). As for the supply side point of view (*sim*), we can



Source: own calculation, WIOD data

Figure 1: Coefficients.

A01	som 2000	som 2014	som av med	Δ	sim 2000	sim 2014	sim av med	Δ	simp 2000	simp 2014	simp av med	Δ
SK	1.904	1.404	1.617	↓	1.896	1.582	1.679	↓	0.231	0.253	0.238	↑
			1.611				1.622				0.231	
CZ	1.943	1.825	1.957	↓	2.231	1.984	2.136	↓	0.178	0.296	0.229	↑
			1.972				2.150				0.219	
HU	1.88	1.676	1.778	↓	2.128	1.971	2.003	↓	0.204	0.265	0.233	↑
			1.766				1.996				0.240	
PL	1.962	1.85	1.896	↓	1.884	2.022	1.922	↑	0.194	0.214	0.199	↑
			1.880				1.884				0.194	

Source: own calculation, WIOD data

Table 3: Agriculture sector – multipliers (2000-2014).

c1012	som 2000	som 2014	som av med	Δ	sim 2000	sim 2014	sim av med	Δ	simp 2000	simp 2014	simp av med	Δ
SK	2.197	1.814	1.931	↓	1.329	1.139	1.236	↓	0.251	0.363	0.318	↑
			1.867				1.196				0.306	
CZ	2.308	2.154	2.249	↓	1.806	1.527	1.710	↓	0.172	0.272	0.210	↑
			2.295				1.740				0.206	
HU	2.168	1.978	2.059	↓	1.496	1.471	1.481	↓	0.283	0.377	0.317	↑
			2.034				1.476				0.315	
PL	2.184	2.238	2.212	↑	1.522	1.572	1.498	↑	0.155	0.249	0.192	↑
			2.205				1.513				0.183	

Source: own calculation, WIOD data

Table 4: Food sector – multipliers (2000-2014).

state that agriculture is a more important supplier of inputs than food sector (*sims* for a01 > *sims* for c1012) what is also logical as most of the food production would serve the final consumption). Each additional domestic production equally stimulates the imports of foreign inputs. In this case, the values of multipliers are in general increasing. Increases in a01 would generate approximately 0.20-0.23€ of foreign inputs, in c1012 approximately 0.20-0.32€ of foreign inputs.

When compared, values of average and median multipliers can be used for a simple evaluation of the stability. Closer values of average and median could be interpreted as a higher stability of multipliers. We can see that in most cases these values are very close to each other. Slightly higher differences can be observed in case of SK and PL food productions (*som, sim)*. This could be considered as an indirect confirmation of a relative stability of observed sectors.

The next step consisted of the analysis of the normalised values of som and sim, i.e. nBL and nFL. Table 5 shows the average values for nBL and nFL in 2 sectors and their variation coefficients (*VC*). Values of nBLs and nFLs can indicate the orientation of the sector either backward or forward. If both linkages are strong, the sector can be considered as a key sector (nBL > 1 and nFL > 1).

From the results presented in Table 5, a01 can be considered as a key sector in CZ (1.11/ 1.15), HU (1.19 /1.25) and PL (1.12/1.11). The strength of the linkages seems to be the most significant for HU a01 (the highest numbers) what could point out to a relatively strong position of the sector in national economy. In CZ and PL the similar values of nBL and nFL confirm also similar position of their agricultures. On the other hand, in case of SK, average values show the stronger backward orientation. As for c1012, there is a strong backward orientation but weaker supply linkages. It is quite logical as the products of food sectors serve mainly for final consumption of various economic subjects. At the same time food production is strongly dependent on the supply of inputs, especially from the agriculture productions.

Based on nBL and nFL we can also determine the extent of the sector's impact; whether the effects of the particular sector are concentrated on few other industries, or its impacts are scattered across a large number of other sectors. The range of influence can be determined thanks to the variation coefficient *VC*. Higher values indicate a stronger concentration on interconnected industries; lower values refer to lower concentrations and thus evenly dispersed impacts across the economy.

As for the 2 observed sectors, their VC are lower than the countries' average VC (Table 5, 6). The only exception is SK and PL a01 with higher VC for backward linkages. From this point of view we cannot affirm that countries have similarly interlinked sectors with similarly distributed concentrations of effects. However, it is obvious that nFL max values are higher than nBL max values. The same can be said for average values. It can be interpreted as a stronger concentration when looking forward and lower concentration (even distribution of effects) when looking backward.

The comparison of most and least important sectors in 4 countries from the concentration point of view is presented in Table 6. The highest concentration is present on the supply side (nFL av > nBL av, also nFL max > nBL max). The highest concentration on supply side seems to be similar for SK, CZ and PL (27 - 29 %), the sectors are however different. The max VC values on demand side are from the rage (5 % for HU to 23 % in SK). As for the average values, these could be interpreted as a measure of the economic structure from the concentration point of view.

	nBL av	nBL VK%	nFL av	nFL VK%		nBL av	nBL VK%	nFL av	nFL VK%
SKa01	0.98	4.41	0.99	6.12	SKc1012	1.17	2.46	0.73	8.51
CZa01	1.11	1.90	1.15	3.39	CZc1012	1.29	1.14	0.93	3.70
HUa01	1.19	2.21	1.25	2.84	HUc1012	1.38	1.18	0.92	4.21
PLa01	1.12	1.74	1.11	10.2	PLc1012	1.30	2.54	0.86	3.80

Source: own calculation, WIOD data

Table 5: Average normalised backward, forward linkages and variation coefficients (2000-2014).

	nBL min	nBL max	nBL av	nFL min	nFL max	nFL av
SK	1.32 (C23)	23.06 (R_S)	4.86	1.75 (N)	28.65(G46)	10.14
CZ	0.93 (P85)	14.01 (A03)	3.73	0.97 (P85)	27.25 (K66)	6.31
HU	0.71 (N)	5.41 (C29)	2.65	1.05 (G46)	19.93 (B)	5.6
PL	0.90 (C22)	12.50 (H50)	2.89	2.21 (J61)	27.49 (C26)	8.41

Source: own calculation, WIOD data

Table 6: Average variation coefficients for nBL and nFL, total economy (2000-2014).

Low average values confirm a more balanced structure of national economy while higher values (e.g. 10 % in SK) point to a strong position of certain sectors. This could be seen as less favourable as their impacts are also stronger and more concentrated. As for the sectors with the highest impact of the sectors, it is not possible to find any common traits. In general, we can conclude that on average, impacts on the demand side are more evenly distributed than on the supply side (VC for nBL > VC for nFL).

Conclusion

The aim of this paper was to present and compare 2 selected sectors in V4 countries. The objective was to verify the similarities in the position and the development of the sectors, to examine backward and forward linkages and their strength in order to identify countries' key sectors and to measure possible concentration of their impacts.

The analyses of the sector shares of total countries' values showed that there were certain similar traits in the structure of economies. Especially the domain of foreign trade seems to be rather similar. Sectors a01 and c1012 have important positions in HU and PL, notably from the point of view of employment and export. In general, it can be said that the shares of production, employment, exports and value added were decreasing while the import shares became more important.

The IOT analyses for 2000-2014 showed a descending trend for tc, ac, som and sim in SK, CZ and HU. Values for Polish sectors were, however, increasing. The ic were in general increasing what could be seen as a confirmation of a growing significance of the imported inputs for both sectors in V4 countries. It also speaks of the trend of replacing domestic inputs by the imported ones. On average, the multipliers seem to be stronger on the demand side for c1012 and on the supply side for a01.

As for the positions of 2 sectors, only a01 can be considered as a key sector in all countries. C1012 presented only strong backward orientation and weaker supply linkages. It is quite logical as the products of food sectors serve mainly for final consumption of various economic subjects. At the same time, food production is strongly dependent on the supply of inputs, especially from the agriculture productions. These findings are somewhat similar to some older studies (Bednaříková, 2012; Heringa et al., 2013) that concluded that on regional level agriculture and food sectors are not key ones. They have, however, strong mutual linkages and their economic impacts are present mainly in the employment and income domain. Lábaj's study (2014) of structure of Slovak economy also confirms higher importance of manufacturing and service sectors as opposed to the agriculture and food production.

The comparison of VC did not reveal any important similarities in sectors' concentrations. In general, the maximum values for nFL were higher that maximum values for nBL. The same can be said for average values. It can be interpreted as a stronger concentration when looking forward and lower concentration when looking backward. Low average VC confirm a more balanced structure of national economy while higher values (e.g. 10 % in SK) point to strong position of certain sectors. This could be seen as less favourable as their impacts are also stronger and more concentrated.

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References

[1] Bednaříková, Z. (2012) "Ekonomický přínos zemědělství pro venkovskou ekonomiku: Aplikace input-output analýzy", *Politická ekonomie,* Vol. 60, No. 2, pp. 265-285. E-ISSN 2336-8225, ISSN 0032-3233. DOI 10.18267/j.polek.841

[2] Benešová, I., Novotná, Z., Šánová, P. and Laputková, A. (2016) "Economic Comparison of Agricultural Sector of Eurasian Countries – Is There Any Potential for Development Through Economic Cooperation?", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 2, pp. 19-31. ISSN 1804-1930. DOI 10.7160/aol.2016.080202.

[3] Cuello, F. A., Mansouri, F. and Hewings, G. J. D. (1992) "The Identification of Structure at the Sectoral Level: A Reformulation of the Hirschman-Rasmussen Key Sector Indices", *Economic Systems Research*, Vol. 4, No. 4, pp. 285-296. E-ISSN 1469-5758, ISSN 0953-5314. DOI 10.1080/09535319200000027.

[4] D'Hernoncourt, J., Cordier, M. and Hadley, D. (2011) "*Input- output multipliers- specification sheet and supporting material*", Spicosa Project Report. [Online]. Available: http://www.coastal-saf.eu/output-step/pdf/Specification%20sheet%20I_O_final.pdf. [Accessed: 15 Oct. 2018].

[5] Drejer, I. (2002) "*Input-output based measures of interindustry linkages revisited – A survey and discussion*", Centre for Economic and Business Research, Ministry of Economic and Business Affairs. [Online]. Available: internete: https://www.researchgate.net/publication/228738366_Input-Output_Based_Measures_of_Interindustry_Linkages_Revisited-A_Survey_and_Discussion [Accessed: 15 Oct. 2018].

[6] Dujava, D., Lábaj, M. and Workie, M. (2011) "*Štruktúra ekonomiky a ekonomický rast: Ako naplniť teóriu číslami*", Bratislava: Iris, 269 p. ISBN 978-80-89256-66-2 (in Slovak).

[7] Duvajová, L. (2014) "Využitie multiplikátorov na kvantifikáciu objemu domácej produkcie vyvolanej výdavkami návštevníkov v cestovnom ruchu", *Trendy v podnikání*, Vol. 5, No. 1, pp. 55-63. ISSN 1805-0603 (In Slovak).

[8] European Commission (2018) "*Agriculture in the European Union. Statistical and Economic Information*". [Online]. Available: https://ec.europa.eu/agriculture/sites/agriculture/files/statistics/agricultural/2012/pdf/full-report_en.pdf [Accessed: 8 Aug. 2018].

[9] Eurostat (2016) "*Statistics explained: Agricultural census in Hungary"*. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agricultural_census_in_Hungary [Accessed: 9 Aug. 2018].

[10] Eurostat (2016) "*Statistics explained: Agricultural census in Poland*". [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_census_in_Poland&oldid=379560 [Accessed: 9 Aug. 2018].

[11] Eurostat (2016) "*Statistics explained: Agricultural census in Slovakia*". [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_Slovakia [Accessed: 8 Aug. 2018].

[12] Eurostat (2016) "*Statistics explained: Agricultural census in Czech Republic*". [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_census_in_the_Czech_Republic&oldid=379567 [Accessed: 8 Aug. 2018].

[13] Eurostat (2018) "*Statistics explained: Organic farming statistics*". [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Organic_farming_statistics [Accessed: 9 Aug. 2018].

[14] Gebeltová, Z. (2017) “Exploitation of Agricultural land in the Czech Republic and EU Countries", *AGRIS on-line Papers in Economics and Informatics*, Vol. 9, No. 4, pp. 33-44. ISSN 1804-1930. DOI 10.7160/aol.2017.090404.

[15] Habrman, M. (2013) “*Vplyv exportu na pridanú hodnotu a zamestnanosť v slovenskej ekonomike*”, EÚ SAV Working Papers, 53. [Online]. Available: http://www.ekonom.sav.sk/uploads/journals/239_wp_53_habrman.pdf. [Accessed: 10 Oct 2018]. ISSN 1337-5598.

[16] Hečková, J. and Chapčáková, A. (2011) “Konkurencieschopnosť odvetvovej štruktúry spracovateľského priemyslu Slovenskej republiky v období 1998 – 2008”, *Ekonomický časopis*, Vol. 59, No. 1, pp. 59-78. ISSN 0013-3035.

[17] Heringa, P. W., van der Heide, C. M. and Heijman, W. J. M. (2013) “The economic impact of multifunctional agriculture in Dutch regions: An input-output model”, *NJAS- Wageningen Journal of Life Sciences*. Vol. 64-65, No. 9, pp. 59-66. ISSN 1573-5214. DOI 10.1016/j.njas.2013.03.002.

[18] Kanemitsu, H. and Hiroshi, O. (1989) "*An Input-Output Analysis of Technological Changes in the Japanese Economy: 1970–1980, Frontiers of Input-Output Analysis*", New York: Oxford University Press, pp. 308-323.

[19] Kubala, J., Lábaj, M. and Silanič, P. (2015) “Štrukturálne väzby v slovenskej ekonomike v roku 2010: identifikácia kľúčových odvetví”, *Ekonomický časopis*, Vol. 63. No. 8, pp. 795-816. ISSN 0013-3035 (in Slovak).

[20] Lábaj, M. (2017) ”Štruktúrna dekompozícia globálnych hodnotových reťazcov: Slovenská ekonomika v medzinárodnom porovnaní”, *Politická ekonomie*, Vol. 65, No. 5, pp. 562-582. E-ISSN 2336-8225, ISSN 0032-3233. DOI 10.18267/j.polek.1162 (in Slovak).

[21] Lábaj, M. (2014) “*Štrukturálne aspekty ekonomického rozvoja - Slovenská ekonomika v globálnych súvislostiach*”, Bratislava: Ekonóm. ISBN 978-80-7144-223-3 (in Slovak).

[22] Lauri, M. (2012) “*General overview of Estonian economy. Agriculture and Forestry*”, Estonica. [Online]. Available: http://www.estonica.org/en/Economy/General_overview_of_Estonian_economy/Agriculture_and_forestry/. [Accessed: 10 Oct 2018].

[23] Leontief, W. (1953) “Domestic Production and Foreign Trade; The American Capital Position Re-Examined”, *Proceedings of the American Philosophical Society*, Vol. 97, No. 4, pp. 332-349.

[24] McLennan, W. (1995) “*Australian national accounts: Introduction to input-output multiplier*”, [Online]. Available: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5246.01989-90?OpenDocument. [Accessed: 10 Oct 2018].

[25] Miller, R. E. and Blair, P. D. (2009) “*Input - Output analysis. Foundation and Extentions*”, 2nd ed., Cambridge, New York: Cambridge University Press. ISBN 978-0-521-739-02-3. DOI 10.1017/CBO9780511626982.

[26] Néméthová, J. and Civáň, M. (2017) “Regional differences in agriculture in Slovakia after its accession to the European Union”, *Quaestiones Geographicae,* Vol. 36, No. 2, pp. 9-21. E-ISSN 2081-6383. DOI 10.1515/quageo-2017-0011.

[27] Pissarenko, D. (2003) “*Basics of input-output analysis*”, [Online]. Available: http://demetrix.sourceforge.net/resources/2003_02_20_ioAnalysis/ioAnalysis.pdf. [Accessed: 10 Oct 2018].

[28] Reis, H. and Rua, A. (2009) “An input-output analysis: Linkages vs leakages”, *International Economic Journal*, Vol. 23, No. 4, pp. 527-544. E-ISSN 1743-517X, ISSN 1016-8737. DOI 10.1080/10168730903372323.

[29] Sonis, M., Guilhoto, J. J. M., Hewings, G. J. D. and Martins, E. B. (1995) "Linkages, key sectors and structural change: some new perspectives“, *The Developing Economies*, Vol. 32, No. 3, pp. 233-270. E-ISSN ISSN:1746-1049. DOI 10.1111/j.1746-1049.1995.tb00716.x

[30] Temursho, U. (2016) "*Backward and forward linkages and key sectors in the Kazakhstan economy*“, Services sector in Kazahstan as an engine for diversified economic growth - Final report. [Online]. Available: https://www.adb.org/sites/default/files/project-documents/47110/47110-001-dpta-en_2.pdf. [Accessed: 15 Oct 2018].

[31] Timmer, M. (2012) “*The world input-output database (WIOD): Contents, Sources and Methods*”, [Online]. Available: http://www.wiod.org/publications/source_docs/WIOD_sources.pdf [Accessed: 15 Oct 2018].

[32] Tounsi, S., Ezzahidi, E., El Alaoui, A. and Nihoo, A. (2011) "Key sectors in the Moroccan economy: an application of input-output analysis“, *Economics e-journal* , Vol. 59, No. 2012-59, pp. 1-18. [Online]. Available: http://www.economics-ejournal.org/economics/discussionpapers/2012-59 [Accessed: 15 Oct 2018].

[33] Trinh, B., Le Hoa, P. and Giang, B. C. (2009) “Import multiplier in input-output analysis”, *Journal of science, economics and business*, Vol. 25, No. 5, pp. 41-45. ISSN 0148-6195.

[34] Turčeková, N., Svetlanská, T., Kollár, B. and Záhorský, T. (2015) “Agri-environmental Performance of EU member states”, *AGRIS on-line Papers in Economics and Informatics*, Vol. 7, No. 4, pp. 199 - 208. ISSN 1804-1930.

[35] UN (2017) "*United Nations International Industrial Classification revision 4. Detailed structure and explanatory notes*". [Online]. Available: https://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27 [Accessed: 13 Nov. 2018].

[36] WIOD (2018) "*World Input Output Database National Input Output Tables – Slovakia, Czech Republic, Hungary, Hungary. 2000 - 2014. 2016 release*", 2017. [Online]. Available: http://www.wiod.org/database/niots16. [Accessed: 10 Aug. 2018].

[37] Záhorský, T. and Pokrivčák, J. (2017) “Assessment of the Agricultural Performance in Central and Eastern European Countries", *AGRIS on-line Papers in Economics and Informatics*, Vol. 9, No. 1, pp. 113 - 123. ISSN 1804-1930. DOI 10.7160/aol.2017.090110.

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Does Agriculture Matter for Environmental Kuznets Curve in Russia: Evidence from the ARDL Bounds Tests Approach

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Abstract

This study explores the relationship between carbon dioxide emissions and their main determinants, which include real income and energy consumption in Russia, employing data for the period 1990-2016. The hypothesis of agriculture being an important determinant of environmental quality in Russia is also tested. For estimating the short-run and long-run relationships the ARDL bounds test approach is employed in this study. The results are consistent with the Environmental Kuznets Curve (EKC) hypothesis and show that the real income and energy consumption have a statistically significant positive impact on the carbon emission and its square has a significant negative effect on the carbon emissions both in the short-run and long-run. Agricultural sector is found to be a relatively important statistically significant determinant of carbon emission in Russia as well. The pairwise Granger causality test also reveals unidirectional causality running from agriculture to the carbon emissions.

Keywords

Environmental Kuznets curve, agriculture, economic growth, CO_2 emission.

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Introduction

1. Environmental pollution: problem statement

Environmental pollution is one of the main areas of research in the field of the environmental economics. The problems of climate changes, global warming and worsening quality of environment, brought to life by an increased industrial output, are related to an increased greenhouse gases emission, which include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as well. According to the estimates of the World Bank (2018), agricultural sector is responsible for 15 % – 35 % of the global greenhouse gases emissions, depending on whether it is related with deforestation or not. On the other hand, agricultural sector remains on the main fields in the national economies, which helps to maintain the national security, at least in part of the food security, not to mention the function of meeting the basic demand of the households.

Given the above, the importance of agricultural sector for the national economy, as well as its role in the environmental pollution under certain assumptions is rather hard to overestimate. Concerning the studied country, one should notice, that Russia takes the 4th place among other countries, contributing in the world CO_2 emissions, after China, the United States of America and India in total kilotons (kt). Yet, in terms of kilogram (kg) of CO_2 emission per GDP, measured in 2010 US dollars, in 2014, according to the World Bank data (2018), Russia with 0.999 kg outplaced the US with 0.324 kg. According to the world tendency among developed countries, CO_2 steadily declines. However, in Russia CO_2 emissions continue to rise. Since 1998 minimum, the level of CO_2 emissions has increased on 14% up to 2014. If the GDP is taken into account, the picture changes: CO_2 emissions, measured as kg per 2010 US dollars of GDP, decline from 1.839 in 1998 to 0.999 in 2014. This tendency is the results of using more friendly-environmental technologies in some sectors of the national economy. However, due to rising share of agriculture in Russian GDP from 3.9% in 2011 up to 5% in 2017, the question of potential increase in CO_2 emissions arises, which advocates the relevance of this study, given the potential threat of increasing CO_2 emissions.

2. Literature review

The problem of environmental pollution has already received much attention in the literature. Most empirical studies are based on the theoretical hypothesis of the environmental Kuznets curve (EKC). The EKC framework underlines the importance of energy consumption in producing the national GDP and assumes the existence of an inverted U-shaped relationship between environmental degradation and real income per capita. As national income rises, environmental pollution initially is rising as well. However, achieving a certain threshold in national economic development, the level of emissions declines and pollution is assumed to decrease (Kuznets, 1955).

The initial wave of empirical studies tested the EKC hypothesis in narrow sense, aiming to describe and explain environmental pollution solely by economic factors, including different proxies for economic growth (Grossman and Krueger, 1995; Heil and Selden, 1999; Akbostanci et al., 2009; Poudel et al., 2009; Narayan and Narayan, 2010; Onafowora and Owoye, 2014).

The second wave of the studies is different in a more deeply oriented approach, taking into consideration the structural issue: these studies seek for additional or structural factors that may amplify or accelerate the environment pollution process. Some studies accentuate importance of energy consumption as a leading factor of environmental degradation (Soytas and Sari, 2009; Acaravci and Ozturk, 2010; Pao and Tsai, 2010; Alam et al., 2012; Dagher and Yacoubian, 2012; Saboori and Sulaiman, 2013; Shahbaz et al., 2015; Benavides et al., 2017; Shahbaz et al., 2017). These studies bring evidence in favor of energy-induced EKC both for developed and developing countries, yet in some cases the results are heterogeneous due to differences in econometric techniques used.

The third wave of empirical research is aimed at mitigating the omitted variables bias and include various additional proxies for incorporation of changes in international environment and globalization processes. Recently, the importance of changes in energy prices and terms of international trade gain attention in testing the EKC. The issue of trade liberalization and globalization has led to a rise in international trade, which spurred the total output, leading to a rise in environmental pollution (Halicioglu, 2009; Rabi et al., 2015; Halicioglu and Ketenci, 2016; El-Aasar and Hanafy, 2018). An increased volatility of energy prices and the export-import status of the country relative to energy resources also gained attention in empirical research. (Richmond and Kaufmann, 2006; He and Richard, 2010; Al-Mulali and Ozturk, 2016) In case when the country is an importer of energy resources and in times of rising energy prices, the stimulus to substitute energy-intensive technologies by renewable energy resources or more environmentally friendly ones, is supposed to be greater. In case of exporting countries, rising global energy prices lead to increased profit and greater output, which, in turn, may lead to higher level of pollution (He and Richard, 2010).

Also empirical research on the EKC hypothesis may be divided for developed and developing countries. The results of the studies are heterogeneous in nature. In some papers, authors find evidence in favor of the inverted U-shaped curve, while in others the N-shaped. E.g., Halicioglu and Ketenci (2016) provided evidence in favor of the existence of EKC only in three out of fifteen transition countries. Onafowora and Owoye (2014) found the N-shaped trajectory in six out of eight studied countries and only in two countries the inverted U-shaped curve was detected. The ambiguity of results may be the consequence of using total pollution as a proxy for environmental degradation, neglecting the differences in the emissions structure in the economy (Stern, 2004).

Although empirical studies, testing the EKC hypothesis, are common today, yet the number of papers, devoted to assessing the role of agriculture in the environmental pollution in the EKC framework are limited. Pretty (2008) stresses the importance of agriculture as an accumulator of carbon when the organic waste is aggregated in the soil, and when it is used as an energy source that substitutes for fossil fuels, thus avoiding carbon. Liu et al. (2017) tested the causality between CO_2, renewable energy and agriculture in selected ASEAN-4 countries. The results do not support the inverted U-shaped EKC hypothesis, as well as no causality is found from renewable energy to agriculture, giving evidence to pollution-inducing character of the agriculture. Zafeiriou et al. examined the intertemporal causal relationship between environmental damage from carbon emissions released by agriculture per 1000 ha of utilized agriculture area and economic performance in the sector of agriculture as described by net value added per capita. The results of the study, which included Bulgaria, Czech Republic, and Hungary, show that the EKC hypothesis is present in the long run for Bulgaria and Czech Republic while in the short run is validated only for the case of Czech Republic, giving evidence in favor of agriculture being an important factor of environment pollution.

Despite the interest in testing the EKC hypothesis, empirical research of the EKC in Russian case is almost absent. Pao and Tsai (2010), testing the EKC hypothesis for BRIC countries, found that emissions are "output inelastic" and the EKC is not supported. Halicioğlu and Ketenci (2016) and Yang et al. (2017) found support for the EKC in Russia, where the economy-related greenhouse emissions are presented by energy consumption, emissions from industrial process, from animal husbandry and fugitive emissions. Ketenci (2018) also find support for the EKC in Russia, stressing importance of energy consumption, real income, education and urbanization levels for environmental pollution in Russia. Also mixed results for Russian case are found by Mihalischev and Raskina (2015), Rudenko (2018) on macro, regional and city-levels. The results of testing the EKC hypothesis are controversial, even when Russia is included in the panel of BRIC countries. The results of Pao and Tsai (2010) speak in favor of the EKC in Russia, while the results of Chang (2015) speak in favor of the U-shaped curve, which is controversial to conventional results.

Unfortunately, none of the studies, devoted to the Russian case, incorporate agriculture as an important variable and determinant of the environmental pollution. Given the above, this study is aimed to fill this gap in the literature.

Materials and methods

1. Research methodology

Given the heterogeneity of the obtained results on the EKC hypothesis, discussed in the previous section, we aim to fill the gap by enquiring into the nature of the relationship between CO_2 emission and agriculture as a share of GDP in the EKC framework. Following methodology for the Russian case, proposed by Ketenci (2018), the basic EKC hypothesis then can be presented as follows:

$$c_t = \beta_0 + \beta_1 e_t + \beta_2 i_t + \beta 3 i_t^2 + \beta_4 a_t + \varepsilon_t \quad (1)$$

where c_t represents CO_2 emission per capita in the sampled country; e_t is commercial energy use per capita; i_t is the real income, measured as national GDP per capita; i_t^2 represents the square of per capita income; a_t is the agriculture, measured as its share in GDP.

Then we transform linear specification of the model into log-linear specification. The log-linear specification provides more appropriate and efficient results compared to simple linear functional form of the model (Cameron, 1994). Moreover, logarithmic form of variables gives direct elasticities for interpretations. Therefore, we specify the estimated equation in log-linear form:

$$Lc_t = \beta_1 + \beta_{et} Le_t + \beta_{it} Li_t + \beta_{i_t^2} Li_t^2 + \beta_{a_t} La_t + \mu_t \quad (2)$$

The theoretical foundation of the EKC hypothesis states that the energy consumption is the primary source of shifts and changes in emissions. Then, it is expected the regression coefficient β_{et} to have a positive sign (Suri and Chapman, 1998). Also the EKC hypothesis states that β_{it} is positive, while $\beta_{i_t^2}$ is negative in sign, demonstrating a rise in CO_2 emissions goes alongside the economic growth till the certain threshold, after achieving of which, the emission declines due to technological changes, leading to increasing environment quality. Coefficient β_{a_t} may be positive or negative, depending on the current stage of development of the national economy, political and institutional factors, stimulating introduction of environment-friendly technologies in the economy and agricultural sector particularly. On the one hand, increasing share of agriculture in Russian GDP is expected to negatively affect the environmental quality due to its energy intensive production cycle. On the other hand, the results may be opposite as well, given the introduction of environment-friendly technologies in the agricultural sector.

In this study we employ the ARDL bound test approach, which allows for I(0), I(1) or fractionally integrated variables. Yet, if the variables are I(2) integrated, the use of this methodology is unacceptable. That is why the first step of this study is to check the stationarity of the sampled variables and determine whether it us achieved without second differencing procedure. For this we employ four alternative unit root tests: the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979), the Dickey–Fuller generalized least squares (DF-GLS) test proposed by Elliot et al. (1996), the Phillips and Perron (1988) PP test and the KPSS (Kwiatkowski et al., 1992) test. The null hypothesis of the ADF, DF-GLS and PP tests states that the there exists a unit root, while the alternative hypothesis states that the series are generated by a stationary process. The null hypothesis of the KPSS test is of reverse nature – it states that the series are stationary, while the alternative hypothesis states that the unit root is present.

After determining the stationary character of the series, the study employs the bounds testing approach, proposed by Pesaran et al. (2001) for cases with low span of data. The bounds testing approach is also known as the autoregressive distributed lag model (ARDL), which has some important advantages over the Johansen cointegration test (Pesaran and Shin, 1999). The most important advantage of the ARDL approach is that the ARDL approach can be used regardless the integration order of variables I(0), I(1) or both. Yet, the approach is invalid in case when the I(2) integrated variables are present. Also of great importance is that the ARDL approach allows differences in lags of the sampled variables in the data generating process. Endogenuity problem is absent in the ARDL approach because it also corrects for residual serial correlation. Also the ARDL approach allows to estimate short-run parameters by the means of the error correction model (ECM) adjustments.

The first step in the ARDL procedure is the determining the co-integration existence between the sampled variables. The bounds test examines long-run relationships, where the ARDL framework of the model (Equation 2) is expressed in Equation 3:

$$\Delta lnc_t = \gamma_1 + \sum_{i=1}^{p}\gamma_i \Delta lnc_{2t-i} + \sum_{j=0}^{q}\gamma_j \Delta lne_{t-j} + \sum_{k=o}^{m}\gamma_k \Delta lni_{t-k} + \sum_{l=0}^{n}\gamma_l \Delta lni_{t-l}{}^2 + \sum_{s=0}^{o}\gamma_5 \Delta lna_{t-s} + \gamma_{c_{t-1}} lnc_{t-1} + \gamma_{e_{t-1}} lne_{t-1} + \gamma_{i_{t-1}} lni_{t-1} + \gamma_{i_{t-1}{}^2} lni_{t-1}{}^2 + \gamma_{a_{t-1}} lna_{t-1} + \mu_t \qquad (3)$$

where $\gamma_{c_{t-1}} = \gamma_{e_{t-1}} = \gamma_{i_{t-1}} = \gamma_{i_{t-1}{}^2} = \gamma_{a_{t-1}} = 0.$ represent short-term coefficients of the sampled variables in the logarithmic forms and $\gamma_i, \gamma_j, \gamma_k, \gamma_l, \gamma_s$ represent the long-term coefficients of the sampled variables in the logarithmic forms. Presence or absence of the relationship is tested by employing the joint F or statistics of the Wald test. The null hypothesis of nocointegration in the model is $\gamma_{c_{t-1}} = \gamma_{e_{t-1}} = \gamma_{i_{t-1}} = \gamma_{i_{t-1}{}^2} = \gamma_{a_{t-1}} = 0.$

The alternative hypothesis of cointegration between the variables is $\gamma_{c_{t-1}} \neq \gamma_{e_{t-1}} \neq \gamma_{i_{t-1}} \neq \gamma_{i_{t-1}{}^2} \neq \gamma_{a_{t-1}} \neq 0$. To test the significance of the obtained results, the critical values for the bound test, reported in Pesaran et al. (2001) are used. The critical bounds are set as if the variables are of I(0) and are of I(1). If the F-statistics is above the upper bound of the critical values, the null hypothesis is rejected. If the F-statistics is below the lower critical bound, the null hypothesis is accepted. If the F-statistics is between the bounds, the results of the test are inconclusive.

In case of the presence of co-integration between the variables, the next stage is the estimation of the ECM of the following type (Equation 3):

$$\Delta lnc_t = \theta_1 + \sum_{i=0}^{p}\theta_2 \Delta lnc_{t-i} + \sum_{k=0}^{q}\theta_3 \Delta lne_{t-k} + \sum_{i=o}^{r}\theta_3 \Delta lni_{t-r} + \sum_{i=0}^{s}\theta_4 \Delta lni_{t-s}{}^2 + \sum_{i=0}^{l}\theta_5 \Delta lna_{t-l} + \delta_1 ECM_{t-1} + \varphi_t \qquad (4)$$

where ECM_{t-1} represents the error correction term and δ_1 is the coefficient, estimating the speed of variables adjustment towards the equilibrium. This coefficient has to be statistically significant and negative in sign. The existence of an ECT implies the changes in dependent variable. These changes are a function of both the levels of disequilibrium in the cointegration relationship and the changes in the other explanatory variables. This indicates the deviation in dependent variable from short span of time to long-run equilibrium path (Masih and Masih, 1997). The goodness of fit for ARDL model is checked through stability tests such as cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ).

2. Data

The study aims to test the short and long-run relationships between carbon emission and their determinants in the framework of the EKC hypothesis. The variables include energy consumption, real income and agriculture in the Russian case for the period 1990-2016. The study employs annual data. The data are collected from the World Bank's World Development Indicators database and Russian statistical database when and where needed.

Carbon emissions are measured by CO_2 emissions per capita in the sampled country, metric tonnes; energy consumption is measured by commercial energy use in Russia per capita, kg of oil equivalent; real income is represented by Russian GDP per capita, constant 2010 US dollars; agriculture is measured as a percentage share of value added by agricultural sector in Russian GDP. All variables then are transformed in natural logarithms.

Results and discussion

Descriptive statistics for the sampled variables are presented in Table 1. Carbon emissions in Russia amounts 11.77 metric tonnes per capita for the period from 1990 to 2016. Commercial energy consumption is 4711.48 kg of oil equivalent per capita. The average share of agriculture in Russian GDP is 5.67 % with the tendency to decrease from 15 % to 3% in the long-run. Yet, beginning from 2011 statistics show a rise in the share of agriculture in Russian GDP up to about 5 %.

The study is based on the usage of Russian data for the sampled variables for the period 1990-2016 and aimed to explore the long and short-run relationships between CO_2 emissions and variables which have the potential to affect the changes in the environmental pollution process under the EKC hypothesis. These include energy consumption, real income and agriculture. For the purposes of the study the ARDL bounds test approach is employed, that assumes the use of the variables with different order of integration, except integration of order above I(1). The first goal, then, should be the investigation of the order of sampled variables integration, achieving which supposes testing the variables for stationarity in order to determine if the ARDL approach suits the study. We employ four different unit root tests, including the ADF, the DF-GLS, the PP and the KPSS tests. The results of testing the variables for stationarity are presented in Table 2.

The results of the tests for stationarity show that all the sampled variables of the study are generated by a stationary process. Given the results of the different unit root tests, we can assume that the variables in the study are integrated of the order 0 or 1 and none is integrated of the order above 1.

Given that the variables of the study are not integrated of the order 2 we can proceed with the ARDL cointegration approach. The first step in the ARDL co-integration analysis requires identification of the optimal lag length

Variable	Mean	Max.	Min.	St. dev.	Obs.
c	11.77003	16.08000	10.12730	1.339353	27
e	4711.481	5928.661	3981.502	497.5094	27
i	8707.101	11803.71	5505.628	2226.278	27
a	5.675496	15.46104	3.160549	2.900097	27

Note: Max. is the abbreviation for maximum value of a variable, Min. is for the minimum value, St. dev. is referred to a standard deviation, Obs. is the number of observations, c is the abbreviation for carbon emission, e is for energy consumption, r is for real income and a is for agriculture share of value added (as a % of GDP).
Source: own calculations

Table 1: Descriptive statistics.

Variable	ADF	DF-GLS	PP	KPSS
c	-3.852911*	-3.003408*	-3.655386**	0.174587
e	-3.207594**	-3.280949*	-3.216722**	0.369353
i	-3.687551**	-2.261857**	-2.358914**	0.308785
a	-3.324449**	-5.386401*	-3.573855**	0.712689

Note: The null hypothesis of ADF, DF-GLS and PP unit root tests is the presence of the unit root. The null hypothesis of the KPSS test is the stationarity of an estimated variable. * and ** denote the rejection of the null hypothesis at the 1% and 5% significance levels, respectively.
Source: own calculations

Table 2: Results of unit root tests.

under the unrestricted vector autoregression. For these purposes we use the Schwarz Criterion (SC), the Akaike Information Criterion (AIC) and the Hannan-Quinn Information criterion (HQ). All the information criteria stand for the lag length of 2 years (Table 3).

Lag	AIC	SC	HQ
0	-10.41324	-10.21822	-10.35915
1	-15.17782	-13.81442	-14.90737
2	-15.56960*	-14.20272*	-15.08278*

Note: * indicates lag order selected by the criterion AIC - Akaike information criterion, SC - Schwarz information criterion, HQ: Hannan-Quinn information criterion.
Source: own calculations

Table 3. Results of optimal lag length selection.

Then we can proceed to determining the long-run relationships between the variables of the study. To check the variables on the existence of the long-run relationship we employ the bound F-test for Equation 2. The results of the bounds test for the estimated equation are presented in Table 4.

The estimated equation includes both dependent and independent variables. Dependent variables include energy consumption, real income and square of the real income, while agriculture stands as an independent variable. The results of the cointegration F-test show that the resulting F-statistics are above the upper bound and statistically significant at 10 %, 5 % and 1% significance level. The results show that the sampled variables are cointegrated and the long-run relationship between the variables exists in the Russian case. The obtained results are in line with the results of Ketenci (2018).

Given that the sampled variables are cointegrated in the long-run, we can proceed to the next stage, that requires estimation of the long and short-run coefficients. Given that the ARDL model was estimated in the logarithmic form, we can estimate how a shock in 1% of the explanatory variables affect the control variable both in the long and short run.

The estimates for the short-run relationships are presented in Table 5.

Regressor	Coefficient	t-statistics
$\Delta \ln e$	0.894	7.674*
$\Delta \ln i$	0.009	1.908*
$\Delta \ln i^2$	-0.014	-2.671*
$\Delta \ln a$	0.082	2.177*
ECM_{t-1}	-0.728	-5.726*
Diagnostic test statistics		
R^2	0.934	
DW-statistic	2.47	
F-statistic	4.69	
RSS	0.01	

Note: * and ** denote the rejection of the null hypothesis at the 1 % and 5 % significance levels respectively. β column reports estimated coefficients.
Source: own calculations

Table 5: ARDL short-run results.

As can be seen from the results of the short-run relationship estimation, the error correction term is negative in sign and statistically significant at 1 % level. This result confirms the presence of the co-integration. The value of the ECM coefficient is 0.728, that allows to assume that in Russia about 73 % of the CO_2 emissions disequilibrium in the short-run is rectified. The diagnostic test results imply the acceptable fit of the model, given the appropriate R^2 and significant F-statistic. Durbin-Watson statistics coefficient shows that the error terms are not correlated. The absence of autocorrelation in the disturbance of the error term is proved by the Breusch-Godfrey test. The normality criterion of the model is also met.

Given the results of the short-run estimates, we obtain evidence in favor of the EKC hypothesis in Russia. Particularly, the energy consumption and the real income have a small yet positive effect on the CO_2 emissions during the sampled

F-statistics	90 % LB	90 % UB	95 % LB	95 % UB	99 % LB	99 % UB
6.46	3.47*	4.45*	4.01*	5.07*	5.17	6.36

Note: Null hypothesis of the ARDL bounds test is: No long-run relationship exists. LB – low bound, UB – upper bound. If the F test statistic falls between lower and upper bounds the result is inconclusive. If it is below lower bound, the null hypothesis cannot be rejected. If the test statistics is above upper bound , the null hypothesis of no co-integration is rejected (*).
Source: own calculations

Table 4: Cointegration F-test, $F(c| e,i,i^2,a)$.

period. E.g., a 1 % rise in energy consumption increases CO_2 emissions by 0.89 %. The signs of the coefficients of GDP and GDP square also speak in favor of the EKC hypothesis in Russia at 1 % significance level: a 1% rise in GDP increases CO_2 emissions by 0.01 %. The square of the real income coefficient has a negative sign, that speaks in favor of the EKC hypothesis in Russia, confirms the results of Ketenci (2018) and supports the results of Halicioglu and Ketenci (2016) as well as Yang et al. (2017) and Chang (2015).

Another finding indicates that agriculture plays a statistically significant role in environmental pollution in Russia, given the positive sign of the β coefficient, that confirms the relative importance of agricultural sector as a short-run source of environmental pollution in Russia. A 1 % rise of agriculture as a share of the national GDP increases CO_2 emissions in Russia by almost 0.1 %. The result is relatively small yet statistically significant, which gives us the right to accept the hypothesis of agriculture being a source of environmental pollution in Russia.

The estimates of the long-run relationship between the studied variables are presented in Table 6.

Regressor	Coefficient	t-statistics
$\Delta \ln e$	0.923	10.263*
$\Delta \ln i$	0.008	1.732*
$\Delta \ln i^2$	-0.017	-2.844*
$\Delta \ln a$	0.091	2.351*
ECM_{t-1}	6.178	5.806*
Diagnostic test statistics		
	t-statistics	*p*-value
χ^2_{SC}	1.85	0.213
χ^2_{FF}	0.12	0.893
χ^2_{N}	3.49	0.294
χ^2_{H}	0.89	0.928

Note: * and ** denote the rejection of the null hypothesis at the 1 % and 5 % significance levels respectively. β column reports estimated coefficients. χ^2_{SC}, χ^2_{FF}, χ^2_{N}, χ^2_{H} present the Breusch-Godfrey serial correlation LM test, the Ramsey RESET test of functional form misspecification, the Jarque-Bera normality test and the Breusch-Pagan-Godfrey heteroscedasticity test, respectively.
Source: own calculations

Table 6: ARDL long-run results.

As can be seen from the results, presented in Table 6, the estimates of the ARDL model are found to be statistically significant. The long-run estimates, as the short-run ones, of the energy consumption, real income and agriculture positively affect the CO_2 emissions in Russia. The impact of the energy consumption is stronger than that of the GDP, which supports the energy-induced pollution hypothesis. An increase in energy consumption per capita in Russia by 1 % leads to an increase in the CO_2 emissions per capita by 0.923 %, while an increase of the real income in 1 % leads to 0.01 % of environmental pollution. A 1 % increase in agriculture as a share of GDP leads to only almost 0.01% increase in the CO_2 emissions in Russia.

These results need interpretation. The presence of the impact of energy consumption on CO_2 emissions in Russia is quite logical, given low energy efficiency and high energy intensity of the Russian economy. Second, the low impact of the GDP on environmental pollution is achieved because of the structure of the Russian economy, where energy intensive and "toxic" sectors (such as oil and gas industry, agriculture and metal industry) account for less than 50 % of the GDP: the share of agriculture being around 5 %, the share of oil and gas industry being around 10 % on average. Then the low impact of the β-coefficient for the Russian GDP becomes quite logical. The impact of the agriculture as a source of the environmental pollution is also relatively small (almost 0.1%) given the national authorities' policies, stimulating the use of environment-friendly technologies, e.g. reducing emissions of NH_3, CO, CO_2, SO_2, CH_4, N_2O, SF, as well as the negative impact of benzene and wood dust from agrarian enterprises.

Given the above results, the EKC hypothesis finds support: the positive sign of the real income is changed by the negative sign of the squared real income, showing an inverted U-shaped relationship between CO_2 emissions and the real income in the Russian case, as well as supporting the relative importance of the agricultural sector as a source of environmental pollution and necessity to increase the level of environment-friendly technologies used in agriculture.

Another important aspect of the long-run estimates is the magnitude of the positive and negative impacts of the real income and the square of the real income on the CO_2 emissions. The magnitude of the positive impact of the GDP on CO_2 emissions in Russia is less than the negative impact of the squared GDP per capita. This implies that the environmental improvement takes its place in the Russian economy after achieving a certain threshold, compared to the initial environment degradation process. This result is confirmed by the World Bank (2018), according to which CO_2 emissions, measured as kg per 2010 US dollars of GDP, have declined in Russia from 1.839 in 1998 to 0.999 in 2014.

Another important test to explore the relationships between the sampled variables is the pairwise Granger causality test. The results of the causality test are presented in Table 7.

Null hypothesis	F-statistic	p-value
$\ln e$ does not Granger cause $\ln c$	3.076	0.001
$\ln c$ does not Granger cause $\ln e$	8.962	0.004
$\ln i$ does not Granger cause $\ln c$	5.901	0.022
$\ln c$ does not Granger cause $\ln i$	4.093	0.049
$\ln i^2$ does not Granger cause $\ln c$	5.084	0.002
$\ln c$ does not Granger cause $\ln i^2$	4.212	0.052
$\ln a$ does not Granger cause $\ln c$	7.209	0.005
$\ln c$ does not Granger cause $\ln a$	0.953	0.431

Source: own calculations

Table 7: Pairwise granger causality test.

According to the results of the pairwise Granger causality test, the unidirectional causality running from agriculture to the CO_2 emissions in Russia exists. Moreover, the bidirectional causality between CO_2 emissions and energy consumption, real income and real income squared has been revealed.

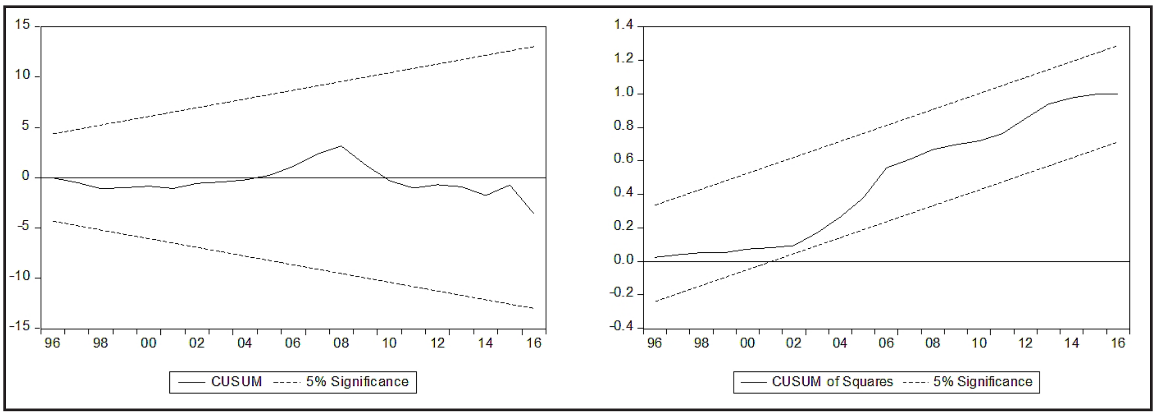
The last step in the ARDL approach is estimating the stability of the model. For this purpose, we employ the cumulative (CUSUM) and the cumulative sum of squares (CUSUMSQ) stability tests, proposed by Brown et al. (1975). The results of the CUSUM and CUSUMSQ tests are presented in Figures 1 and 2.

As can be seen from Figures 1 and 2, the plots of the CUSUM and the CUSUMSQ statistics are located within the 5% significance critical bounds, which proves the stability of the developed model.

Conclusion

This study explores the relationship between carbon dioxide emissions and their main determinants, which include real income and energy consumption in Russia, employing data for the period 1990-2016. The hypothesis of agriculture being an important determinant of environmental quality in Russia is also tested. For estimating the short-run and long-run relationships the ARDL bounds test is employed in this study. To check the causal relationship, the pairwise Granger causality test is employed.

The results of the cointegration F-test show that the resulting F-statistics are above the upper bound and statistically significant at 10 %, 5 % and 1 % significance level. The results show that the sampled variables are cointegrated and the long-run relationship between CO_2 emissions, energy consumption, real income and agriculture exists in the Russian case. According to the results of the short-run relationship estimation, the value of the ECM coefficient is 0.728, that allows to assume that in Russia about 73 % of the CO_2 emissions disequilibrium in the short-run is rectified, which also gives evidence in favor of the EKC hypothesis in Russia. Another empirical finding is that agriculture plays a small yet statistically significant role in environmental pollution in Russia, that confirms the importance of agricultural sector as a short-run source of environmental pollution in Russia. The long-run estimates, as the short-run ones, of the energy consumption, real income and agriculture positively affect CO_2 emissions



Source: own calculations

Figures 1 and 2: Results of the stability tests.

in Russia. E.g., an increase in energy consumption per capita in Russia by 1 % leads to an increase in the CO_2 emissions per capita by 0.923 %. An increase of the real income in 1 % causes only 0.01 % of environmental pollution. A 1 % increase in agriculture as a share of GDP leads to an almost 0.1% increase in the CO_2 emissions in Russia. The results of the pairwise Granger causality test also confirm the unidirectional causality running from agriculture to the CO_2 emissions in Russia.

Given above, the present study supports the existence of the inverted U-shaped relationship between CO_2 emissions, real income an energy consumption, providing evidence in favor of the EKC hypothesis in Russia. Moreover, agricultural sector in Russia is found to be a statistically significant variable in explaining environmental pollution despite the small share in the national GDP.

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References

[1] Akbostanci, E., Asik, S. and Tunc, G. I. (2009) "The relationship between income and environment in Turkey: is there an environmental Kuznet curve?“, *Energy Policy*, Vol. 37, No. 3, pp. 861-867. ISSN 0301-4215. DOI 10.1016/j.enpol.2008.09.088.

[2] Acaravci, A. and Ozturk, I. (2010) "On the relationship between energy consumption, CO_2 emissions and economic growth in Europe“, *Energy*, Vol. 35, No. 12, pp. 5412-5420. ISSN 0360-5442. DOI 10.1016/j.energy.2010.07.009.

[3] Alam, M. J., Begum, I. A., Buysse, J. and Huylenbroeck, G.V. (2012) "Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis“, *Energy Policy*, Vol. 45, pp. 217-225. ISSN 0301-4215. DOI 10.1016/j.enpol.2012.02.022

[4] Al-Mulali, U. and Özturk, I. (2016) "The investigation of environmental Kuznets curve hypothesis in the advanced economies: The role of energy prices“, *Renewable & Sustainable Energy Reviews*, Vol. 54, pp. 1622-1631. ISSN 1364-0321. DOI 10.1016/j.rser.2015.10.131.

[5] Benavides, M., Ovalle, K., Torres, C. and Vinces, T. (2017) “Economic growth, renewable energy and methane emissions: Is there an environmental Kuznets Curve in Austria?“, *International Journal of Energy Economics and Policy*, Vol. 7, No. 1, pp. 259-267. ISSN 2146-4553.

[6] Brown, R. L., Durbin, J. and Evans, J. M. (1975) “Techniques for testing the constancy of regression relations over time”, *Journal of the Royal Statistical Society. Series B. Methodological*, Vol. 37, pp. 149-163. ISSN 1467-9868.

[7] Cameron, S. (1994) “A review of the econometric evidence on the effects of capital punishment.” *Journal of Socio-Economics*, Vol. 23, No. 1-2, pp. 197-214. ISSN 1053-5357. DOI 10.1016/1053-5357(94)90027-2. DOI 10.1111/j.2517-6161.1975.tb01532.x.

[8] Chang, M.-C. (2015) "Room for improvement in low carbon economies of G7 and BRICS countries based on the analysis of energy efficiency and environmental Kuznets curves“, *Journal of Cleaner Production*, Vol. 99, pp. 140-151. ISSN 0959-6526. DOI 10.1016/j.jclepro.2015.03.002.

[9] Chow, G. C. (1960) "Test of equality between sets of coefficients in two linear regressions“, *Econometrica*, Vol. 28, No. 3, p. 591-605. ISSN 1468-0262. DOI 10.2307/1910133.

[10] Dagher, L. and Yacoubian, T. (2012) "The causal relationship between energy consumption and economic growth in Lebanon“, *Energy Policy*, Vol. 50, pp. 795-801. ISSN 0301-4215. DOI 10.1016/j.enpol.2012.08.034.

[11] Dickey, D. A. and Fuller, W. A. (1979) "Distribution of the estimators for autoregressive time series with a unit root“, *Journal of the American Statistical Association*, Vol. 74, No. 366a, pp. 427-431. ISSN 1537274X. DOI 10.1080/01621459.1979.10482531.

[12] El-Aasar, K. M. and Hanafy, S. A. (2018) “Investigating the Environmental Kuznets Curve Hypothesis in Egypt: The Role of Renewable Energy and Trade in Mitigating GHGs”, *International Journal of Energy Economics and Policy*, Vol. 8, No. 3, pp. 177-184. ISSN 2146-4553.

[13] Elliot, G., Rothenberg, T. and Stock, J. (1996) “Efficient tests for an autoregressive unit root”, *Econometrica*, Vol. 64, No. 4, pp. 813-836. ISSN 1468-0262. DOI 10.2307/2171846.

[14] Grossman, G. M. and Krueger, A. B. (1995) “Economic growth and the environment”, *The Quarterly Journal of Economics*, Vol. 112, No. 2, pp. 353-378. ISSN 0033-5533. DOI 10.2307/2118443.

[15] Halicioglu, F. (2009) “An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey”, *Energy Policy*, Vol. 37, No. 3, pp. 1156-1164. ISSN 0301-4215. DOI 10.1016/j.enpol.2008.11.012.

[16] Halicioglu, F. and Ketenci, N. (2016) “The impact of international trade on environmental quality: The case of transition countries”, *Energy*, Vol. 109, pp. 1130-1138. ISSN 0360-5442. DOI 10.1016/j.energy.2016.05.013.

[17] He, J. and Richard, P. (2010) “Environmental Kuznets curve for CO_2 in Canada”, Ecological Economics, Vol. 69, No. 5, pp. 1083-1093. ISSN 0921-8009. DOI 10.1016/j.ecolecon.2009.11.030

[18] Heil, M. T., Selden, T. M. (1999) “Panel stationarity with structural breaks: carbon emissions and GDP”, *Applied Economics Letters*, Vol. 6, pp. 223-225. ISSN 1466-4291. DOI: 10.1080/135048599353384.

[19] Ketenci, N. (2018) “The environmental Kuznets curve in the case of Russia”, *Russian Journal of Economics*, Vol. 4, No. 3, pp. 249-265. ISSN 2405-4739. DOI 10.3897/j.ruje.4.28482

[20] Ivanova, V. I. and Vertkina, D. (2017) “Environmental Kuznets curve: Russian cities’ case”, In Yasin, Y. G. (Ed.), *XVII International science conference on economic and social development problems*, Moscow: National Research University Higher School of Economics, pp. 156-165.

[21] Kuznets, S. (1955) “Economic growth and income inequality”, *American Economic Review*, Vol. 45, No. 1, pp. 1-28. ISSN 0002-8282.

[22] Kwiatkowski, D., Phillips, P., Schmidt, P. and Shin, Y. (1992) “Testing the null hypothesis of stationarity against the alternative of a unit root”, *Journal of Econometrics*, Vol. 54, No. 1-3, pp. 159-178. ISSN 0304-4076. DOI 10.1016/0304-4076(92)90104-Y.

[23] Liu, X., Zhang, S. and Bae, J. (2017) “The impact of renewable energy and agriculture on carbon dioxide emissions: Investigating the environmental Kuznets curve in four selected ASEAN countries”, *Journal of Cleaner Production*, Vol. 164, pp. 1239-1247. ISSN 0959-6526. DOI 10.1016/j.jclepro.2017.07.086.

[24] Masih, A. M. M. and Masih, R. (1997) “On temporal causal relationship between energy consumption, real income and prices: some new evidence from Asian energy dependent NICs based on a multivariate cointegration vector error correction approach”, *Journal of Policy Modeling*, Vol. 19, pp. 417-440. ISSN 0161-8938. DOI 10.1016/S0161-8938(96)00063-4.

[25] Mihalischev S. and Raskina, Y. (2015) "Environmental Kuznets Curve: The Case of Russia", EUSP Department of Economics Working Paper Series Ec-03/15, European University at St. Petersburg, Department of Economics.

[26] Narayan, P. K. and Narayan, S. (2010) “Carbon dioxide emissions and economic growth: Panel data evidence from developing countries”, *Energy Policy*, Vol. 38, No. 1, pp. 661-666. ISSN 0301-4215. DOI 10.1016/j.enpol.2009.09.005.

[27] Onafowora, O. A. and Owoye, O. (2014) "Bounds testing approach to analysis of the environment Kuznets curve hypothesis", *Energy Economics*, Vol. 44, pp. 47-62. ISSN 0140-9883. DOI 10.1016/j.eneco.2014.03.025.

[28] Pao, H. T. and Tsai, C. M. (2010) "CO_2 emissions, energy consumption and economic growth in BRIC Countries", *Energy Policy*, Vol. 38, No. 12, pp. 7850-7860. ISSN 0301-4215. DOI 10.1016/j.enpol.2010.08.045.

[29] Poudel, B. N., Paudel, K. P. and Bhattarai, K. (2009) "Searching for an environmental Kuznets curve in carbon dioxide pollutant in Latin American countries", *Journal of Agricultural and Applied Economics*, Vol. 41, No. 1, pp. 13-27. ISSN 1074-0708. DOI 10.1017/S1074070800002522.

[30] Pesaran, M. H. and Shin, Y. (1999) "An autoregressive distributed lag modeling approach to cointegration analysis", In Strom S. (ed.) "*Econometrics and Economic Theory in the 20th Century*", Cambridge University Press, Cambridge, pp. 371-413.

[31] Pesaran, M. H., Shin, Y. and Smith, R. (2001) "Bounds testing approaches to the analysis of level relationships", *Journal of Applied Econometrics*, Vol. 16, No. pp. 289-326. ISSN 1099-1255. DOI 10.1002/jae.616.

[32] Phillips, P. C. and Perron, P. (1988) "Testing for a unit root in time series regression", *Biometrika*, Vol. 75, No. 2, pp. 335-346. ISSN 0006-3444. DOI 10.1093/biomet/75.2.335.

[33] Pretty, J. (2008) "Agricultural sustainability: concepts, principles and evidence", *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol. 363, pp. 447-465. ISSN 1471-2970. DOI 10.1098/rstb.2007.2163.

[34] Rabbi, F., Akbar, D. and Kabir, S. M. Z. (2015) "Environment Kuznets curve for carbon emissions: a cointegration analysis for Bangladesh", *International Journal of Energy Economics and Policy*, Vol. 5, No. 1, pp. 45-53. ISSN 2146-4553.

[35] Richmond, A. K. and Kaufmann, R. K. (2006) "Is there a turning point in the relationship between income and energy use and/or carbon emissions?", *Ecological Economics*, Vol. 56, No. 2., pp. 176-189. ISSN 0921-8009. DOI 10.1016/j.ecolecon.2005.01.011.

[36] Rudenko, D. (2018) "Environment and economic growth in the Russian Arctic", *International Journal of Global Environmental Issues*, Vol. 17, No. 2/3, pp. 163-174. ISSN 1741-5136. DOI 10.1504/IJGENVI.2018.10012372.

[37] Saboori, B., Sulaiman, J. (2013) "Environmental degradation, economic growth and energy consumption: evidence of the Environmental Kuznets Curve in Malaysia", *Energy Policy*, Vol. 60, pp. 892-905. ISSN 0301-4215. DOI 10.1016/j.enpol.2013.05.099

[38] Shahbaz, M., Ozturk, I., Afza, T. and Ali, A. (2013) "Revisiting the Environmental Kuznets Curve in a global economy", *Renewable and Sustainable Energy Reviews*, Vol. 25, pp. 494-502. ISSN 1364-0321. DOI 10.1016/j.rser.2013.05.021.

[39] Shahbaz, M., Dube, S., Ozturk, I. and Jalil, A. (2015) "Testing the Environmental Kuznets Curve Hypothesis in Portugal", *International Journal of Energy Economics and Policy*, Vol. 5, No. 2, pp. 475-481. ISSN 2146-4553.

[40] Soytas, U. and Sari, R. (2009) "Energy consumption, economic growth, and carbon emissions: challenges faced by an EU candidate member", *Ecological Economics*, Vol. 68, pp. 1667-1675. ISSN 0921-8009. DOI 10.1016/j.ecolecon.2007.06.014.

[41] Stern, D. I. (2004) "The rise and fall of the environmental Kuznets curve", *World Development*, Vol. 32, No. 8, pp. 1419-1439. ISSN 0305-750X. DOI 10.1016/j.worlddev.2004.03.004.

[42] Suri, V. and Chapman, D. (1998) "Economic growth, trade and energy: Implications for the environmental Kuznets curve", *Ecological Economics*, Vol. 25, No. 2, pp. 195-208. ISSN 0921-8009. DOI 10.1016/S0921-8009(97)00180-8

[43] World Bank (2018) "World Development Indicators". [Online]. Available: http://databank.worldbank.org/data/views/re-ports/tableview.aspx?isshared=true [Accessed: 25 Sept. 2018].

[44] Yang, X., Lou, F., Sun, M., Wang, M. and Wang, Y. (2017) "Study of the relationship between greenhouse gas emissions and the economic growth of Russia based on the environmental Kuznets curve", *Applied Energy*, Vol. 193, pp. 162-173. ISSN 0306-2619. DOI 10.1016/j.apenergy.2017.02.034

[45] Zafeiriou, E., Sofios, S. and Partalidou, X. (2017) "Environmental Kuznets curve for EU agriculture: empirical evidence from new entrant EU countries", *Environmental Science and Pollution Research*, Vol. 24, No. 18, pp. 15510-15520. ISSN 0944-1344. DOI 10.1007/s11356-017-9090-6.

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Factors Affecting Food Purchases in Vysočina Region with Focus on Regional Food

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Abstract

The article presents the results of a research study that analyses chosen factors that affect food purchases in Vysočina Region with focus on a regional food. The quantitative research, conducted in 2015 in each district of Vysočina Region (Jihlava, Žďár nad Sázavou, Třebíč, Havlíčkův Brod and Pelhřimov), analysed the opinions of 819 respondents. They were selected by quota sampling methods according to gender. Data have been processed with correspondence analysis; the results show that brand and price are significant factors that influence consumers in Vysočina Region when they buy food, the labels on the food packaging do not seem to be a strong signal of quality. Statistical tests based on contingency tables proved that regional food is strongly preferred by women and consumers over 65 years old.

Keywords

Regional food, consumer buying behaviour, food industry, marketing, branding.

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Introduction

Food and place are intertwined in robust ways, the place of food seems to be center of the discourses in the emerging movements and practices, that represent resistance and counter-pressure to conventional globalizing food system (Van Der Ploeg, 2008). Demand for regional food has been increasing in the Czech Republic in the last decade (Turčínková, Kalábová, 2011; Bošková, Ratinger, Kličková, 2016), the similar trend emerged in EU countries from the beginning of this century (e.g. Loureiro, Umberger, 2005; McEntee, 2010; Reiff et al., 2016; Fogarassy et al., 2018). A regional product is the one, whose quality and (or) fame can be attributed to its region of origin define and it is marketed using the name of the region of origin (Van Ittersum, Candel and Meulenberg, 2007; Śmigielska and Stefańska, 2017). Fonte (2010) does not only associate it with qualitative and geographical characteristics (i.e. direct connection with the region / particular territory), but also with its inhabitants, institutions, and she also notes the importance of the historical context (tradition). Lošťák, Karanikolas, Draganová and Zagata (2014) speak in this context rather about the retro-innovations, i.e. the application of the current form of traditional methods. Čadilová (2011) adds that regional products must above all meet the basic requirement that they should be made from local raw materials and also be somewhat exceptional. Frequently, manual work and environmental friendliness are required for such products (de Bruin, 2011). Hájková (2014), who explored the potential of using VYSOČINA Regional Product label in tourism, emphasizes the aspect of the authenticity of such products – creating a specific experience for the visitors. Petrenko, Brinkman and Olsson (2014) emphasize among other characteristics of regional food the importance of distinct regional identity – such products should be a ‚regional specialty', that can be consumed locally but also being marketed on the national or international level. The authors distinguish regional and local food, admitting the concept is open to different interpretations (see Table 1).

Regional foods are distinguished from local foods, which should primarily have a short distribution

Attributes	Local Food	Regional Food
Geography – food produced and processed within a local area (100 – 200 km)	X	X
Geography – consumed within a local area (100-200 km)	X	-
Distribution – short supply chain (i.e. with few intermediaries)	X	-
Production – produced in an environmentally sustainable and socially responsible manner	X	X
Identity – distinct regional identity (e.g. label)	-	X

Source: Petrenko, Brinkman, Olson (2014, p.12), own adjustment

Table 1: Attributes of regional and local food (X marks the relevance of the attribute).

chain with a low number of intermediaries from the producer to the consumer - from the use of local ingredients and ingredients that have been grown / farmed, processed and consumed entirely within a given geographically defined area an action radio in the range of 100 to 200 km. De Lind (2011) sees the value of local foods in two main areas: it is a tool for local development (or a restart of development) as well as a personal development tool (in terms of positive health effects, when these products are perceived as more fresh and ripe). Blake et al. (2010) believe that the essence of local food is hidden in associations that are connected with the word ‚local': trust, shared values, quality, heritage, simplicity, craftsmanship, and the community. This ‚international' consumer behaviour also confirms f. e. Maitah et al. (2015). Born and Purcell (2006) have voiced doubts and warned against ‚local traps' - the local scale may not automatically pose positive product characteristics. Conversely, if the product remains local for a long time, the possible explanation is that no one else is interested in it.

As it is also evident from Tab. 1, regional foods, in contrast to local ones, have a particularly strong regional identity, possibly via regional labelling. However, distinguishing local and regional foods can be viewed as redundant to the Czech market, especially for consumers. On the other hand, it is very important to avoid misuse of the concept of a regional product, f.e. when common conventional products produced by multinational corporations are beeing labelled and marketed as ‚regional products'. In the United States, an attention is drawn to the fact that, as a result of globalization pressures, there is an increasing occurrence of the fact that a food product bears the name of a place, but that does not mean that it really comes from this place (Giovannucci et al., 2010). Others (Ilbery, Maye, 2007; Healy, McDonaugh, 2009) also note that regional foods are partly made from ingredients that do not come from the region and sometimes also without the use of local labour. Wilson and Whitehead (2012), based on their research (as well as Sonnino and Marsden, 2005, and Schermer, 2015), talk about the dichotomy between regional and conventional foods, where, due to the same ingredients used, there is no real distinction between the two concepts. Healy and Mc Donagh (2009) then warn that ‚wrongful' use of regional or local terms can have detrimental consequences for the regions themselves as it can wash away the last remnants of ‚true regional/local' identity associated with a particular territory.

Czech experts, who identified the visions of the food industry in the Central European region (FutureFood6 project) by 2020, indicated as the basic vision increased the availability of quality regional/ local specific foods. The most crucial starting point is the definition of regional (local) food, that should be discussed. Furthermore, there is a pressing need of the criteria determination by which these foods could be identified as regional/ local specifics, in cooperation with state institutions and associations of entrepreneurial subjects in agriculture and food industry (Valenta, Hladík et al., 2011; Musová et al., 2018).

The paper first discusess respondents' food buying process with a special focus on regional food, the next section is devoted to the methodology of the research, followed by a discussion of the results. Research limitations and recommendations for the future analysis focus are presented at the end of the article.

Materials and methods

The research was focused on the level of awareness of the food labels in Vysočina Region with special focus on the regional labels: VYSOČINA Regional Product® and Regional Food Vysočina Region and consumers' behaviour when buying food. The research was conducted in January – March 2015 in each of the region's district; it had a quantitative design. The structure was determined in accordance with the structure of Vysočina Region population, data came from the Czech Statistical Office (2015), see Table 2.

Criterion	Group	Respondents	Respondents
		Abs. fr.	Rel. fr.
Total	Population aged 15-65	819	100.00
Gender	Male	418	51 %
	Female	401	49 %
Age	15-25 years	192	23 %
	26-35 years	153	19 %
	36-45 years	171	21%
	46-55 years	124	15 %
	56-65 years	122	15 %
	65+ years	57	7 %
District	Jihlava	230	28 %
	Havlíčkův Brod	93	11 %
	Pelhřimov	124	15 %
	Třebíč	184	23 %
	Žďár nad Sázavou	188	23 %

Source: own research

Table 2: Vysočina Region population aged 15-65+ by gender, age groups and districts.

Questionnaires (857) were completed using the help of interviewers outside supermarkets/hypermarkets, and shopping centres, 819 of them were processed (quota sampling according to gender) in all districts of Vysočina Region – Jihlava, Havlíčkův Brod, Pelhřimov, Třebíč and Žďár nad Sázavou (not the quota sampling). The fact, that data was collected in front of larger retail chains, impacted the results, as this type of shops is usually not listing regional products as much as small/local shops located in the countryside (f.e. COOP). Respondents were asked to complete demographic questions and the ones regarding their buying decisions process (what factors influence their buying decisions). They were also asked to answer what food labels do they recognise and if they are aware of particular regional labels.

Data have been processed with correspondence analysis (CA), a multivariate statistical technique that provides a means of displaying or summarising a set of data in two-dimensional graphical form (Nenadić, Greenacre; 2007). Contingency tables display relations among categorical data, depending on the character of the data we then use suitable tests of independence. For the case of a contingency table of the *r* x *c* type (*r* is the number of rows, *c* is the number of columns) the test statistic is the most often used (Řezanková, 1997):

$$\chi^2 = \sum_i \sum_j \frac{(n_{ij} - e_{ij})^2}{e_{ij}}, \qquad (1)$$

e_{ij} is an expected and n_{ij} observed frequency. The statistic χ^2 in Pearson´s chi-square test with asymptotical distribution is beeing used, the null hypothesis of the test assumes independence, for further details see Hebák et al. (2010). To use the Pearson's chi-square test the condition that a maximum 20 % of the expected frequencies are less than five must be met, see Hendl (2012). In another case, we use Fisher´s exact test, or we calculate simulated p-value of χ^2 statistic.

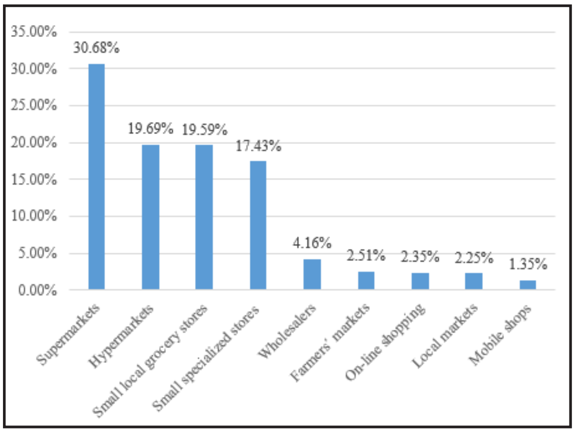
Correspondence analysis (CA) is an exploratory technique that provides a mean of displaying or summarising a set of data in two-dimensional graphical form (Šánová, Svobodová, Laputková, 2017). It is traditionally applied to contingency tables - CA decomposes the chi-squared statistic associated with this table into orthogonal factors. The distance among single points is defined as a chi-squared distance.The distance between i-th and i'-th row is given by the formula:

$$D(i,i') = \sqrt{\sum_{j=1}^{c} \frac{(r_{ij} - r_{i'j})^2}{c_j}}, \qquad (2)$$

where r_{ij} are the elements of row profiles matrix *R* and weights c_j are corresponding to the elements of column loadings vector c_T, which is equal to mean column profile (centroid) of column profiles in multidimensional space. The distance between columns *j* and *j'* is defined similarly. The aim of this analysis is to reduce the multidimensional space of row and column profiles and to save maximally original data information, within the ambit of explorative-descriptive analyses. The total variance of the data matrix is measured by the inertia, which resembles a chi-square statistic but is calculated on relative observed and expected frequencies (Di Franco, 2015). There have also been contingency tables constructed based on respondents' age and gender; Chi-square test was counted to confirm or disapprove relation between variables. Software UNISTAT and STATISTICA were used for processing primary data.

Results and discussion

The first part of the research focused on the respondents' buying behaviour. An opening question aimed to find out, whether the respondents were affecting not only their own food choices but also the other members of their household. Most people (507 of 819, i.e. 61.9%) bought the food not only for themselves but also for the whole family. Others (185; 22.6%) bought it mostly for themselves, and only a minor part (127; 15.5%) bought the food exclusively for themselves. In the next question, respondents should identify where they buy food most often (they could give more answers). As can be seen from Figure 1, the most common place to buy food was a supermarket (30.7%).

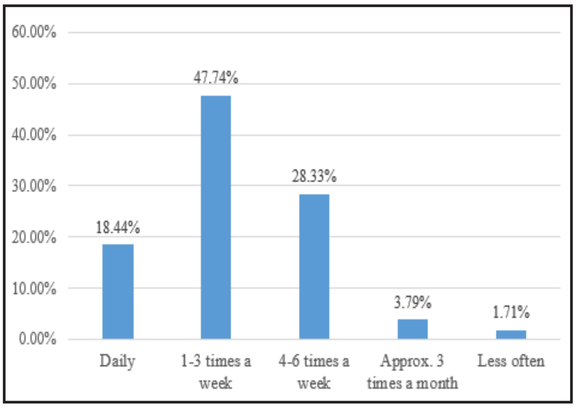


Source: own research

Figure 1: The most frequent places to buy respondents' food.

Other favourite stores were hypermarkets and small local grocery stores (both almost 20%). Small specialized stores (17.4%) are also very popular. The research shows different results from the INCOMA survey (Skála, 2017), which conducts regular consumer research called Shopping Monitor. The results from 2017 show that consumers in the Czech Republic do their shopping mostly in hypermarkets (46%), and only 17% of them choose supermarkets. In small stores, food is bought by up to 24% of consumers - the prevalence of hypermarkets in the Czech Republic is more than 10 years old. This difference is mainly because there is only one city in the Vysočina Region with 50,000 inhabitants (Jihlava) and hypermarket chains place their stores in the vicinity of larger cities. Regional producers (especially SMEs) may find it difficult to place their products in the market, the distribution has been frequently identified to be the challenge (Dreyer et al., 2014; Gellynck et al., 2012). Region Vysočina is one of the few in the Czech Republic that has established a network of shops selling regional products in 2012 (Vysočina Region, 2018), with focus on the production certified with the label Vysočina Regional Product – logos should be displayed in the shops (in May 2018, there have been 35 members of the network). Bošková, Ratinger and Kličková (2016) think it was an attempt in the right direction, but the network fails in exhibiting a certain level of cohesion in marketing regional products.

Respondents also say they mostly buy their food 1 – 3 times a week (391, i.e. 47.7%), or 4 – 6 times a week (232, i.e. 28.3%), as shown in Figure 2.



Source: own research

Figure 2: Frequency of respondents' food purchases.

The shopping habits were examined by the question asking whether the respondents were focused on impulse behaviour. Nearly half of them (406) said they mostly went to the shop with a particular idea, but their choice depended on the present or special offer. Almost 13% (104) of the respondents can do without a shopping plan, while the rest (38%; 309) stick to the previously written list.

Furthermore, respondents were supposed to determine what factors influence their choice of food, and to what extent. From their responses, it is clear their choice mostly follows the brand (1.37) and the price (1.97) (Table 3). Respondents from the Vysočina Region do not differ from other consumers in the Czech Republic, for whom the food price has long been one

To what extent are your food choices influenced by the following factors? 1 - significant influence, 5 - no influence (mean - 3)			
Factors	**Average**	**Dispersion**	**Standard deviation**
Brand	1.37	1.377	1.174
Price	1.97	1.229	1.085
Habits - according to previous experience	2.47	1.304	1.166
Origin - made in the Czech Republic	2.67	1.657	1.287
The priorities of my family / my own priorities	2.69	1.537	1.240
Positive information from acquaintances / friends	2.75	1.321	1.150
Advertisement	2.85	1.662	1.289
Quality confirmed by the labeling on the packaging	2.91	1.599	1.265
Nutritional values	2.93	1.556	1.247
Environmental friendliness of the product	3.02	1.445	1.202
Origin - made abroad	3.10	1.557	1.248
Media information	3.33	1.467	1.211

Source: own research

Table 3: Factors affecting food purchases.

of the essential factors in their choice (Hes, 2008). On the other hand, Pícha and Skořepa (2018) claim, that those respondents who prefer food with a regional label, do not consider the price as strongly important.

The origin of food plays an important part, the Czech food origin (2.67) was slightly more significant for the respondents than the foreign production (3.1). The results are in line with the research of Kalábová, Mokrý and Turčínková (2013) – their data showed a higher preference of domestic food compared to those from abroad for consumers in Vysočina Region (unlike other regions of the Czech Republic).

Interestingly, of these factors, respondents have attributed the smallest influence on their food purchases that of media (3.33). Also, the quality confirmed by the labelling on the packaging also has only an average impact on them, f.e. the research of Šánová et al. (2017) and Horská et al. (2011) indicated that qualitative parameters are generally very important for the Czech customers when buying food. Our results may indicate that respondents do not see the labels on the food packaging as a strong signal of quality.

In the following part, the hypotheses on the dependence of the gender and age of the respondents were tested, using the Pearson chi-quadrate test. To evaluate the results of the research, the correspondence analysis was used, too, as another suitable method of evaluating the categorical type of data, which makes it possible to compare the results from the contingency table (Zámková, Prokop, 2014).

Test of Hypothesis H1: Preference of the food from the Vysočina Region depends on the respondents‘ gender.

Statistical analysis of the question whether respondents prefer food from the Vysočina Region showed a significant dependence on the respondents' gender ($\chi^2 = 24.01$; $p = 0.00002$).

The origin of the food is not important for men, they also tend more not to take into account the fact that the food is from Vysočina Region (see Table 4). The results are not surprising, as many types of researches in the Czech Republic (f.e. Turčínková, Brychtová and Urbánek, 2012; Stávková et al., 2007) demonstrated that behaviour of men and women shows considerable differences when shopping for food.

Test of Hypothesis H2: Preference of the food from the Vysočina Region depends on the respondents‘ age.

Statistical analysis of the question whether respondents prefer food from the Vysočina Region showed dependence on the respondents' age ($\chi^2 = 2.616$; $p = 0.03202$), but the differences between age groups are not significant (see Table 5). Origin of the food is not for the respondents under the age of 25. On the other hand, respondents with age over 65 years highly prefer food from the Vysočina Region.

Figure 3 displays how respondents of different age categories prefer regional food, nearby points in the graphical output of CA analysis mean that respondents of age over 65 try to buy food

Respondents' gender (column rel. frequencies)				
When you buy food, do you prefer products from the Vysočina Region?		**Female**	**Male**	
A	I disregard the origin of the food when buying it	12.26 %	18.64 %	
B	I only sometimes take into account the fact that the product comes from the Region Vysočina	48.82 %	58.28 %	
C	Preferentially, I try to buy food from the Vysočina Region	31.18 %	18.93 %	
D	I clearly prefer food from the Vysočina Region	7.74 %	4.14 %	
Total relative frequency		100 %	100 %	
Pearson's chi-squared test		χ^2	sv	P
Pearson's chi-squared		24.00963	df=3	p=0.00002

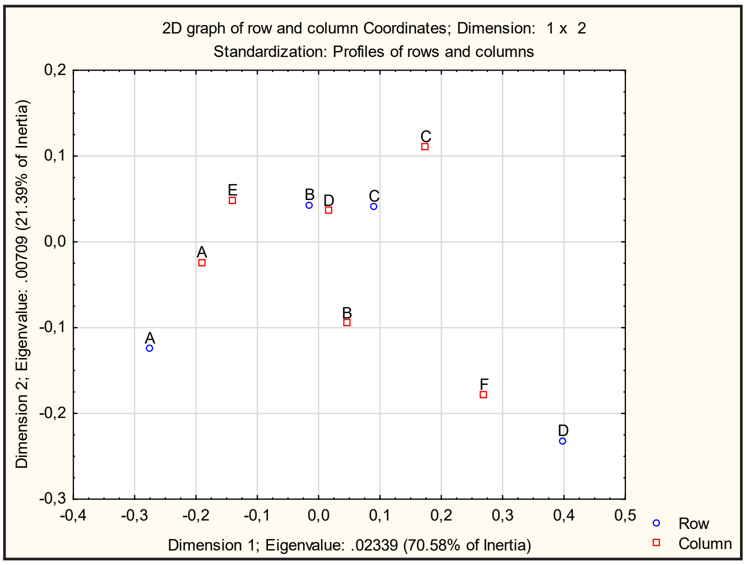
Source: own research

Table 4: Preference of the food from the Vysočina Region in dependence on the respondents' gender.

Respondents' gender (column rel. frequencies)							
When you buy food, do you prefer products from the Vysočina Region?		**Up to 25 years old**	**26 – 35 y.o.**	**36 – 45 y.o.**	**46. – 55 y.o.**	**56 - 65 y.o.**	**Over 65 years old**
A	I disregard the origin of the food when buying it	20.42 %	16.44 %	7.78 %	13.93 %	17.36 %	10.71 %
B	I only sometimes take into account the fact that the product comes from the Region Vysočina	53.93 %	46.58 %	55.09 %	52.46 %	56.20 %	51.79 %
C	Preferentially, I try to buy food from the Vysočina Region	21.99 %	28.77 %	29.94 %	27.87 %	23.14 %	23.21 %
D	I clearly prefer food from the Vysočina Region	3.66 %	8.22 %	7.19 %	5.74 %	3.31 %	14.29 %
Total relative frequency		100 %	100 %	100 %	100 %	100 %	100 %
Pearson's chi-squared test			χ^2		sv		P
Pearson's chi-squared			2.61624		df=15		p=0.03202

Source: own research

Table 5: Preference of the food from the Vysočina Region in dependence on the respondent's age.



Source: own research

Figure 3: Correspondence Analysis - Preference of the regional food according to the age of respondents in the Vysočina Region.

from Vysočina with the strongest preference (Category D). On the other hand, it is visible, that respondents that are younger than 25, are the ones that disregard origin of the food (Category A).

Conclusion

Regional food products represent a cultural richness of regions, but as Minta (2015) highlights, in many cases consumers in the local market undervalue them. Regional food however may play an important role in building local identity (Bingen, 2012). Regional food production is supported in the Czech Republic with the strong marketing communication, however, success of such campaigns is dependent on their ability to reach adequate target market (Pícha, Skořepa, 2018). The similar situation is on the Polish market. F.e. Borowska (in Bryla, 2015) listed weaknesses of market development for traditional and regional products in Poland, such as low recognition of products, insufficient confirmation of the premium quality with certificates, low number of the specialised distribution channels or shortage of financial support for adequate marketing communication. Regional food labelling may be interesting marketing support for small and medium agricultural and food enterprises (f.e. small local farmers) who has a limited budget for their marketing and business investment. This general specific financial situation of those small Czech farmers has confirmed by the research of Řezbová et al. (2013). Our research focused on Vysočina Region in the Czech Republic and the presented findings revealed that respondents from Vysočina Region claim that when buying food, the brand and price play the most significant role. Other factors, such as their habits and the origin of the products (the fact that they were made in the Czech Republic) are also important. Inhabitants of Vysočina seem to prefer local production, the similar results showed the research of Kalábová et al. (2013). The data regarding preference of the regional food showed interesting results. Regional food is strongly preferred by women and older consumers (especially those of age over 65), as it was proved by statistical test based on contingency table. Jarossová and Pazurikova (2014) also stated that women in Slovakia tend to know regional labels and prefer buying regional food significantly more than men. Younger respondents (younger than 25) tend not to pay attention to the origin of the food. It is often observed that young consumers have specific ideas about the quality of the product and its image, they are more confident (Benda Prokeinová, Paluchová, 2014). Aprile, Caputo and Nayga (2015) observed a similar situation on the Italian market. From the marketing perspective, it is important to understand who buys regional food and why is valuable for targeting efforts by producers, retailers, shop owners, restaurants, and others needing information on consumer demand for regional food. Previous analysis (Chalupová, Rojík, Prokop, 2016) confirmed that the preference of regional food in Vysočina Region is strongly depends on the residence in Vysočina Region districts, the lowest preference of the Vysočina regional food is in Žďár nad Sázavou district, respondents living in this district being significantly different in their preferences from the others. The authors are aware of the limitations of the research, as it would be important to know opinions of the Vysočina Region visitors, as the regional labels also aim at them, test awareness and attitudes towards this labelled production on other regional markets to identify possible business potential. The research should also focus on the experience of the firms - those that take part in the regional certification systems and the ones that stay willingly away from the regional labelling systems.

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References

[1] Aprile, M. C., Caputo V. and Nayga Jr., R. M. (2016) "Consumers' Preferences and Attitudes Toward Local Food Products", *Journal of Food Products Marketing*, Vol. 22, No. 1, pp. 19-42. E-ISSN 1540-4102, ISSN 1045-4446. DOI 10.1080/10454446.2014.949990.

[2] Benda Prokeinová, R. and Paluchová, J. (2014) "Identification of the Patterns Behavior Consumptions by Using Chosen Tools of Data Mining - Association Rules", *AGRIS On-Line Papers in Economics and Informatics,* Vol. 6, No. 3, pp. 3-12. ISSN 1804-193.

[3] Bingen, J. (2012) "Labels of Origin for Food, the New Economy and Opportunities for Rural Development in the US", *Agriculture and Human Values*, Vol. 29, No. 4, pp. 543-552. E-ISSN 1572-8366. DOI 10.1007/s10460-012-9400-z.

[4] Bošková, I., Ratinger, T. and Kličková, K. (2016) "The food industry structure under the effect of increasing number of regional products and small processing entities in the Czech Republic", *149th EAAE Seminar 'Structural change in agri-food chains: new relations between farm sector, food industry and retail sector'* Rennes, France. [Online]. Available: file:///C:/Users/chalupm/AppData/Local/Temp/Boskova%20et%20al_149EAAE_Rennes.pdf. [Accesed 3 Jun 2018].

[5] Blake, M. K., Mellor, J. and Crane, J. (2010) "Buying Local Food: Shopping Practices, and Consumption Networks in Defining Food as 'Local'", *Annals of the Association of Ameican Geographer,* Vol. 100, No. 2. E-ISSN 2469-4460, ISSN 2469-4452. DOI 10.1080/00045601003595545.

[6] Born, B. and Purcell, M. (2006) "Avoiding the Local Trap: Scale and Food Systems in Planning Research", *Journal of Planning Education and Research,* Vol. 26, pp. 195-207. E-ISSN 1552 6577, ISSN 0739 456X. DOI 10.1177/0739456X06291389.

[7] Bryla, P. (2015) "The role of appeals to tradition in origin food marketing. A survey among Polish consumers", *Appetite,* Vol. 91, pp. 302-310. ISSN 0195-6663. DOI 10.1016/j.appet.2015.04.056.

[8] Chalupová, M., Prokop, M. and Rojík, S. (2016) "Preference of the Regional Food and Recognition of Regional Labels in Vysočina Region (Czech Republic)", *European Countryside*, Mendel University in Brno, Czech Republic, pp. 109-122. ISSN 1803-8417. DOI 10.1515/euco-2016-0009.

[9] Čadilová, K. (2011) "R*egionální značení v České republice a na Slovensku"* (Regional Branding Throughout Europe), Collection of papers 'Regionální značení napříč Evropou', 1st ed., Prague: Asociace regionálních značek, o.s.,, 8 p. ISBN 978-80-254-9506-3. (In Czech).

[10] Czech Statistical Office (2015) "*Kraj Vysočina*", Prague. [Online]. Available: https://www.czso.cz/csu/czso/zakladni-tendence-demografickeho-socialniho-a-ekonomickeho-vyvoje-kraje-vysocina-2013-dsdmcqx1nq. [Accessed: 8. Jan 2019]. (In Czech).

[11] De Bruin, R. (2011) "Regional labelling and regional products in the Netherlands", In Čadilová, K. "*Regionální značení v České republice a na Slovensku*", 11st ed., Prague: Asociace regionálních značek, o.s., pp. 62-73. ISBN 978-80-254-9506-3. (In Czech).

[12] De Lind, L. B. (2011) "Are Local Food and the Local Food Movement Taking Us Where We Want To Go? Or Are We Hitching Our Wagons to the Wrong Stars?", *Agricultural and Human Values*, Vol. 28, No. 2, pp 273-283. ISSN 0889-048X. DOI 10.1007/s10460-010-9263-0.

[13] Di Franco, G. (2016) "Multiple correspondence analysis: one only or several techniques?", *Quality & Quantity*, Vol. 50, No. 3, pp 1299-1315. E-ISSN 1573-7845, ISSN 0033-5177. DOI 10.1007/s11135-015-0206-0.

[14] Dreyer, H. C., Strandhagen, J. O., Thomassen, M. K., Romsdal, A. and Gran, E. (2014) "Supply Chain Design and Control Principles in Local Food Production: A Norwegian Case Study", *Journal on Food System Dynamics*, Vol. 5, No. 2, ISSN 1869-6945. DOI 10.18461/ijfsd.v5i2.521.

[15] Fonte, M. (2010) "Europe's integration in the diversities of local food nad local knowledge", In: Fonte, M., Papadopoulos, A. G. (eds.) "*Naming food after places. Food relocalization and knowledge dynamics in rural development*", pp. 265-273. Farnham, Ashgate.

[16] Gellynck, X., Kühne, B., B., Carraresi, L. and Stranieri, S. (2012) "Market orientation and marketing management of traditional food producers in the EU", *British Food Journal*, Vol. 114, No. 4, pp 481-499. ISSN 0007-070X. DOI 10.1108/00070701211219513.

[17] Giovannucci, D., Barham, E. and Pirog, R. (2010) "Defining and marketing 'local' foods: geographical indications for US products", *The Journal of World Intellectual Property*, Vol. 13, No. 2, pp. 94-120. E-ISSN 1747-1796. DOI 10.1111/j.1747-1796.2009.00370.x.

[18] Fogarassy, C., Nguyen, H. H., Olah, J. and Popp, J. (2018) "Transition management applications to accelerate sustainable food consumption – comparative analysis between Switzerland and Hungary, *Journal of International Studies*, Vol. 11, No. 3, pp. 31-43. E-ISSN 2306-3483, ISSN 2071-8330. DOI 10.14254/2071-8330.2018/11-3/3.

[19] Hájková, H. (2014) "Možnosti využití regionální značky 'Vysočina – regionální produkt v cestovním ruchu´"(Possibilities of use of regional mark - Vysočina - regional product in tourism), In Jedlička, P. "*Hradecké ekonomické dny 2014, Ekonomický rozvoj a management regionů",* Hradec Králové: Gaudeamus, pp. 270 -280, ISBN 978-80-7435-366-6.

[20] Hebák, P., Hustopecký, J. and Malá, I. (2010) "Vícerozměrné statistické metody" (Multidimensional statistical methods), Prague: Informatorium, spol. s.r.o. ISBN 978-80-7333-036-1. (In Czech).

[21] Hendl, J. (2012) "Přehled statistických metod: analýza a metaanalýza dat" (Review of statistical methods: analysis and metaanalýsis of data), 4th ed. Prague: Portál. (In Czech). 736 p. ISBN 978-80-262-0200-4.

[22] Healy, N., McDonagh, J. (2009) "Commodification and Conflict: What Can the Irish Approach to Protected Area Management Tell Us?", *Society & Natural Resources*, Vol. 22, No. 4, pp, 381-391. E-ISSN 1521-0723, ISSN 0894-1920. DOI 10.1080/08941920801978622.

[23] Hes, A. (2008) "Chování spotřebitele při nákupu potravin" (Behaviour of consumer in food purchasing), 1st ed. Prague: Alfa nakladatelství. ISBN 978-80-903962-0-3. (In Czech).

[24] Horská, E., Ürgeová, J., Prokeinová, R. (2011) "Consumers' food choice and quality perception: Comparative analysis of selected Central European countries", *Agricultural Economics – Czech*, Vol. 57, No. 10, pp. 493-499. E-ISSN 1805-9295, ISSN 0139-570X. DOI 10.17221/103/2011-AGRICECON.

[25] Ittersum Van, K., Meulenberg, M. T. G., Trijp, H. C. M. and Candel, M. J. J. M (2007) "Consumers' Appreciation of Regional Certification Labels: A Pan-European Study", *Journal of Agricultural Economics*, Vol. 58, No. 1, pp. 1-23. E-ISSN 1477-9552. DOI 10.1111/j.1477-9552.2007.00080.x.

[26] Ilbery, B. and Maye, D. (2007) "Marketing sustainable food production in Europe: case study evidence from two Dutch labelling schemes", *Tijdschrift voor Economische en Sociale Geografie*, Vol. 98, pp. 507-518. E-ISSN 1467-9663. DOI 10.1111/j.1467-9663.2007.00418.x.

[27] Jarossová, M. A. and Pazuriková, V. (2014) "Traditional and regional food: the knowledge of regional labelling", In *Studia commercialia Bratislavensia: Scientific Journal of Faculty of Commerce*, University of Economics in Bratislava, Faculty of Business, Vol. 7, No. 28, pp. 520-536. ISSN 1337-7493. (in Slovak).

[28] Kalábová, J., Mokrý, S. and Turčínková, J. (2013) "Regional differences of consumer preferences when shopping for regional products", A*cta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 56, No. 7, pp. 2255–2259. E-ISSN 2464-8310, ISSN 1211-8516. DOI 10.11118/actaun201361072255.

[29] Lošťák, M., Karanikolas, P., Draganová, M. and Zagata, L. (2014) "Local quality and certification schemes as new forms of governance in sustainability transition, in Sutherland", In L.-A., Darnhofer, I., Wilson, G. A., Zagata, L. (eds.) "*Transition Pathways towards Sustainability in Agriculture, Case studies from Europe*". CABI, 246 p. ISBN 1780642199.

[30] Loureiro, M. L. and Umberger, W. J. (2005) "Assessing Consumer Preferences for Country -of-Origin Labelling", *Journal of Agricultural and Applied Economics*, Vol. 37, No. 1, pp. 49-63. ISSN 1074-0708. DOI 10.1017/S1074070800007094.

[31] Maitah, M., Hodrab, R., Malec, K. and Shaneb, S. A. (2015) "Exploring the Determinants of Consumer Behavior in West Bank, Towards Domestic and Imported Dairy Products", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*. Vol. 63, No. 1, pp. 355-368. E-ISSN 2464-8310, ISSN 1211-8516. DOI 10.11118/actaun201563010355.

[32] McEntee, J. (2010) "Contemporary and Traditional Localism: Conceptualisation of Rural Local Food", *Local Environment: The International Journal of Justice and Sustainability*, Vol. 15, No. 9, pp. 785-803. ISSN 1469-6711. DOI 10.1080/13549839.2010.509390.

[33] Minta, S. (2015) "Regional food products: only for tourists or also for residents", *Agriculture & Forestry*, Vol. 61, No. 1, pp. 51-58. E-ISSN 1800-6492, ISSN 0554-5579. DOI 10.17707/AgricultForest.61.1.06.

[34] Musová, Z., Musa, H. and Ludhova, L. (2018) "Environmentally responsible purchasing in Slovakia", Economics and Sociology", Vol. 11, No. 4, pp. 289-305. E- ISSN 2306-3459, ISSN 2071-789X. DOI 10.14254/2071-789X.2018/11-4/19.

[35] Pícha, K. and Skořepa, L. (2018) "Preference to food with a regional brand“, *Quality – Access to Success*. Vol. 19, No. 162, pp. 134-139. ISSN 1582-2559.

[36] Reiff, M, Surmanová, K., Balcerzak, A. P. and Pietrzak, M. B. (2016) "Multiple Criteria Analysis of European Union Agriculture", *Journal of International Studies*, Vol. 9, No 3, pp. 62-74. E-ISSN 2306-3483, ISSN 2071-8330. DOI 10.14254/2071-8330.2016/9-3/5.

[37] Řezbová, H., Rosochatecká, E. and Žídková, E. (2013) "Impact of investments in agriculture on the structure of long-term assete“, *INPROFORUM*, The International Scientific Conference. University of South Bohemia in České Budějovice. ISSN 2336-6788. (In Czech).

[38] Schermer, M. (2015) "From ´Food from Nowhere´ to ´Food from Here´: changing producer-consumer relations in Austria“, *Agricultural Human Values*. Vol 32. pp. 121-132. E-ISSN 1572-8366, ISSN 0889-048X. DOI 10.1007/s10460-014-9529-z.

[39] Skála, Z. (2017) "*Papírové letáky čte 61 procent domácností*“ (61 per cents of households read paper leaflets), In [Online]. Available: https://www.gfk.com/.../2017/171213_GfK_TZ_GfK_Shopping_Monitor_2018_czfin.p. [Accessed: 23 Jan. 2019]. (In Czech).

[40] Stávková, J., Prudilová, H. and Toufarová, Z. and Nagyoová, L. (2007) "Factors influencing the consumer behaviour when buying food“, *Agricultural Economics*, Vol. 53, pp. 276-284. ISSN 0139-570X. DOI 10.17221/983-AGRICECON.

[41] Sonnino, R. and Marsden, T. (2005) "Beyond the divide: rethinking relationships between alternative and conventional food networks in Europe“, *Journal of Economic Geography*, pp 181-199. E-ISSN 1468-2710, ISSN 1468-2702. DOI 10.1093/jeg/lbi006.

[42] Šánová, P., Svobodová, J. and Laputková, A. (2018) "Using Multiple Correspondence Analysis to Evaluate Selected Aspects of Behaviour of Consumers Purchasing Local Food Products“, *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*. Vol. 65, No. 6, pp. 2083-2093. E-ISSN 2464-8310, ISSN 1211-8516. DOI 10.11118/actaun201765062083.

[43] Van Der Ploeg, J. (2008) "*The New Peasantries: Struggles For Autonomy and Sustainability in an Era of Empire and Globalization*“, London, Sterling, Earthscan. ISBN 978-1-84407-558-4. DOI 10.1111/j.1471-0366.2011.00323.x.

[44] Turčínková, J. and Kalábová, J. (2011) "Preference regionálních potravinářských produktů v České republice a na Slovensku" (Regional Food Products Preference in the Czech and Slovak Republics), In Petranová, D., Čábyová, Ľ. "*Špecifiká regionálneho a neziskového marketingu*". Trnava, Slovakia: Faculty of Massmedial Communication, University of St. Cyril and Metod in Trnava, pp. 206-209. ISBN 978-80-8105-333-7. (In Czech).

[45] Turčínková, J., Brychtová, J. and Urbánek, J. (2012) "Preferences of men and women in the Czech Republic when shopping for food“, *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol 60, No. 7, pp 425-432. E-ISSN 2464-8310, ISSN 1211-8516. DOI 10.11118/actaun201260070425.

[46] Valenta, O. and Hladík, P. (2011) "Budoucnost kvality a bezpečnosti potravin v Česku" (Future of quality and safety of food in Czech Republic), Prague: Sociologické nakladatelství pro Technologické centrum AV ČR, 1st ed. ISBN 978-80-7419-056-8. (In Czech).

[47] Vysočina Region (2018) "*Gastronomy. Regional Products*". [Online]. Available: http://www.region-vysocina.cz/temata/temata/gastronomie/regionalni-produkty. [Accesed: 3. Jan 2019]. (In Czech).

[48] Wilson, G. A. and Whitehead, I. (2012) "Local Rural Product as a Relic Spatial Strategy in Globalised Rural Spaces: Evidence from County Clare (Ireland)“, *Journal of Rural Studies*, Vol. 28, pp.199-207, ISSN 0743-0167. DOI 10.1016/j.jrurstud.2012.01.003.

[49] Zámková, M. and Prokop, M. (2014) "Comparison of consumer behavior of Slovaks and Czechs in the market of organic products by using correspondence analysis“, *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*. Vol 62, No. 4, pp. 783-795. E-ISSN 2464-8310, ISSN 1211-8516. DOI 10.11118/actaun201462040783.

Horizontal Price Transmission on the Russian Dairy Market: Nonlinear Approach

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Abstract

Spatial (horizontal) price transmission analysis provides specific evidence as to the competitiveness of markets, the effectiveness of arbitrage and the pricing efficiency. The paper investigates spatial price transmission and market integration in the Russian Federal Districts using monthly milk prices within the period 2000-2018. Using Hansen-Seo technique, threshold effects have been found and threshold vector error correction model with two regimes has been estimated for three markets. Market integration analysis revealed a long-run relationship for all the price pairs in the milk markets. The linear VECM analysis showed a rather low degree of integration, especially for the Southern Federal District milk market. Compared to VECM, the TVECM estimation provided different findings depending on regimes and markets.

Keywords

Spatial price transmission, market integration, Threshold Vector Error Correction model, milk market, Russia.

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Introduction

The nature of markets and their role in price determination are central to economics. Geographic markets are particularly relevant to agriculture since agricultural products are typically bulky and/or perishable and areas of production and consumption are separated; hence, transportation is costly (Sexton et al., 1991). Market integration characterizes price transmission degree on geographic markets. Price transmission is when a change of prices in one market causes prices in another one to change. Commonly, it is measured in terms of the transmission elasticity, defined as the percentage change in the price in one market given a 1% change in the price in another market.

The market integration measurement and transmission of food price shocks is a major determinant of price stability and food security, particularly in developing countries such as Russia. Russia is aiming at self-sufficiency in milk production. This is part of a broader plan to move Russia away from reliance on imported foodstuffs, and into a net exporter within the next 10 years. In accordance with the doctrine of food security, the share of domestic milk in the Russian market should be 90%. In 2017 it amounted to 80.8 % based on the last data from the Federal State Statistics Service of Russia (available online at http://www.gks.ru). According to the forecast of the Ministry of agriculture, milk production in 2018 will increase by 2 % compared to the last year.

Information on spatial price transmission may, therefore, provide specific evidence as to the competitiveness of markets, the effectiveness of arbitrage (it exists as a result of market inefficiencies and would, therefore, not exist if all markets were perfectly efficient), and the efficiency of pricing. However, it may be difficult to recognize the specific cause(s) of observance or failure to observe the law of one price (Sexton et al., 1991). Consequently, it is worth evaluating the degree of market integration on the Russian milk market by means of the latest econometric techniques.

A vast literature on spatial price transmission has been accumulated over the last years. Some researchers (Zakari et al., 2014; Conforti, 2004; Minot, 2011) analyzed the relationship between world and domestic food markets, investigating how world prices are transmitted in domestic food markets. Many authors (Brosig et al., 2011; Habte, 2017; Ganneval, 2016) analyzed spatial price transmission among regions and provinces with regard to food markets. There is some gap in our knowledge concerning horizontal price transmission on Russian milk market that the paper sought to fill.

In the literature, a great deal of econometric techniques are used to measure the integration and price transmission between spatially separated markets. The models that analyze price transmission are based on the regression of differentiated price variables and on lagged price differences. The majority of literature on spatial price transmission relies on co-integration technique and error correction modelling. Huge number of studies (Jena, 2016; Savadatti, 2018; Zhou and Koemle, 2015; Arnade et al., 2017) examined the market integration and horizontal price transmission using the time series techniques of co-integration and linear vector error correction models (VECM). However, analyzing spatial price transmission, researchers often have the lack of information on transaction costs. Linear VECM relies only on price data and does not take into consideration transaction costs.

In order to incorporate effects of transaction costs into price transmission analysis, threshold vector error correction model (TVECM) has been developed. Balke and Fomby (1997) introduced the threshold cointegration approach. Extension to a threshold VECM has been made by several authors (Barrett, 2001; Barrett and Li, 2002; Baulch, 1997; McNew and Fackler 1997; Hansen and Seo, 2002; Seo, 2006). In a TVECM, transaction costs from one market to another market can be estimated by a threshold estimator. Compared to the standard VECM, TVECMs not only show price dynamics between two spatial markets, but also measure the level of spatial price efficiency (Hu and Wade Brorsen, 2017).

Many studies use threshold error correction models to analyze horizontal price transmission. For example, Chen and Saghaian (2016) estimated TVECM for rice price data from Thailand, Vietnam and United States. They found that export prices in the three countries are cointegrated, with Thailand and the United States the price leaders, and that the Vietnamese price adjusts faster to long-run equilibrium when it is above its equilibrium level with Thai and U.S. prices. Wu and Guan (2018) evaluated a threshold vector error correction model allowing for two- layer regime switching with using daily tomato prices for the U.S. and Mexican markets. Their analysis provides evidence that the price floors are effective in influencing spatial price linkages. Models imply much slower adjustments in response to deviations from equilibrium when the price floors are binding. The results confirm that the U.S. and Mexican markets are more tightly integrated when trade is not affected by price floors.

Our study is expected to contribute to the existing literature on spatial price transmission and market integration. The contribution of the paper is twofold. Firstly, it provides a review dealing with the issue of spatial price transmission in the Russian milk market. Secondly, it gives empirical evidence of the extent of market integration in the Russian dairy sector by means of using threshold cointegration approach.

Materials and methods

The horizontal price transmission analysis has been implemented using 224 monthly prices for cow whole milk at the wholesale level from January 2000 to August 2018 in four Russian Federal Districts (Central Federal District, Volga Federal District, Northwestern Federal District and Southern Federal District). The source of the data is the Federal State Statistics Service of Russia (available online at http://www.gks.ru). In order to calculate price elasticities and mitigate fluctuations of time series, we use the logarithmic transformation of monthly prices measured in Russian rubles per tonne.

Most of the price time series are non-stationary that generally leads to spurious regression and cannot be estimated correctly with OLS method. In order to avoid model misspecification, we tested all the price series for the stationarity. To test the unit root presence, some methodological approaches are available. Widely used among them are the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) and the Phillips-Perron test (Phillips and Perron, 1988). The Phillips-Perron and ADF tests specify the null hypothesis that the price series is non-stationary, i.e. unit root is present. In small samples, the general observation is that the Augmented Dickey-Fuller and Phillips-Perron tests have low power. In our case we have sufficient number of observations, that is desirable. The number of the optimum lags was chosen based on the Akaike (1973) information criterion (AIC). To select the highest number of lags for unit root tests, we applied the rule by Schwert (1989) as follows:

$$P_{max} = 12 \times \sqrt[4]{\frac{T}{100}} \quad (1)$$

where T is sample size.

There might be a linear combination of nonstationary and same integrated price series that is stationary. Price series tend to move identically over time and have common stochastic trend, i.e. series are cointegrated. In that case we obtain not just consistent OLS-estimates (as in the case of classical regression), but super-consistent estimates for the model parameters. One of the first to introduce the cointegration concept was Granger (1981). The basis of the cointegration framework developed by Engle and Granger (1987). However, in our analysis we applied the Johansen approach based on likelihood ratio tests (Johansen, 1988; Johansen and Joselius, 1990; Johansen, 1991; Johansen, 1995). Compared to Engle-Granger technique there is no need to choose which price variable should be dependent. Moreover, the Johansen procedure is capable of dealing with multivariate system of nonstationary price variables. In order to identify the number of cointegration vectors in the Johansen test, the trace statistic and the maximum eigenvalue are used. The null hypothesis for the trace test is that the number of cointegration vectors is r=r*<k, versus the alternative that r=k. Testing proceeds sequentially for r*=1,2… and the first non-rejection of the null is taken as an estimate of r. The null hypothesis for the maximum eigenvalue test is as for the trace test but the alternative is r=r*+1 and, again, testing proceeds sequentially for r*=1,2… with the first non-rejection used as an estimator for r. If two tests produce different results, we rely on trace statistic since it tends to have superior power in empirical studies (Lutkepohl et al., 2001).

The cointegrated price variables have a Vector Error Correction model (VECM) representation. The VECM takes into account price deviations around the long-run equilibrium. VECM can be defined as follows:

$$\Delta P_t = c + \Pi P_{t-1} + \sum_{i=1}^{k} \Gamma_i \Delta P_{t-i} + \varepsilon_t \qquad (2)$$

where c is the constant; P_t is the (2x1) vector of price variables defined in the model (logarithms of the two price pairs); the long-run matrix Π can be decomposed into $\Pi=\alpha\beta'$, where α is the vector, representing the speed of adjustments of the price variables toward long-run equilibrium and β is the cointegration vector, reflecting the linear relationships among the variables in the long-run equilibrium. ΠP_{t-1} can be rewritten as $\alpha\beta' P_{t-1}$, where $\beta' P_{t-1}$ is also denoted as the error correction term ECT_{t-1}, representing the deviation from the long-run equilibrium at period t-1; the Γ_i is the (2x2) matrix of coefficients for an i order lag process that represent temporary effects of price changes in previous periods on current price changes; ε_t is (2x1) vector of i.i.d normal disturbances. The optimum lag length is defined in accordance with the AIC and the Schwarz-Bayesian (1978) information (BIC) criterions as a result of VAR modeling.

For spatial price transmission analysis aforementioned VECM has serious restriction in the aspect of linearity. The linear VECM determines that price pairs adjust to the long-run equilibrium at a constant speed (α). To take into account the presence of no-arbitrage band and model various adjustment speeds to long-run equilibrium, linear VECM is extended to a Threshold VECM (TVECM). In the TVECM framework, adjustments occur once the deviations in the long-run equilibrium have exceeded critical threshold (transaction costs). TVECM belongs to the class of regime-switching models. The model can be specified with a constant, a trend or none. Two-regime TVECM can be defined as follows:

$$\Delta P_t = \begin{cases} c1 + \alpha 1 ECT_{t-1} + \sum_{i=1}^{k} \Gamma 1_{t-i} \Delta P_{t-i} + \varepsilon 1_t, \ if\ ECT_{t-1} \le \gamma \\ c2 + \alpha 2 ECT_{t-1} + \sum_{i=1}^{k} \Gamma 2_{t-i} \Delta P_{t-i} + \varepsilon 2_t, \ if\ ECT_{t-1} > \gamma \end{cases} \qquad (3)$$

where γ is threshold parameter for the error correction term ECT_{t-1}. For one threshold and cointegration vector, the model is linear, so estimation of the regression parameters can be done by CLS (Conditional Least Squares). The search of the threshold and cointegrating parameters values which minimize the residual sum of squares (SSR) is made on a grid search. The model estimation was carried out using open-source package "tsDyn" in the econometric software "R" developed by Stigler (2013).

In order to detect the threshold effects, we use the supreme Lagrange Multiplier (SupLM) test with the null hypothesis of linear VECM against the alternative of threshold cointegration developed by Hansen and Seo (2002). The SupLM test statistic can be defined as follows:

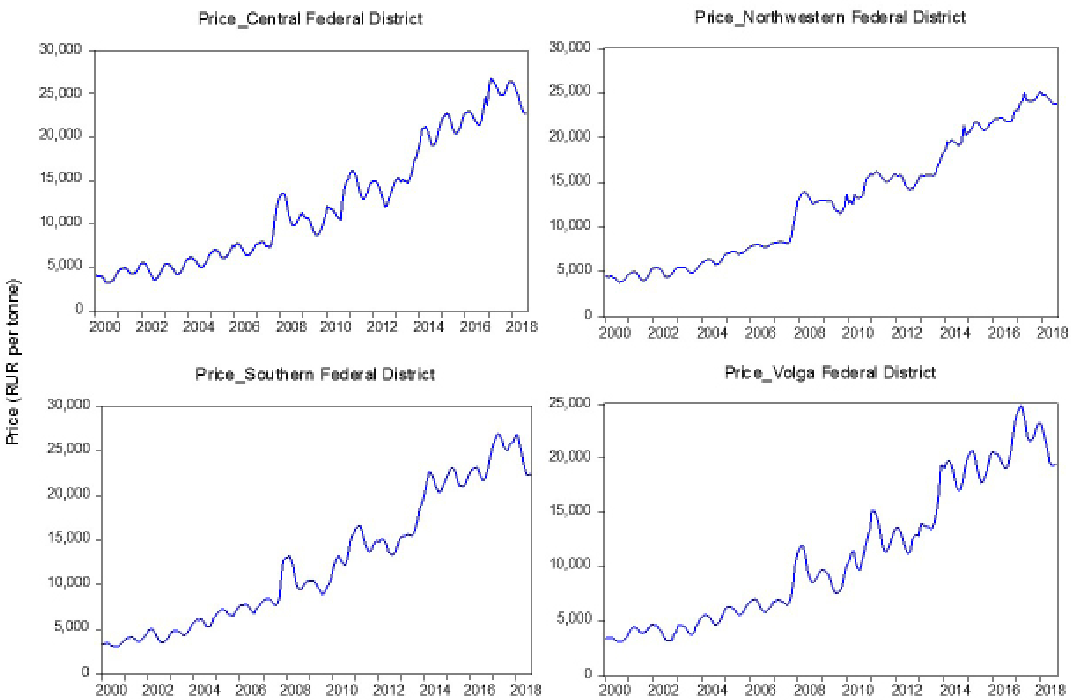
$$SupLM = \underset{\gamma_L \le \gamma \le \gamma_U}{SupLM}(\tilde{\beta}, \gamma) \qquad (4)$$

where γ is the threshold value; $\tilde{\beta}$ is the estimated cointegration coefficient from linear VECM; γ_L is the trimming parameter (π_0) percentile of ECT_{t-1}, and γ_U is the $(1-\pi_0)$ percentile of ECT_{t-1}. The trimming parameter is used to provide a minimum number of observations in each regimes. Andrews (1993) revealed that setting π_0 within the range from 0.05 to 0.15 is typically good choice. We set π_0 equal to 0.1. A grid search within γ_L and γ_U is carried out to obtain γ, which maximizes the SupLM test statistic. To compute asymptotic critical values of the distribution we use 1000 bootstrap replications with two bootstrap approaches (a fixed-regressor and a residual bootstrap).

Results and discussion

The trend and price fluctuations in four Federal districts over the period since 2000 can be observed in the Figure 1. As seen from the figure, prices seem to change synchronously with the common upward tendency within the period under consideration. Hence, there might be co-integration relationships and some kind of price transmission is present. Visual examination of graphs suggests probable price series non-stationarity. Constant should be included in the models for unit root test since times series have a changing mean.

Non-stationarity of the logged price series was identified with the ADF and Phillips-Perron test. We set the maximum lag based on Schwert (1989) rule and used the information criterion AIC to select the optimal lag order. The null hypothesis H0 is rejected if the critical value is greater than the test statistic (p-value is less than level of significance). The findings are presented in the Table 1. The output summarized in the table shows that null hypothesis of non-stationary price series in levels was not rejected for all variables. Tests based on first differences show that all



Source: Federal State Statistics Service of Russia

Figure 1: Price series for raw cow milk in the Russian Federal Districts, January 2000-August 2018.

Logged price variable	Augmented Dickey-Fuller (ADF) test				Phillips-Perron (PP) test			
	Lag	Levels	Lag	1st difference	Bandwidth	Levels	Bandwidth	1st difference
Plog_CFD	14	-0.7936	14	-4.7334***	2	-1.0851	5	-6.5930***
Plog_NFD	14	-0.9655	13	-4.0036***	2	-0.8595	7	-7.7026***
Plog_SoFD	14	-1.2765	14	-4.7233***	2	-1.2597	10	-4.2059***
Plog_VFD	14	-0.8541	14	-4.9189***	3	-1.2610	4	-7.1786***

Note: All models include a constant; */**/*** null hypothesis of non-stationarity rejected at 10%, 5% and 1% of significance
Source: own calculations

Table 1: Unit root test results.

the test statistics are significant at 1% critical level. Therefore, we can infer that all logged price variables are integrated of the order one, I (1). Our findings allow us to run co-integration test between price pairs.

Given that price variables are integrated of the same order, we tested them by Johansen technique in order to find out if the non-stationary series are co-integrated. The optimal lag has been selected based on the information criterions as a result of VAR modeling. The Table 2 presents the results of pair-wise co-integration tests for the all logged price series. The Johansen test revealed one co-integrating equation in all the six price pairs, based on the trace and maximum eigenvalue statistics (the H_0 of r=0 is rejected at the 1 % or 5 % significance level). This implies that the price variables are co-integrated, they have linear long-term relationship during the period and demonstrate common stochastic trend. Hence, we are able to estimate a linear VECM for each price pair.

As seen from the Table 3, linear VEC model reveals that ECT values are statistically significant and negative, indicating adjustment towards equilibrium in the system. The higher ECT value, the faster speed of adjustment to the equilibrium. The Table 3 reveals that the adjustment parameter of Central Federal District (CFD) prices is higher with all other markets (circa 14, 16 and 21 % of prices are adjusted by CFD milk market with three other markets respectively). The CFD market shows the highest adjustment (21 %) with Volga Federal District (VFD) milk prices. That is in line with the fact that VFD and CFD markets are the first and the second one in terms of raw milk production and population number. In the long-term period, a 1 percent of increase

Price Pairs	Hypothesized number of co-integrating equation	Trace statistics	Max- Eigen values	Price Pairs	Hypothesized number of co-integrating equation	Trace statistics	Max- Eigen values
Plog_CFD-Plog_NFD	None (r=0)	30.065***	29.116***	Plog_NFD-Plog_SoFD	None (r=0)	17.524**	15.975**
	At most 1 (r≤1)	0.948	0.948		At most 1 (r≤1)	1.549	1.549
Plog_CFD-Plog_SoFD	None (r=0)	20.170***	16.702**	Plog_NFD-Plog_VFD	None (r=0)	18.191**	17.289**
	At most 1 (r≤1)	3.468*	3.468*		At most 1 (r≤1)	0.901	0.901
Plog_CFD-Plog_VFD	None (r=0)	25.626***	23.882***	Plog_SoFD-Plog_VFD	None (r=0)	24.804***	22.551***
	At most 1 (r≤1)	1.744	1.744		At most 1 (r≤1)	2.253	2.253

Note: ***/**/* denotes rejection of the null at 1, 5 or 10 % significance level
Source: own calculations

Table 2: Pair-wise Johansen co-integration test for logged price series.

Price Pairs	Co-integrating vector (β) in the long-run	Speed of adjustment	Robustness tests		
			Serial Correlation LM test (p-value)	White's Heteroscedasticity (p-value)	Doornik-Hansen Normality test (p-value)
Plog_CFD-Plog_NFD	1.000-1.034	-0.142*** -0.012	0.0026	0	0
Plog_CFD-Plog_SoFD	1.000-0.929	-0.158*** -0.056*	0.0120	0	0
Plog_CFD-Plog_VFD	1.000-0.993	-0.208*** 0.067	0.0213	0.0046	0
Plog_NFD-Plog_SoFD	1.000-0.907	-0.077*** 0.025	0.0005	0	0
Plog_VFD-Plog_NFD	1.000-1.049	-0.070** 0.038*	0.0001	0	0
Plog_VFD-Plog_SoFD	1.000-0.961	-0.111** 0.003	0.0350	0.019	0

Note: ***/**/* denotes rejection of the null at 1, 5 or 10 % significance level
Source: own calculations

Table 3: Linear VECM results.

in the VFD milk prices leads to 0.99 percent increase in the CFD milk prices, indicating an almost perfect ("one-to-one") price transmission. Meanwhile, there is low degree of integration of the Southern Federal District (SoFD) milk market due to the lack of well-developed transportation and communication infrastructure. We can observe a quiet small adjustment of the SoFD market with the CFD one (5.6 %), which is only significant at 90 per cent. ECT for SoFD market are not significant and just 2.5 and 0.3 percent with Northwestern Federal District (NFD) and Volga Federal District (VFD) respectively. Our VECM is well specified because model residuals do not suffer from serial autocorrelation, there is no heteroscedasticity and the residuals are normally distributed.

The SupLM test rejects the null hypothesis of linear integration, detecting the threshold effects for three out of six price pairs at the 5 % significance level (CFD-NFD, CFD-VFD and VFD-SoFD markets). Due to the Table 4 results, only the linear VECM is estimated for three markets: CFD-SoFD, NFD-SoFD and VFD-NFD.

Table 5 presents the TVECM results for three price

Price Pairs	Type of bootstrap simulation	Cointegrating vector, β	Threshold parameter, γ	SupLM test statistics	Critical Value at 5 % significance
Plog_CFD-Plog_NFD	Fixed regressor	-1.034	-0.329	20.369** (0.024)	18.989
	Residual bootstrap			20.369** (0.012)	17.347
Plog_CFD-Plog_SoFD	Fixed regressor	-0.929	0.651	23.652 (0.384)	30.34
	Residual bootstrap			23.652 (0.161)	27.711
Plog_CFD-Plog_VFD	Fixed regressor	-0.993	0.159	34.947*** (0.004)	29.209
	Residual bootstrap			34.947*** (0.001)	27.031
Plog_NFD-Plog_SoFD	Fixed regressor	-0.907	0.954	23.935 (0.343)	29.451
	Residual bootstrap			23.935 (0.121)	26.791
Plog_VFD-Plog_NFD	Fixed regressor	-1.049	-0.649	19.127 (0.791)	28.986
	Residual bootstrap			19.127 (0.287)	26.577
Plog_VFD-Plog_SoFD	Fixed regressor	-0.961	0.235	43.622** (0.044)	43.253
	Residual bootstrap			43.622** (0.026)	40.22

Note: ***/**/* denotes rejection of the null at 1, 5 or 10 % significance level; the values in parentheses indicate p-value.
Source: own calculations

Table 4: SupLM test results.

Price Pairs	$P_{log_}$CFD (P1)-$P_{log_}$NFD (P2)		$P_{log_}$CFD (P1)-$P_{log_}$VFD (P2)		$P_{log_}$VFD (P1)-$P_{log_}$SoFD (P2)	
	Lower Regime (69.4%)	Upper Regime (30.6%)	Lower Regime (28.8 %)	Upper Regime -71.20%	Lower Regime (44.8%)	Upper Regime (55.2%)
Cointegrating vector, β	-1.034		-0.993		-0.961	
Threshold parameter, γ	-0.329		0.159		0.235	
ECT	-0.176***	-0.021	-0.198	-0.015	-0.21	-0.033
	-0.004	0.174	0.289	0.210*	-0.033	0.042
Constant	-0.068***	-0.012	0.041	-0.002	0.058*	0.004
	0.004	0.051	-0.035	-0.040*	0.015	-0.011
$P1_{logt-1}$	0.697***	0.391**	0.231	0.781***	0.754***	0.379***
	0.499***	0.208*	0.218	0.648***	0.692***	0.314***
$P2_{logt-1}$	0.297*	0.247	0.378*	0.002	0.414**	0.880***
	-0.165	0.457***	0.456***	0.112	0.386***	0.737***
$P1_{logt-2}$					0.218	0.04
					0.118	0.02
$P2_{logt-2}$					-0.666***	-0.631***
					-0.617***	-0.360**

Note: ***/**/* denotes rejection of the null at 1, 5 or 10 % significance level
Source: own calculations

Table 5: TVECM results.

pairs. Lag selection has been selected based on both information criterions (BIC, AIC). They provide the same results. In order to overcome some criticism on ignoring the presence of transaction costs in spatial price transmission studies, we use threshold vector error correction model. TVECM takes in account the impact of transaction costs on horizontal price transmission, without directly relying on transaction cost data. In our study TVECM shows better results for short-term relationship between Central Federal District and Volga Federal District, Southern Federal District and Volga Federal District, Southern Federal District and Volga Federal District markets compared to a linear VECM. As expected, TVECM provides a bit different results compared to the linear model. The significant difference in adjustment speeds between lower and upper regimes defends the nonlinear adjustment towards equilibrium. For the CFD-NFD price pair, in the lower regime CFD adjustment speed is rather close to that in linear VECM (-0.176 in TVECM and -0.142 in linear VECM), meanwhile, in the upper regime CFD prices move to the equilibrium at the slower speed (-0.021). TVECM estimations for the CFD and NFD market prices series defend the asymmetry in responses from the both markets. If prices are lower than the threshold, the CFD milk market adjusts by circa 18 percent and if the prices are higher than the threshold CFD milk market adjusts by approximately 2 percent. Nonlinear model suggests VFD price leadership within CFD-VFD market (statistically significant coefficient of speed adjustment is 0.21), that is in line with the fact Volga Federal district is the largest region in terms of milk production and consumption per capita. We found no short-run price adjustment to equilibrium within VFD and SoFD milk markets because adjustments to milk price changes in two regimes are statistically insignificant at the 1, 5 and 10 % levels of significance. This finding might be due to the poor transportation infrastructure and short common border between two Federal districts.

Conclusion

The paper investigates horizontal relationships between milk prices in the European part of Russia by taking into account nonlinear (threshold) effects. Price transmission was evaluated in the co-integration framework, using widely-known Johansen as well as Hansen-Seo (2002) approaches. We specify TVECM with two regimes to take into account the effects of transaction costs. Estimation results indicate that milk markets are well integrated in the long-run term. However, in the short-run some markets are only partially integrated. Based on the model estimations, we found evidence of the rather low degree of integration of milk markets with each other. The speed of adjustments in the short run is slow. Approximately 7-20 percent adjustments towards the equilibrium is observed in the linear VECM. Especially the CFD market shows the higher adjustment with another milk prices. The SoFD market is less integrated in the short-run with NFD and VFD markets. Our estimations revealed threshold effects only within three milk markets: CFD-NFD, CFD-VFD and VFD-SoFD. We found statistically insignificant price adjustments in two regimes for VFD-SoFD milk market. The Volga FD (VFD) and Southern FD (SoFD) markets appear to be isolated in the short run. This resulted from the poor transportation system and logistics infrastructure between two Federal districts (based on the Russian Government directive-2011 №1538-r about the approval of social and economic development Strategy for the Southern Federal District until 2020).

This study can be extended with including another Federal districts from Eastern part of Russia.

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References

[1] Akaike, H. (1973) "Information theory and an extension of the maximum likelihood principle", in Petrov, B. N. and Csaki, F. (eds), *Proceedings of the 2nd International Symposium on Information Theory,* Budapest: Akademiai Kiado, pp. 267-281.

[2] Andrews, D. W. K. (1993) "Tests for Parameter Instability and Structural Change with Unknown Change Point", *Econometrica*, Vol. 61, No. 4, pp. 821-856. ISSN 0012-9682. DOI 10.2307/2951764.

[3] Arnade, C., Cooke, B. and Gale, F. (2017) "Agricultural price transmission: China relationships with world commodity markets", *Journal of Commodity Markets*, Vol. 7, pp. 28-40. ISSN 2405-8513. DOI 10.1016/j.jcomm.2017.07.001.

[4] Balke, N. and Fomby, T. (1997) "Threshold Cointegration", *International Economic Review*, Vol. 38, No. 3, pp. 627-645. E-ISSN 1468-2354. DOI 10.2307/2527284.

[5] Barrett, Ch. B. (2001) "Measuring Integration and Efficiency in International Agriculture Markets", *Applied Economic Perspectives and Policy,* Vol. 23, No. 1, pp. 19-32. E-ISSN 2040-5804, ISSN 2040-5790. DOI 10.1111/1058-7195.00043.

[6] Barrett, Ch. B. and Li, J. R. (2002) "Distinguishing between equilibrium and integration in spatial price analysis", *American Journal of Agricultural Economics,* Vol. 84, No. 2, pp. 292-307. E-ISSN 1467-8276, ISSN 0002-9092. DOI 10.2139/ssrn.257342.

[7] Baulch, B. (1997) "Transfer costs, spatial arbitrage, and testing for food market integration", *American Journal of Agricultural Economics,* Vol. 79, No. 2, pp. 477-487. E-ISSN 1467-8276. ISSN 0002-9092. DOI 10.2307/1244145.

[8] Brosig, S., Glauben, T., Götz, L., Weitzel, E. and Bayaner, A. (2011) "The Turkish Wheat Market: Spatial Price Transmission and the Impact of Transaction Costs", *Agribusiness*, Vol. 27, No. 2, pp. 147-161. E-ISSN 1520-6297. DOI 10.1002/agr.20257

[9] Chen, B. and Saghaian, S. H. (2016) "Market Integration and Price Transmission in the World Rice Export Markets", *Journal of Agricultural and Resource Economics*, Vol. 41, No. 3, pp. 444-457. ISSN 1068-5502

[10] Conforti, P. (2004) "*Price Transmission in Selected Agricultural Markets*", Commodity and Trade Policy Research Working Paper, No. 7, FAO, Rome. [Online]. Available: http://www.fao.org/tempref/docrep/fao/006/ad766e/ad766e00.pdf [Accessed: 25 Nov. 2018].

[11] Dickey, D. A., Fuller, W. A. (1979) "Distribution of the estimators for autoregressive time series with a Unit Root", *Journal of the American Statistical Association*, Vol. 74, pp. 427-431. ISSN 01621459. DOI 10.1080/01621459.1979.10482531.

[12] Ganneval S. (2016) "Spatial price transmission on agricultural commodity markets under different volatility regimes", *Economic Modelling*, Vol. 52 Part A, pp. 173-185.ISSN 0264-9993. DOI 10.1016/j.econmod.2014.11.027.

[13] Granger, C. (1981) "Some Properties of Time Series Data and Their Use in Econometric Model Specification", *Journal of Econometrics*, Vol. 16, No. 1, pp. 121-130. ISSN 0304-4076. DOI 10.1016/0304-4076(81)90079-8.

[14] Engle, R. F., Granger, C. W. J. (1987) "Co-Integration and Error Correction: Representation, Estimation, and Testing", *Econometrica*, Vol. 55, No. 2, pp. 251-276. ISSN 0012-9682. DOI 10.2307/1913236.

[15] Habte, Z. (2017) "Spatial market integration and price transmission for papaya markets in Ethiopia", *Journal of Development and Agricultural Economics*, Vol. 9, No. 5, pp. 129-136. ISSN 2006-9774. DOI 10.5897/JDAE2016.0777.

[16] Hansen, B. E. and Seo, B. (2002) "Testing for Two-Regime Threshold Cointegration in Vector Error Correction Models", *Journal of Econometrics,* Vol. 110, pp. 293–318. ISSN 0304-4076. DOI 10.1016/S0304-4076(02)00097-0.

[17] Hu, Z. and Wade Brorsen, B. (2017) “Spatial Price Transmission and Efficiency in the Urea Market”, *Agribusiness,* Vol. 33, No. 1. E-ISSN 1520-6297. DOI 10.1002/agr.21475.

[18] Jena, P. K. (2016) “Commodity market integration and price transmission: Empirical evidence from India”, *Theoretical and Applied Economics*, Vol. XXIII, No. 3(608), pp. 283-306. ISSN 1844-0029.

[19] Johansen, S. (1988) “Statistical analysis of co-integration vectors”, *Journal of Economic Dynamics and Control*, Vol. 12, No. 2-3, pp. 231-254. ISSN 0165-1889. DOI 10.1016/0165-1889(88)90041-3.

[20] Johansen, S. (1991) "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models", *Econometrica*, Vol. 59, No. 6, pp. 1551-1580. ISSN 0012-9682.

[21] Johansen, S. (1995) “*Likelihood-based Inference in Cointegrated Vector Autoregressive Models*”, Oxford University Press. ISBN-13 9780198774501. DOI 10.2307/2938278.

[22] Johansen, S. and Juselius, K. (1990) “Maximum Likelihood Estimation and Interence on Cointegration – with Applications to the Demand for Money”, *Oxford Bulletin of Economics and Statistics,* Vol. 52, No. 2, pp. 169-210. E-ISSN 1468-0084.

[23] Lütkepohl, H., Saikkonen, P. and Trenkler, C. (2001) “Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process”, *The Econometrics Journal*, Vol. 4, pp. 287-310. E-ISSN 1368-423X, ISSN 1368-4221. DOI 10.1111/1368-423X.00068.

[24] McNew, K. and Fackler, P. L. (1997) “Testing market equilibrium: Is cointegration informative?”, *Journal of Agricultural and Resource Economics*, Vol. 22, No. 2, 17, p. 191-207. ISSN 0162-1912.

[25] Minot, N. (2011) “*Transmission of World Food Price Changes to Markets in Sub-Saharan Africa*”, IFPRI Discussion Paper, No. 01059, Washington, DC. [Online]. Available: http://www.ifpri.org/publication/transmission-world-food-price-changes-markets-sub-saharan-africa [Accessed: 28 Nov. 2018].

[26] Phillips, P. C. B. and Perron, P. (1988) “Testing for a Unit Root in Time Series Regression”, *Biometrica*, Vol. 75, No. 2, pp. 335-346. E-ISSN 1464-3510, ISSN 0006-3444. DOI 10.1093/biomet/75.2.335.

[27] Savadatti P. (2018) “Spatial Market Integration of Arhar (Split) Wholesale Prices in India: Application of Vector Error Correction Model”, *Indian Journal of Marketing*, Vol. 48, No. 4, pp. 21-29. ISSN 0973-8703. DOI 10.17010/ijom/2018/v48/i4/122623.

[28] Schwarz, G. E. (1978) “Estimating the dimension of a model”, *The Annals of Statistics*, Vol. 6, No. 2, pp. 461-464. ISSN 0090-5364. DOI 10.1214/aos/1176344136.

[29] Schwert, G. W. (1989) “Tests for Unit Roots: A Monte Carlo Investigation”, *Journal of Business and Economic Statistics*, Vol. 7, pp. 147-160. ISSN 0735-0015. DOI 10.3386/t0073 .

[30] Seo, M. (2006) “Bootstrap testing for the null of no cointegration in a threshold vector error correction model”, *Journal of Econometrics*, Vol. 134, No. 1, pp. 129-150. ISSN 0304-4076. DOI 10.1016/j.jeconom.2005.06.018.

[31] Sexton, R., Kling, C. and Carman, H. (1991) “Market Integration, Efficiency of Arbitrage, and Imperfect Competition: Methodology and Application to U.S. Celery”, *American Journal of Agricultural Economics*, Vol. 7, No. 3, pp. 568-580. E-ISSN 1467-8276, ISSN 0002-9092. DOI 10.2307/1242810

[32] Stigler, M. (2013) “*Threshold cointegration: overview and implementation in R*”, R package. [Online]. Available: https://cran.r-project.org/web/packages/tsDyn/vignettes/ThCoint Overview.pdf [Accessed: 28 Nov. 2018].

[33] Wu, F. and Guan, Z. (2018) “Spatial Price Transmission in the Presence of Floor Prices”, Conference paper at the 2018 *Agricultural and Applied Economics Association Annual Meeting*, Washington, D.C., [Online]. Available: https://ageconsearch.umn.edu/record/273995 /files/Abstracts_18_05_24_10_43_35_94__128_227_173_121_0.pdf [Accessed: 20 Nov. 2018].

[34] Zakari S., Ying L. and Song B. (2014) "Market Integration and Spatial Price Transmission in Niger Grain Markets", *African Development Review*, Vol. 26, No. 2, pp. 264-273. E-ISSN 1467-8268. DOI 10.1111/1467-8268.12080.

[35] Zhou, D. and Koemle, D. (2015) "Price transmission in hog and feed markets of China", *Journal of Integrative Agriculture*, Vol. 14, No. 6, pp. 1122-1129. ISSN 2095-3119. DOI 10.1016/S2095-3119(14)60995-3.

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Economic Impact of Food Loss and Waste

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Abstract

Research background: The unproductive use of natural resources such as land and water, resulting from food loss and waste, constrains the pursuit of such tasks as overcoming hunger and poverty, ensuring adequate nutrition, increasing income and economic growth. Purpose of the article: According to the results of empirical research to identify the level of economic damage and lost revenue as a result of the food loss and waste, as well as to identify potential benefits for the agricultural land use in reducing those losses. Methods: The analysis was conducted in terms of regions and product types. The methodology proposed by FAO is used to calculate the food loss and waste for each type of product in Ukraine. Findings & Value added: Firstly, it has been empirically proven that food loss and waste result in significant economic damage and lost revenue. Secondly, the reduction of food loss and waste has positive environmental and social consequences.

Keywords

Economic damage, food loss, food waste, cereal crops, potato, vegetables, fruits and fruits, meat, milk, regions, Ukraine.

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Introduction

The unproductive use of natural resources such as land and water, resulting from food loss and waste, constrains the pursuit of such tasks as overcoming hunger and poverty, ensuring adequate nutrition, increasing income and economic growth. In subsistence farming systems of small producers, quantitative losses of food lead to a decrease in the physical availability of food and increase, thus, the level of food insecurity. Rural elderly are particularly vulnerable to such effects, as they often have less access to appropriate technology, infrastructure, storage and markets, than other groups. Lowering the quality of food products also leads to poor nutrition - low-quality foods can be dangerous because of their adverse effects on health, well-being and productivity of consumers.

Food loss is essentially a loss of economic value for food business entities. The value of food loss and waste at the global level is estimated at 1 trillion US dollars (SAVE FOOD, 2015). Today, food industry chains are becoming more and more globalized – certain foods are produced, processed and consumed in completely different parts of the world. Foods that are sold in international markets and lost in one part of the world can affect the availability of food and prices in another part.

For Ukraine, this issue is of particular importance for several reasons: firstly, Ukraine has joined the group of countries in implementing the Sustainable Development Goals 2016-2030; secondly, the actual production of major food groups in Ukraine is sufficient to provide a rational standard of nutrition, but the actual level of consumption does not correspond to rational standards for half of the specified product list; thirdly, most of the agricultural producers, as in the former Soviet Union, still prefer extensive and intensive management practices that create further environmental pressures on land without proper economic and social impact.

The aim of the study is to determine the amount of economic losses and foregone earnings resulting from food waste and food by-products in Ukraine (according to the results of the empirical study), as well as to identify potential social and environmental benefits from food waste and food by-products' reduction.

The object of the study is the effects of food loss and waste.

The subject of the study includes indicators of economic damage and lost revenue resulting from food loss and waste, including per 100 hectares of agricultural land and 100 people in terms of regions of Ukraine and types of products (cereals, vegetables, potatoes, meat, milk, fruits and fruits).

Materials and methods

The author's methodological approach to assessing the impact of food loss and waste on the level of economic damage and lost revenue is based on the following principles:

(1) principle of purpose – assessment of the impact of food loss and waste on the level of utilization of land resources in Ukraine;

(2) principle of unity – a time lag (2016) and a defined system of indicators of evaluation;

(3) systematic principle – systematization of indicators by product and region;

(4) scientific principle – the use of various methods of empirical research;

(5) principle of maximum informativeness, including – visual perception.

In accordance with the purpose of the study and these principles, an appropriate system of indicators that has been developed to meet the following criteria:

- combine environmental, social and economic aspects;
- understandable and unambiguous interpretation for decision makers;
- have a quantitative expression;
- rely on the existing system of national statistics and do not require significant expenditures for the collection of information and calculations;
- are representative of interregional comparisons;
- have an opportunity to assess in time dynamics;
- have a limited number.

The system of indicators, their economic and inappropriate methods and calculation methods are given below.

The economic damage resulting from the food loss and waste (ED, formula 1) is calculated at constant prices for agricultural products to calculate the agricultural production index, approved by the State Statistics Committee of Ukraine dated 22.12.2011, No. 362 (State Statistics Service of Ukraine, 2011):

$$ED = FLW \cdot CP, \quad (1)$$

where *FLW* – volume of food loss and waste for a particular type of products, ths. tons; *CP* – constant price for a particular type of agricultural products, EUR per 1t: 1027.5 – for cereals; 1007.6 – for potatoes; 1793.8 – for vegetables; 2251.8 – for fruits; 12734.6 – for meat; 2486.6 – for milk.

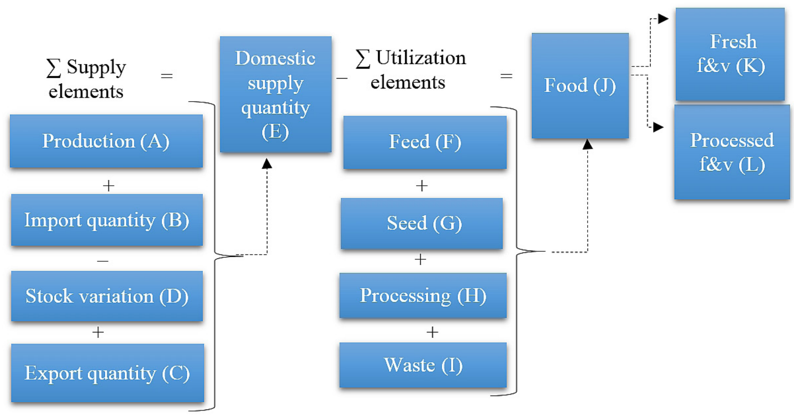
Lack of income due to food loss and waste (SI, formula 2) is calculated at actual prices in 2016 for agricultural products:

$$SI = FLW \cdot AP, \quad (2)$$

where *AP* – the actual price in 2016 for a particular type of agricultural product, EUR per 1 t: 3414.0 – for cereals; 2631.8 – for potatoes; 3924.2 – for vegetables; 5863.8 – for fruits; 22468.0 – for meat; 5461.8 – for milk.

Accordingly, the amounts of these indicators by type of product or region are correspond to the total economic damage and lost revenue.

Author used methodology, proposed by FAO (Figure 1), in order to calculate food loss and waste for each type of product in Ukraine.



Scource: FAO (2011. p. 33-35)

Figure 1: Method for calculation of food loss and waste.

A + B + C - D = E- (F + G + H + I) = J = K + L

Example: Calculations on losses and waste of milk in Ukraine. The below shows the mass flow of total milk (thousand tons) in the 2016.

Waste percentage in each step of the FSC:

Agricultural production = 3.5%

Postharvest handling and storage = 0.5%

Processing and packaging = 1.2%

Distribution (fresh & processed) = 0.5%

Consumption (fresh & processed) = 7%

Calculations on primary equivalent milk losses and waste in each step of the FSC:

Agricultural production: (0.035/(1 - 0.035))*10382 = 376.5 thousand tons

Postharvest handling and storage: 0.005*10382 = 51.9 thousand tons

Processing and packaging = 0.012*(2850 + 6090) = 107.3 thousand tons

Distribution (fresh): 0.005*58 = 0.3 thousand tons

Distribution (processed):

0.005*(2850 + 6090 - 107.7) = 44.2 thousand tons

Consumption (fresh):
0.07*(58 - 0.3) = 4.0 thousand tons

Consumption (processed):
0.07*(2850 + 6090 - 107.3 - 44.2)
= 615.2 thousand tons

Conversion factors:

peeling by hand = 1.0;

industrial peeling = 1.0;

mean = 0.1

Calculations on edible milk losses and waste in each step of the FSC:

Agricultural production:
376.5*1.0 = 376.5 thousand tons

Postharvest handling and storage:
51.9*1.0 = 51.9 thousand tons

Processing and packaging:
107.3*1.0 = 107.3 thousand tons

Distribution:
(0.3*1.0) + (44.2*1.0) = 44.5 thousand tons

Consumption:
(4.0*1.0) + (615.2*1.0) = 619.2 thousand tons

Physical mass of food produced for human consumption and of food lost and wasted throughout the food supply chain in Ukraine have been quantified, using available data (State Statistics Service of Ukraine, 2017). Results of food losses and waste in other countries were taken from FAO reports.

For each commodity group a mass flows model was used to account for food losses and waste in each step of the commodity's FSC. Model equations are provided in Graph 1.

The production volumes for all commodities were collected from the SSSU "Balances and consumption of the main food products by the population of Ukraine" 2017 (State Statistics Service of Ukraine, 2017).

Allocation factors have been applied to determine the part of the produce oriented to human consumption (and not for animal feed). "Conversion factors have been applied to determine the edible mass and are in accordance with the developed FAO. The different commodities addressed are grouped according to FAOSTAT's Food Balance Sheets and SSSU's Balances and consumption of the main food products by the population of Ukraine: 1. Cereals (excluding beer): wheat, rice (milled), barley, maize, rye, oats, millet, sorghum, other cereals. 2. Roots and Tubers: potatoes. 3. Fruit: apples (excl. cider), grapes (excl. wine), other fruit. 4. Vegetables: tomatoes, onions, other vegetables. 5. Meat: bovine meat, mutton/goat meat, pig meat, poultry meat, other meat, offals. 6. Dairy products: milk. As there are no balances for "Oilseeds and Pulses" and "Fish and Seafood" groups in Ukraine, so the calculations for these product groups have not being conducted.

At each stage of the Food Supply Chain, losses and waste were estimated using SSSU's Balances and consumption of the main food products by the population of Ukraine from the years 2015-2017 and results from a thorough calculations of global food waste.

The figures used are presented in Table 1.

The official data of the State Statistics Service of Ukraine for 2015-2017 were used as the information base in terms of regions and types of products.

Type of production	Agricultural Production	Postharvest handling and storage	Processing and packaging	Distribution: Supermarket Retail	Consumption
Cereals	2	4	0.5-10	2	25
Roots and tubers	20	9	15	7	17
Oilseeds and pulses	10	1	5	1	4
Fruits and vegetables	20	5	2	10	19
Meat	3.1	0.7	5	4	11
Fish and seafood	9.4	0.5	6	9	11
Milk	3.5	0.5	1.2	0.5	7

Scource: FAO (2011. p. 33-35)

Table 1: Weight percentages of food and waste losses (as a percentage of what is included at each stage) for Europe.

Results

The study is based on empirical research methods as well as on the author's methods of assessment of economic impact of food loss and waste.

The problem of food loss and waste is extensively investigated by foreign scientists, in particular, in the EU and the USA. Among the most important studies that cover the national and global levels of the problem, the following works should be highlighted.

"Reducing Food Loss and Waste" (Lipinski et al., 2013) focuses on food loss and waste in global terms (according to 2009), defines the terms "loss of food" and "food waste" and also propose strategies to reduce food loss and waste.

The study "Global food losses and food waste - Extent, causes and prevention" (FAO, 2011) covers losses that occur along the food chain, and estimates their value; also, the causes of food losses and possible ways of their prevention are determined.

"Food Initiative on Food Loss and Waste Reduction" (SAVE FOOD, 2015) addresses the issues of "food loss" and "food waste" terminology, the conditions for the emergence and consequences of food and food waste loss, as well as - strategies to reduce food loss and waste in a globalized world.

“Food Wastege Footprint: Impacts on Natural Resources” (FAO, 2013) study provides a global assessment of the environmental consequences of food and food waste loss at each stage of the food chain, focusing on the impacts on climate, water, land and biodiversity, as well as economic a quantitative estimate based on world producer prices. The paper answers two main questions: what are the consequences of a loss of nutrition on natural resources, and where these consequences are coming from. As a result, researchers identify "hot spots of the environment" and thus determine the directions and measures to reduce their impact.

"Business Case for Reducing Food Loss and Waste" (Hanson and Mitchell, 2016) presents the results of interviews with government and business leaders, which resulted in a set of strategic but non-financial motivators for reducing food loss and waste related to food security, waste management, environmental sustainability, stakeholder relations and ethical responsibility. Therefore, the authors propose a business criterion for reducing the losses of food and waste for the public and private sectors, built on the principle: goals – objective – actions.

Schuster Monica and Torero Máximo in the "Toward a sustainable food system: Reducing food loss and waste" (Schuster and Torero, 2018) investigate the issues of terminology and methodology for measuring food and food waste losses, as well as developing an effective policy to solve the problem in within the food chain.

Martin Julius Chegere in "Post-harvest losses reduction by small-scale maize farmers: The role of handling practices" (Chegere, 2018) has shown that reducing post-harvest losses is a key component complementing the efforts to address problems of food safety and increase of incomes of agricultural enterprises, especially for low-income households. The research analyzes the role of recommended methods of harvest handling when it is reduced, and evaluates the losses and benefits associated with the practice of food loss reduction during storage.

Wondimagegn Tesfaye and Tirivayi, N. in the "The impacts of postharvest storage innovations on food security and welfare in Ethiopia" (Tesfaye and Tirivayi, 2018) analyzed the impact of advanced storage technologies, safety and welfare of food through national representative data from Ethiopia. The study found that the use of advanced food storage technologies increases dietary diversity and reduces child malnutrition. Overall, research shows that improved storage technologies can improve food and nutrition security and can play a key role in mitigating nutrition problems of the growing population.

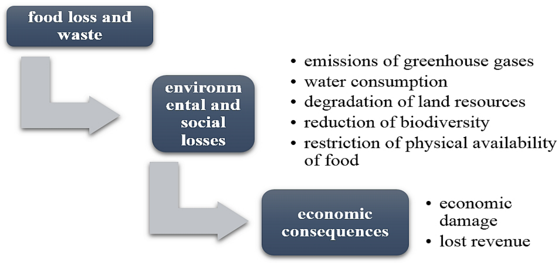
Timothy J. Richards and Stephen F. Hamilton in "Food waste in the sharing economy" (Richards and Hamilton, 2018) explore the potential for commercial peer-to-peer network interactions (CPMS) or enterprises that use shared economic resources, to enter the market as a platform for the exchange of surplus food. Scientists' findings suggest that secondary markets have key elements needed to succeed CPMS, and policy tools aimed at facilitating transactions in secondary markets can be very effective in reducing food waste.

"Future of food safety and nutrition – Seeking win-wins, coping with trade-offs" (Mylona et al., 2018) devoted to research the possible effects of global trends such as climate change and resource scarcity for food security. The document is based on the results of the study on safety and food in the EU by 2050.

Scientific paper "Food counts. Measuring food consumption and expenditures in household consumption and expenditure surveys (HCES). Introduction to the special issue" (Zezza et al., 2017) presents the results of an international multidisciplinary research project on measuring food intake in national household's surveys. The paper synthesized case studies in developing countries and OECD countries.

The article "Food Loss and Waste in Sub-Saharan Africa" (Sheahan and Barrett, 2018) explores current approaches to mitigate the effects of food loss and waste in Africa.

The synthesis of research results leads to the conclusion that the potential benefits of reducing food loss and waste are concentrated in three areas: environmental (rational use of resources to reduce anthropogenic load on the environment), social (increased food availability, poverty reduction and gender inequality, especially in rural areas) and economic (prevention of economic losses, saving money and resources), provided that sufficient food supplies are maintained (Figure 2).



Scource: own work

Figure 2: Economic consequences of food loss and waste.

Our research focuses on economic aspects, in particular: economic damage and lost revenue in a result of food loss and waste in Ukraine.

The consequence of environmental and social losses in the result of food loss and waste is economic damage and lost revenue. We have defined the volumes of these indicators in Ukraine in terms of groups of cultures.

According to the calculations made, the losses from food waste and food by-products in Ukraine from 2015 to 2017 amounted to 5793.8 thousand tons of grain, 14014.6 thousand tons of potatoes, 9173.6 thousand tons of vegetables, 3050.7 thousand tons of fruits, 2450.1 thousand tons of meat and 5408,3 thousand tons of milk (Table 2). In relation to the volumes of production, the largest are losses from food waste and food by-products in fruits (42%), meat (35%) and vegetables (31%), and the smallest are in grain (3%).

It is important to note that the amount of food waste and food by-products' losses do not practically change at runtime, but the largest are in 2016, especially in grain that is determined to be the main indicator of food security. It is inappropriate to calculate over a longer period, as, according to previous studies (Babych and Kovalenko, 2018), the level of production and consumption of food per capita in Ukraine over the past 5 years has not changed substantially. That is why further calculations are carried out according to the data of 2016. Such insignificant fluctuations can be explained by the fact that production and consumption of the main products' types as well as technologies of production, storage and processing of agricultural products remain almost unaltered.

Thus, economic damage and lost revenue in the result of food loss and waste on grain in Ukraine in 2016 amounted respectively to 90.5 and 300.6 million EUR (Table 3). The largest amount of losses was found in Poltava and Vinnytsya regions (correspondingly, 11.5 and 10.3 million EUR), and the smallest in Chernivtsy region (0.1 million EUR). In this case, the actual amount of grain consumed, taking into account lost food and food waste, is 34.5 centners per 1 hectare, i.e., from each hectare of crops was lost 1.8 centners of grain.

Economic damage and lost revenue in the result of food loss and waste of potatoes in Ukraine in 2016 amounted to 155.0 and 404.8 million EUR, respectively (Table 4). The largest amount of losses was found in Kyiv region (16.9 million EUR), and the smallest in Kherson region (2.5 million EUR). In fact, the consumed amount of potatoes, taking into account food loss and waste, is 130.4 centners per 1 hectare, i.e. from each hectare of crops was lost 35.4 centners of potatoes.

Economic damage and lost revenue in the result of food loss and waste on vegetables in Ukraine in 2016 amounted to 187.4 and 410.0 million EUR respectively (Table 5). The largest amount of losses was found in Kherson region (23.2 million EUR), and the smallest in Chernihiv region (4.5 million EUR). In fact, the amount of vegetables consumed, taking into account food loss and waste, is 153.0 centners per 1 hectare, i.e., from each hectare of crops was lost 70.6 centners of vegetables.

Economic damage and lost revenue in the result of food loss and waste of fruits in Ukraine in 2016 amounted to 73.4 and 191.2 million EUR respectively (Table 6). The largest amount of losses was found in Kyiv and Odesa regions (7.1 and 8.5 million EUR respectively), and the smallest in Sumy and Chernihiv regions (respectively, 0,8 and 0,7 million EUR). In fact, the amount of fruits consumed, taking into account food loss, is 71.2 centners per 1 hectare, i.e., from each hectare of plantations was lost 50.1 centners of fruits.

Economic damage and lost revenue in the result of food loss and waste of meat in Ukraine in 2016 amounted respectively to 344.4 and 607.7 million EUR (Table 7). The largest losses recorded in Dnipro and Kyiv regions (37.0 and 38.8 million EUR respectively), while the smallest in Mykolayiv and Chernivtsi regions (5.4 million and 5.7 EUR million respectively).

Step of the FSC	Meat			Milk			Fruits			Cereals (grain crops)			Roots (potatoes)			Vegetables		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
Agricultural production	74.3	74.3	74.2	385.0	376.5	372.9	215.0	208.7	215.0	429.5	371.6	442.3	1943.2	1903.2	1943.2	850.5	874.8	850.5
in percentages relative to data on losses	9.1	9.1	9.1	22.0	22.0	19.2	20.8	21.2	20.8	26.5	14.6	27.3	41.5	41.0	41.5	28.4	27.7	28.2
Postharvest handling and storage	16.3	16.3	16.2	53.1	51.9	51.4	4.3	4.2	4.3	84.2	72.8	86.7	70.0	68.5	70.0	17.0	17.5	17.0
in percentages relative to data on losses	2.0	2.0	2.0	3.0	3.0	2.7	0.4	0.4	0.4	5.2	2.9	5.3	1.5	1.5	1.5	0.6	0.6	0.6
Processing and packaging	192.9	192.8	192.7	182.2	178.2	209.6	43.2	41.4	43.1	524.7	995.9	517.6	1165.2	1166.3	1165.2	108.4	114.8	109.4
in percentages relative to data on losses	23.6	23.6	23.6	10.4	10.4	10.8	4.2	4.2	4.2	32.3	39.1	31.9	24.9	25.1	24.9	3.6	3.6	3.6
Distribution: Supermarket Retail	146.6	146.5	146.4	75.9	74.3	87.5	284.7	269.6	283.9	44.1	83.7	43.5	462.2	462.6	462.2	745.8	792.7	754.3
in percentages relative to data on losses	17.9	17.9	17.9	4.3	4.3	4.5	27.5	27.4	27.5	2.7	3.3	2.7	9.9	10.0	9.9	24.9	25.1	25.0
Consumption	387.1	386.9	386.6	1057.3	1034.4	1218.2	486.9	460.9	485.4	539.9	1024.8	532.6	1043.9	1044.9	1043.9	1275.3	1355.5	1289.9
in percentages relative to data on losses	47.4	47.4	47.4	60.3	60.3	62.8	47.1	46.8	47.1	33.3	40.2	32.8	22.3	22.5	22.3	42.6	43.0	42.7
In total	817.1	816.9	816.1	1753.4	1715.3	1939.6	1034.1	984.8	1031.8	1622.3	2548.9	1622.6	4684.6	4645.4	4684.6	2997.1	3155.3	3021.2
In total for 2015-2017	2450.1			5408.3			3050.7			5793.8			14014.6			9173.6		
In percentages relative to data on production	35.2	35.2	35.2	16.5	16.5	18.9	42.1	41.3	42.0	2.7	4.9	2.6	21.1	21.4	21.1	30.8	31.6	31.1

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 2: Food loss and waste of the main food groups in Ukraine, thousand tons.

Region	Gross production, ths. tons			Yield, centners of 1 ha			Gross products, mln. EUR			Economic losses, mln. EUR	Lost revenue, mln. EUR
	In fact	taking into account the lost production		In fact	taking into account the lost production		In fact	taking into account the lost production			
		In total	at the production stage		In total	at the production stage		In total	at the production stage		
Ukraine	52022.2	49473.3	51650.6	36.3	34.5	36.0	1770.0	1679.5	1757.3	90.5	300.6
Vinnytska	4648.6	4345.6	4615.4	53.6	50.1	53.2	158.2	147.9	157.0	10.3	34.3
Volynska	659.1	609.8	654.4	22.4	20.7	22.2	22.4	20.7	22.3	1.7	5.6
Dnipropetrovska	2211.2	2173.5	2195.4	20.2	19.9	20.1	75.2	74.0	74.7	1.3	4.3
Donetska	1294.8	1248.2	1285.6	23.8	23.0	23.7	44.1	42.5	43.7	1.6	5.3
Zhytomyrska	1807.6	1673.7	1794.7	46.2	42.8	45.9	61.5	56.9	61.1	4.6	15.1
Zakarpatska	153.7	138.1	152.6	16.7	15.0	16.6	5.2	4.7	5.2	0.5	1.8
Zaporizka	1966.9	1894.8	1952.9	22.3	21.5	22.1	66.9	64.5	66.4	2.5	8.1
Ivano-Frankivska	482.1	446.3	478.7	31.9	29.5	31.6	16.4	15.2	16.3	1.2	4.0
Kyivska	2958.8	2768.4	2937.7	52.2	48.8	51.8	100.7	94.2	100.0	6.5	21.5
Kirovohradska	2982.6	2779.1	2961.3	36.9	34.4	36.6	101.5	94.6	100.8	6.9	23.0
Luhanska	1035.1	1003.1	1027.7	27.3	26.4	27.1	35.2	34.1	35.0	1.1	3.6
Lvivska	972.1	900.7	965.2	32.0	29.6	31.8	33.1	30.6	32.8	2.4	8.1
Mykolaivska	1888.3	1828.8	1874.8	22.6	21.9	22.5	64.2	62.2	63.8	2.0	6.7
Odeska	3319.8	3216.1	3296.1	27.8	26.9	27.6	113.0	109.4	112.1	3.5	11.7
Poltavska	4779.9	4440.5	4745.8	51.1	47.5	50.7	162.6	151.1	161.5	11.5	38.4
Rivnenska	881.3	845.5	875.0	32.7	31.4	32.5	30.0	28.8	29.8	1.2	4.0
Sumska	3578.0	3356.3	3552.4	55.4	52.0	55.0	121.7	114.2	120.9	7.5	25.1
Ternopilska	1920.8	1835.2	1907.1	41.3	39.4	41.0	65.4	62.4	64.9	2.9	9.7
Kharkivska	3025.8	2929.0	3004.2	30.8	29.8	30.6	102.9	99.7	102.2	3.3	10.9
Khersonska	1390.7	1348.8	1380.8	21.0	20.3	20.8	47.3	45.9	47.0	1.4	4.7
Khmelnytska	2693.5	2503.9	2674.3	50.4	46.8	50.0	91.6	85.2	91.0	6.5	21.4
Cherkaska	3614.0	3410.7	3588.2	54.8	51.8	54.4	123.0	116.0	122.1	6.9	23
Chernivetska	186.5	182.8	185.2	15.2	14.9	15.1	6.3	6.2	6.3	0.1	0.4
Chernihivska	3571.0	3484.0	3545.5	54.6	53.3	54.2	121.5	118.5	120.6	3.0	9.8

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 3: Economic losses as a result of food loss and waste in Ukraine in 2016 by grain crops.

Region	Gross production, ths. tons			Yield, centners of 1 ha			Gross products, mln. EUR			Economic losses, mln. EUR	Lost revenue, mln. EUR
	In fact	taking into account the lost production		In fact	taking into account the lost production		In fact	taking into account the lost production			
		In total	at the production stage		In total	at the production stage		In total	at the production stage		
Ukraine	21750.5	17105.1	19847.3	165.8	130.4	151.3	725.7	570.7	662.2	155.0	404.8
Vinnytska	1848.5	1472.7	1686.8	170.8	136.1	155.9	61.7	49.1	56.3	12.5	32.7
Volynska	1132.4	943.8	1033.3	157.3	131.1	143.5	37.8	31.5	34.5	6.3	16.4
Dnipropetrovska	602.1	419.6	549.4	113.0	78.7	103.1	20.1	14.0	18.3	6.1	15.9
Donetska	409.1	254.5	373.3	114.6	71.3	104.6	13.6	8.5	12.5	5.2	13.5
Zhytomyrska	1316.6	1031.2	1201.4	189.4	148.4	172.9	43.9	34.4	40.1	9.5	24.9
Zakarpatska	534.3	429.4	487.5	158.1	127.0	144.2	17.8	14.3	16.3	3.5	9.1
Zaporizka	263.7	181.2	240.6	120.4	82.7	109.9	8.8	6.0	8.0	2.8	7.2
Ivano-Frankivska	975.1	781.3	889.8	164.2	131.5	149.8	32.5	26.1	29.7	6.5	16.9
Kyivska	1703.1	1197.8	1554.1	179.5	126.2	163.8	56.8	40.0	51.9	16.9	44.0
Kirovohradska	603.4	445.7	550.6	148.3	109.5	135.3	20.1	14.9	18.4	5.3	13.7
Luhanska	252.8	153.0	230.7	147.0	89.0	134.1	8.4	5.1	7.7	3.3	8.7
Lvivska	1618.9	1319.4	1477.2	172.4	140.5	157.3	54.0	44.0	49.3	10.0	26.1
Mykolaivska	268.5	188.8	245.0	141.3	99.4	128.9	9.0	6.3	8.2	2.7	6.9
Odeska	541.1	403.5	493.8	148.7	110.9	135.7	18.1	13.5	16.5	4.6	12.0
Poltavska	1065.4	891.3	972.2	196.6	164.4	179.4	35.5	29.7	32.4	5.8	15.2
Rivnenska	1249.4	1035.4	1140.1	178.7	148.1	163.1	41.7	34.5	38.0	7.1	18.6
Sumska	1065.6	838.4	972.4	185.3	145.8	169.1	35.6	28.0	32.4	7.6	19.8
Ternopilska	987.0	810.6	900.6	168.4	138.3	153.7	32.9	27.0	30.0	5.9	15.4
Kharkivska	1077.7	834.6	983.4	175.2	135.7	159.9	36.0	27.8	32.8	8.1	21.2
Khersonska	279.6	204.3	255.1	117.5	85.8	107.2	9.3	6.8	8.5	2.5	6.6
Khmelnytska	1320.5	1085.5	1205.0	200.7	165.0	183.1	44.1	36.2	40.2	7.8	20.5
Cherkaska	839.2	660.7	765.8	164.2	129.3	149.9	28.0	22.0	25.5	6.0	15.6
Chernivetska	594.7	470.7	542.7	175.4	138.8	160.1	19.8	15.7	18.1	4.1	10.8
Chernihivska	1201.8	1051.4	1096.6	151.4	132.4	138.1	40.1	35.1	36.6	5.0	13.1

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 4: Economic losses as a result of food loss and waste in Ukraine in 2016 on potatoes.

Region	Gross production, ths. tons			Yield, centners of 1 ha			Gross products, mln. EUR			Economic losses, mln. EUR	Lost revenue, mln. EUR
	In fact	taking into account the lost production		In fact	taking into account the lost production		In fact	taking into account the lost production			
		In total	at the production stage		In total	at the production stage		In total	at the production stage		
Ukraine	9997.9	6842.6	9123.1	223.6	153.0	204.1	593.9	406.4	541.9	187.4	410.0
Vinnytska	506.9	358.8	462.5	233.6	165.3	213.1	30.1	21.3	27.5	8.8	19.2
Volynska	288.7	206.4	263.4	218.7	156.4	199.5	17.1	12.3	15.6	4.9	10.7
Dnipropetrovska	765.4	542.3	698.4	214.4	151.9	195.6	45.5	32.2	41.5	13.3	29.0
Donetska	228.1	63.6	208.1	153.1	42.7	139.7	13.5	3.8	12.4	9.8	21.4
Zhytomyrska	298.9	207.3	272.7	255.5	177.2	233.1	17.8	12.3	16.2	5.4	11.9
Zakarpatska	267.2	185.4	243.8	207.1	143.7	189.0	15.9	11.0	14.5	4.9	10.6
Zaporizka	437.0	301.0	398.8	244.1	168.2	222.8	26.0	17.9	23.7	8.1	17.7
Ivano-Frankivska	172.2	107.8	157.1	164.0	102.7	149.6	10.2	6.4	9.3	3.8	8.4
Kyivska	641.7	382.1	585.6	223.6	133.1	204.0	38.1	22.7	34.8	15.4	33.7
Kirovohradska	256.2	181.2	233.8	150.7	106.6	137.5	15.2	10.8	13.9	4.5	9.7
Luhanska	180.1	106.4	164.3	191.6	113.2	174.8	10.7	6.3	9.8	4.4	9.6
Lvivska	505.7	336.6	461.5	199.1	132.5	181.7	30.0	20.0	27.4	10.0	22.0
Mykolaivska	528.3	365.2	482.1	276.6	191.2	252.4	31.4	21.7	28.6	9.7	21.2
Odeska	380.4	238.7	347.1	156.5	98.2	142.8	22.6	14.2	20.6	8.4	18.4
Poltavska	546.6	395.8	498.8	223.1	161.6	203.6	32.5	23.5	29.6	9.0	19.6
Rivnenska	236.2	163.9	215.5	196.8	136.6	179.6	14.0	9.7	12.8	4.3	9.4
Sumska	208.5	145.3	190.3	196.7	137.1	179.5	12.4	8.6	11.3	3.8	8.2
Ternopilska	259.5	181.5	236.8	221.8	155.1	202.4	15.4	10.8	14.1	4.6	10.1
Kharkivska	759.4	547.9	693.0	248.2	179.1	226.5	45.1	32.5	41.2	12.6	27.5
Khersonska	1504.1	1114.1	1372.5	368.7	273.1	336.4	89.3	66.2	81.5	23.2	50.7
Khmelnytska	229.0	158.6	209.0	206.3	142.9	188.3	13.6	9.4	12.4	4.2	9.1
Cherkaska	367.9	261.6	335.7	179.5	127.6	163.8	21.9	15.5	19.9	6.3	13.8
Chernivetska	237.4	161.2	216.6	194.6	132.1	177.5	14.1	9.6	12.9	4.5	9.9
Chernihivska	192.5	129.9	175.7	179.9	121.4	164.2	11.4	7.7	10.4	3.7	8.1

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 5: Economic losses as a result of food loss and waste in Ukraine in 2016 by vegetable.

Region	Gross production, ths. tons			Yield, centners of 1 ha			Gross products, mln. EUR			Economic losses, mln. EUR	Lost revenue, mln. EUR
	In fact	taking into account the lost production		In fact	taking into account the lost production		In fact	taking into account the lost production			
		In total	at the production stage		In total	at the production stage		In total	at the production stage		
Ukraine	2385.1	1400.3	2176.4	121.3	71.2	110.6	177.8	104.4	162.3	73.4	191.2
Vinnytska	273.2	184.5	249.3	123.1	83.1	112.3	20.4	13.8	18.6	6.6	17.2
Volynska	37.3	20.0	34.0	79.4	42.6	72.3	2.8	1.5	2.5	1.3	3.4
Dnipropetrovska	154.5	91.6	141.0	115.3	68.4	105.2	11.5	6.8	10.5	4.7	12.2
Donetska	90.5	47.7	82.6	139.2	73.4	127.1	6.7	3.6	6.2	3.2	8.3
Zhytomyrska	41.8	23.8	38.1	113.0	64.3	103.0	3.1	1.8	2.8	1.3	3.5
Zakarpatska	153.3	105.9	139.9	123.6	85.4	112.8	11.4	7.9	10.4	3.5	9.2
Zaporizka	67.2	35.9	61.3	85.1	45.4	77.6	5.0	2.7	4.6	2.3	6.1
Ivano-Frankivska	49.5	27.0	45.2	58.2	31.8	53.2	3.7	2.0	3.4	1.7	4.4
Kyivska	71.5	-24.2	65.2	82.2	-27.8	74.9	5.3	-1.8	4.9	7.1	18.6
Kirovohradska	30.7	15.2	28.0	62.7	31.0	57.1	2.3	1.1	2.1	1.2	3.0
Luhanska	27.4	6.6	25.0	57.1	13.8	52.1	2.0	0.5	1.9	1.5	4.0
Lvivska	109.0	65.8	99.5	86.5	52.2	79.0	8.1	4.9	7.4	3.2	8.4
Mykolaivska	87.5	50.7	79.8	182.3	105.6	166.3	6.5	3.8	6.0	2.7	7.1
Odeska	316.3	202.6	288.6	390.5	250.1	356.3	23.6	15.1	21.5	8.5	22.1
Poltavska	79.1	50.8	72.2	138.8	89.1	126.7	5.9	3.8	5.4	2.1	5.5
Rivnenska	77.9	55.1	71.1	118.0	83.5	107.7	5.8	4.1	5.3	1.7	4.4
Sumska	15.8	5.2	14.4	54.5	17.9	49.7	1.2	0.4	1.1	0.8	2.1
Ternopilska	73.7	47.9	67.3	124.9	81.2	114.1	5.5	3.6	5.0	1.9	5.0
Kharkivska	79.1	29.6	72.2	125.6	47.0	114.6	5.9	2.2	5.4	3.7	9.6
Khersonska	91.2	56.2	83.2	123.2	75.9	112.4	6.8	4.2	6.2	2.6	6.8
Khmelnytska	201.1	140.5	183.5	142.6	99.6	130.1	15.0	10.5	13.7	4.5	11.8
Cherkaska	51.3	26.3	46.8	95.0	48.7	86.7	3.8	2.0	3.5	1.9	4.9
Chernivetska	191.4	130.4	174.7	119.6	81.5	109.2	14.3	9.7	13.0	4.5	11.8
Chernihivska	14.8	5.2	13.5	46.3	16.3	42.2	1.1	0.4	1.0	0.7	1.9

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 6: Economic losses as a result of food loss and waste in Ukraine in 2016 on fruits.

Region	Gross production, ths. tons			Gross products, mln. EUR			Economic losses, mln. EUR	Lost revenue, mln. EUR
	In fact	taking into account the lost production		In fact	taking into account the lost production			
		In total	at the production stage		In total	at the production stage		
Ukraine	2323.6	1506.7	2249.3	979.8	635.4	948.4	344.4	607.7
Vinnytska	324.3	238.6	313.9	136.7	100.6	132.4	36.1	63.8
Volynska	122.4	90.9	118.5	51.6	38.3	50.0	13.3	23.4
Dnipropetrovska	239.7	152.0	232.0	101.1	64.1	97.8	37.0	65.2
Donetska	86.2	28.0	83.4	36.3	11.8	35.2	24.5	43.3
Zhytomyrska	53.3	36.9	51.6	22.5	15.6	21.8	6.9	12.2
Zakarpatska	51.3	35.8	49.7	21.6	15.1	21.0	6.5	11.5
Zaporizka	57.1	32.0	55.3	24.1	13.5	23.3	10.6	18.7
Ivano-Frankivska	80.0	57.0	77.4	33.7	24.0	32.6	9.7	17.1
Kyivska	198.7	106.8	192.3	83.8	45.0	81.1	38.8	68.4
Kirovohradska	52.1	35.9	50.4	22.0	15.1	21.3	6.8	12.1
Luhanska	21.2	2.9	20.5	8.9	1.2	8.6	7.7	13.6
Lvivska	123.0	77.3	119.1	51.9	32.6	50.2	19.3	34.0
Mykolaivska	31.0	18.3	30.0	13.1	7.7	12.6	5.4	9.4
Odeska	46.2	21.1	44.7	19.5	8.9	18.8	10.6	18.7
Poltavska	80.2	52.5	77.6	33.8	22.1	32.7	11.7	20.6
Rivnenska	55.0	37.5	53.2	23.2	15.8	22.4	7.4	13.0
Sumska	45.5	30.3	44.0	19.2	12.8	18.6	6.4	11.3
Ternopilska	52.6	34.2	50.9	22.2	14.4	21.5	7.8	13.7
Kharkivska	95.1	55.3	92.1	40.1	23.3	38.8	16.8	29.6
Khersonska	41.5	26.2	40.2	17.5	11.0	17.0	6.5	11.4
Khmelnytska	66.0	44.8	63.9	27.8	18.9	26.9	8.9	15.8
Cherkaska	323.6	243.4	313.2	136.5	102.6	132.1	33.8	59.7
Chernivetska	42.0	28.4	40.7	17.7	12.0	17.2	5.7	10.1
Chernihivska	35.6	20.7	34.5	15.0	8.7	14.5	6.3	11.1

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 7: Economic losses as a result of food loss and waste in Ukraine in 2016 for meat.

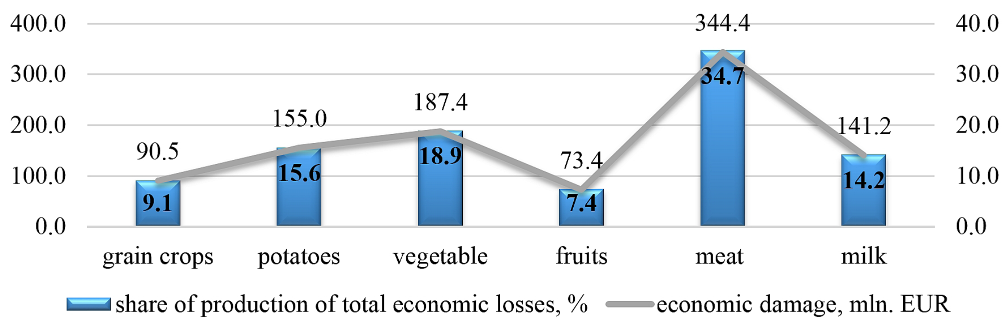
Economic damage and lost revenue in the result of food loss and waste on milk in Ukraine in 2016 amounted to 141.2 and 310.2 million EUR, respectively (Table 8). The largest amount of losses was established in Vinnytsya and Kyiv regions (respectively 9.9 and 10.9 million EUR), and the smallest in Zakarpattia, Luhansk and Chernivtsy regions (respectively 3.3, 3.2 and 3.0 million EUR).

Such indicators are totally unacceptable, given the fact that the level of profitability of agricultural production in Ukraine in 2016 amounted to 37.8 % for cereals, 19.7 % for vegetables, 18.2 % for milk, and potato and meat production was generally unprofitable.

On a global scale, the amount of economic losses and income foregone, in 2016, respectively, amounted to 991.9 and 2224.5 million EUR. Figure 3 and 4 show that meat (34.7%) is the main source of economic damage and lost revenue in the result of food loss and waste in Ukraine in 2016, on second place – vegetables, on the third – potatoes, on the fourth – milk, on the fifth – grain, on the last position – fruits.

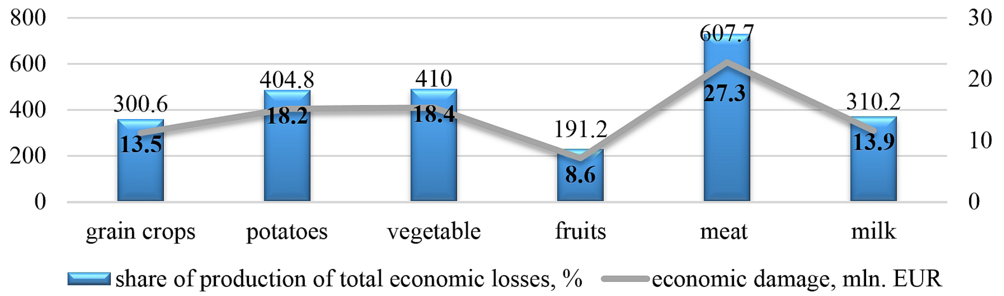
By regions and by economic damage in the result of food loss and waste, the leading position on meat remains in virtually all regions except for six: Donetsk and Sumy regions have the highest share of economic losses on potatoes (respectively 28.1 and 24.3%); Mykolayiv and Kherson regions – on vegetables (respectively, 35.8 and 57.9 %); Chernihiv region – by milk (25.2 %); Kirovohrad region – by grain (24.4 %) (Table 9).

Figure 5 data show that the contribution of regions to the total amount of economic damage in the result of food loss and waste in Ukraine in 2016 ranges from 2.1 % in the Luhansk region to 9.6 % in Kyiv region.



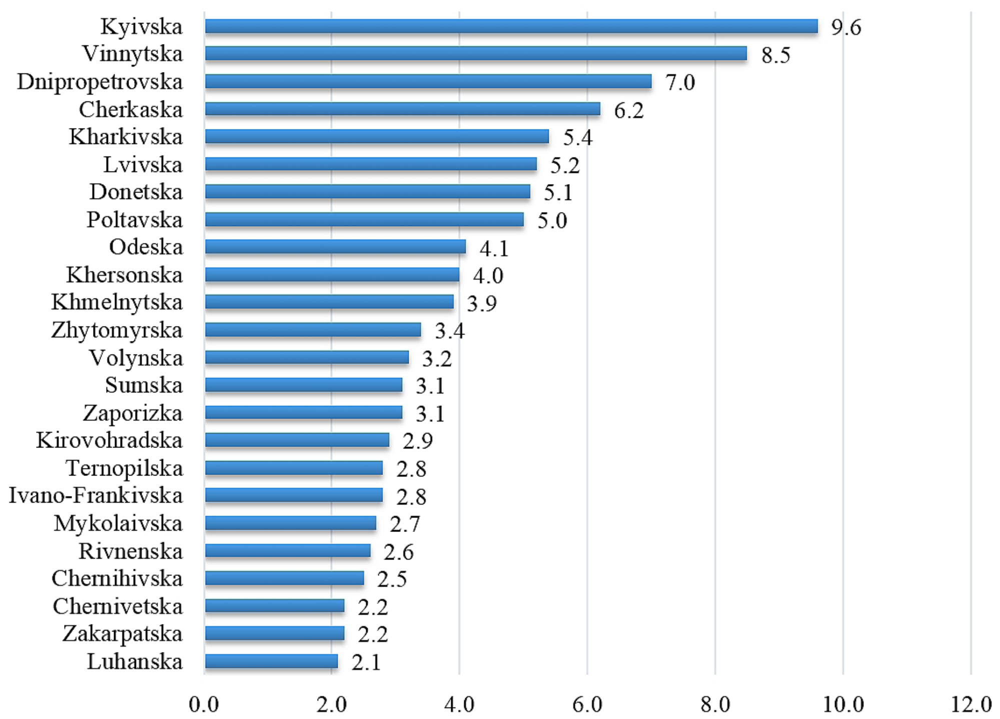
Source: own calculations based on State Statistics Service of Ukraine (2016).

Figure 3: Contribution of each type of product to economic losses as a result of food loss and waste in Ukraine in 2016.



Source: own calculations based on State Statistics Service of Ukraine (2016).

Figure 4: The contribution of each type of product to the lost revenue as a result of food loss and waste in Ukraine in 2016.



Source: own calculations based on State Statistics Service of Ukraine (2016).

Figure 5: Contribution of each region to economic losses as a result of food loss and waste in Ukraine in 2016, %.

Region	In total	Including:											
		grain crops		potatoes		vegetable		fruits		meat		milk	
		share of the region	share of production	share of the region	share of production	share of the region	share of production	share of the region	share of production	share of the region	share of production	share of the region	share of production
Ukraine	100.0	100.0	9.1	100.0	15.6	100.0	18.9	100.0	7.4	100.0	34.7	100.0	14.2
Vinnytska	8.5	11.4	12.2	8.1	14.9	4.7	10.4	9.0	7.8	10.5	42.9	7.0	11.8
Volynska	3.2	1.9	5.3	4.1	20.0	2.6	15.6	1.8	4.1	3.9	42.3	2.8	12.7
Dnipropetrovska	7.0	1.4	1.8	3.9	8.8	7.1	19.1	6.4	6.7	10.7	53.2	5.1	10.4
Donetska	5.1	1.8	3.1	3.3	10.1	5.2	19.2	4.3	6.3	7.1	48.2	4.7	13.1
Zhytomyrska	3.4	5.0	13.4	6.1	28.1	2.9	16.0	1.8	4.0	2.0	20.4	4.3	18.1
Zakarpatska	2.2	0.6	2.4	2.3	15.7	2.6	21.8	4.8	15.9	1.9	29.4	2.3	14.8
Zaporizka	3.1	2.7	8.1	1.8	9.0	4.3	26.5	3.2	7.7	3.1	34.7	3.0	14.0
Ivano-Frankivska	2.8	1.3	4.4	4.2	23.2	2.0	13.7	2.3	6.0	2.8	34.8	3.5	17.8
Kyivska	9.6	7.2	6.8	10.9	17.6	8.2	16.1	9.7	7.5	11.3	40.5	7.7	11.4
Kirovohradska	2.9	7.7	24.4	3.4	18.5	2.4	15.7	1.6	4.1	2.0	24.1	2.7	13.3
Luhanska	2.1	1.2	5.1	2.1	15.6	2.3	20.5	2.1	7.3	2.2	36.2	2.3	15.2
Lvivska	5.2	2.7	4.7	6.4	19.2	5.4	19.3	4.4	6.2	5.6	37.0	5.0	13.6
Mykolaivska	2.7	2.2	7.5	1.7	9.8	5.2	35.8	3.7	10.1	1.6	19.8	3.2	17.0
Odeska	4.1	3.9	8.6	3.0	11.2	4.5	20.5	11.5	20.7	3.1	25.8	3.8	13.2
Poltavska	5.0	12.8	23.3	3.7	11.7	4.8	18.1	2.9	4.3	3.4	23.5	6.7	19.2
Rivnenska	2.6	1.3	4.7	4.6	27.4	2.3	16.5	2.3	6.5	2.1	28.3	3.1	16.6
Sumska	3.1	8.3	24.1	4.9	24.3	2.0	12.0	1.1	2.5	1.9	20.5	3.7	16.5
Ternopilska	2.8	3.2	10.4	3.8	21.0	2.5	16.5	2.6	6.9	2.3	27.7	3.5	17.6
Kharkivska	5.4	3.6	6.1	5.2	15.1	6.7	23.3	5.0	6.9	4.9	31.2	6.7	17.5
Khersonska	4.0	1.6	3.6	1.6	6.3	12.4	57.9	3.6	6.5	1.9	16.1	2.7	9.6
Khmelnytska	3.9	7.1	16.8	5.1	20.5	2.2	10.9	6.2	11.8	2.6	23.3	4.5	16.6
Cherkaska	6.2	7.6	11.2	3.8	9.6	3.4	10.2	2.5	3.0	9.8	54.8	4.9	11.1
Chernivetska	2.2	0.1	0.6	2.7	18.7	2.4	20.5	6.2	20.6	1.7	25.9	2.2	13.7
Chernihivska	2.5	3.3	11.8	3.2	20.1	2.0	14.9	1.0	2.9	1.8	25.1	4.5	25.2

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 9: Contribution of each region and product type to economic losses as a result of food loss and waste in Ukraine in 2016, %.

However, in terms of product types, there are significantly higher fluctuations, except for milk, for which the ratio between the highest and lowest values is 1:3.5. Thus, in the total amount of economic losses caused by food loss and waste in Ukraine in 2016, the largest contribution was made by the Poltava region (12.8 %), potatoes – Kyiv region (10.9 %), vegetables – Kherson (12.4 %), fruits – Odesa (11.5 %), milk – Kyiv (7.7 %), for meat almost equal shares in Vinnytsya (10.5 %), Dnipro (10.7 %) and Kyiv (11.3 %) region.

Economic damage resulting from food loss and waste per 100 hectares of agricultural land in Ukraine in 2016 amounted to about 2.8 thousand EUR, of which almost 589.4 EUR at the production stage (Table 10).

Among the 24 regins of Ukraine, half has higher losses per 100 hectares of agricultural land compared to averaged data on Ukraine, in particular: in Vinnytsya, Volyn, Dnipro, Donetsk, Zakarpattia, Ivano-Frankivsk, Kyiv, Lviv, Rivne, Ternopil, Cherkasy and Chernivtsi regions. At the same time, at the production stage, 14 regions have higher losses per 100 hectares of agricultural land compared to averaged data on Ukraine, in particular: in Vinnytsya, Volyn, Zhytomyr, Zakarpattia, Ivano-Frankivsk, Kyiv, Lviv, Poltava, Rivne, Ternopil, Kherson, Khmelnytsky, Cherkasy and Chernivtsi regions. More than 5 thousand EUR of economic damage were recorded in Zakarpattia, Ivano-Frankivsk, Kyiv, Lviv and Chernivtsi regions; less than 2 thousand EUR – in Zaporizhia, Kirovohrad, Mykolayiv, Luhanska, Odeska and Chernihiv regions.

Economic damage due to food loss and waste per 100 people in Ukraine in 2016 amounted to about 2.5 thousand EUR, of which almost 520 EUR at the production stage (Table 11).

Almost half of the 24 regions have higher rates of loss per 100 population compared to averaged data on Ukraine, in particular: Vinnytsya, Volyn, Zhytomyr, Kyiv, Kirovohrad, Poltava, Sumy, Ternopil, Kherson, Khmelnytsky and Cherkasy regions. At the same time, at the production stage, 15 regions have higher losses per hectare of 100 hectares of agricultural land compared to averaged data on Ukraine, in particular: Vinnytsya, Volyn, Zhytomyr, Kyiv, Kirovohrad, Mykolayiv, Poltava, Rivne, Sumy, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernivtsi and Chernihiv regions.

Region	Cost of gross output per 100 hectares of farmland:					
	In fact		Food loss and waste			
	thousand EUR	in percentages relative to data on Ukraine	thousand EUR	in percentages relative to data on Ukraine	at the production stage	
					EUR	in percentages relative to data on Ukraine
Ukraine	14.6	100.0	2.8	100.0	589.4	100.0
Vinnytska	26.0	177.9	4.6	161.7	973.5	165.0
Volynska	19.9	136.3	3.8	132.9	970.2	164.9
Dnipropetrovska	12.7	87.1	3.2	111.4	523.2	88.6
Donetska	7.3	50.2	2.9	100.9	284.8	48.1
Zhytomyrska	15.1	103.8	2.6	92.6	662.3	112.1
Zakarpatska	25.4	173.8	5.7	202.3	1450.3	245.8
Zaporizka	7.2	49.0	1.4	50.5	258.3	43.8
Ivano-Frankivska	27.4	187.5	5.6	198.9	1351.0	229.2
Kyivska	21.2	145.2	6.3	222.5	890.7	151.3
Kirovohradska	10.4	71.3	1.6	55.9	314.6	53.6
Luhanska	4.4	30.3	1.2	44.0	162.3	27.6
Lvivska	22.0	150.6	5.2	181.6	1145.7	194.3
Mykolaivska	8.6	58.7	1.5	53.6	337.7	57.3
Odeska	10.3	70.3	1.9	65.5	367.5	62.6
Poltavska	18.3	125.3	2.7	95.2	602.6	102.5
Rivnenska	19.1	130.8	3.3	116.4	970.2	164.7
Sumska	15.5	106.1	2.2	76.0	486.8	82.4
Ternopilska	18.5	126.6	2.9	102.2	748.3	127.0
Kharkivska	12.5	85.7	2.5	86.8	509.9	86.8
Khersonska	10.9	74.8	2.2	79.1	615.9	104.7
Khmelnytska	16.2	111.1	2.6	90.9	649.0	110.4
Cherkaska	27.0	185.1	4.7	165.2	874.2	148.3
Chernivetska	21.7	148.4	5.0	176.0	1278.1	217.1
Chernihivska	13.4	91.7	1.4	50.3	433.8	73.4

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 10: Economic losses as a result of food loss and waste per 100 hectares of agricultural land in Ukraine in 2016.

Region	Cost of gross output per 100 hectares of farmland:					
	In fact		Food loss and waste			
	thousand EUR	in percentages relative to data on Ukraine	thousand EUR	in percentages relative to data on Ukraine	at the production stage	
					EUR	in percentages relative to data on Ukraine
Ukraine	12.9	100.0	2.5	100.0	519.9	100.0
Vinnytska	30.0	233.3	5.3	212.0	1125.8	216.3
Volynska	15.9	123.7	3.0	120.7	778.1	149.6
Dnipropetrovska	8.7	67.3	2.2	86.0	354.3	68.4
Donetska	3.1	23.9	1.2	47.9	119.2	22.8
Zhytomyrska	15.8	122.5	2.7	109.3	688.7	132.2
Zakarpatska	7.8	60.7	1.8	70.7	447.0	85.8
Zaporizka	8.7	68.0	1.8	70.0	314.6	60.7
Ivano-Frankivska	9.8	76.1	2.0	80.7	483.4	92.9
Kyivska	18.5	143.8	5.5	220.3	778.1	149.7
Kirovohradska	19.3	150.1	2.9	117.5	586.1	112.7
Luhanska	4.4	30.3	1.2	44.0	162.3	27.6

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 11: Economic losses as a result of food loss and waste per 100 population in Ukraine in 2016 (to be continued).

Region	Cost of gross output per 100 hectares of farmland:					
	In fact		Food loss and waste			
	thousand EUR	in percentages relative to data on Ukraine	thousand EUR	in percentages relative to data on Ukraine	at the production stage	
					EUR	in percentages relative to data on Ukraine
Lvivska	8.8	68.1	2.1	82.1	457.0	87.8
Mykolaivska	13.2	102.9	2.4	94.0	523.2	100.4
Odeska	9.5	73.8	1.7	68.7	341.1	65.7
Poltavska	23.5	183.0	3.5	139.0	778.1	149.6
Rivnenska	13.0	100.7	2.2	89.6	658.9	126.8
Sumska	20.3	157.8	2.8	113.1	635.8	122.5
Ternopilska	16.9	131.2	2.6	105.9	682.1	131.5
Kharkivska	10.1	78.7	2.0	79.7	413.9	79.7
Khersonska	18.4	143.3	3.8	151.6	1043.0	200.4
Khmelnytska	18.7	145.6	3.0	119.1	751.7	144.5
Cherkaska	28.9	224.7	5.0	200.4	933.8	179.8
Chernivetska	10.6	82.1	2.4	97.3	622.5	120.0
Chernihivska	22.7	176.3	2.4	96.7	731.8	141.0

Source: own calculations based on State Statistics Service of Ukraine (2016).

Table 11: Economic losses as a result of food loss and waste per 100 population in Ukraine in 2016 (continuation).

More than 5 thousand EUR of economic losses were recorded in Vinnytsya, Kyiv and Cherkasy regions; less than 2 thousand EUR – in Donetsk, Zakarpanska, Zaporizka, Luhansk and Odeska regions.

In relation to the volume of manufactured goods in the region, the largest are economic losses in the Donetsk region (39.1%), and the smallest – in Chernihiv region (10.7%).

The calculations confirm the thesis of the significant potential benefits of reducing food loss and waste, in particular as a strategy to meet the food deficit, which is projected to occur in 2050 with 9.3 billion people.

Discussions

Domestic scientists devote insufficient attention to this problem: Ukraine does not have full-scale studies of food and food waste losses at the regional or national level.

Undoubtedly, there are scholarly works dealing with certain aspects of the problem under study, but they are local and unsystematic. There is no study of the impact of food and food waste on the level of degradation of land resources in Ukraine at all.

The vast majority of scientific works, in which the issue of food and food waste is studied in one way or another, belongs to a foreign scientific school. However, in the global food loss and waste calculations conducted by FAO, Ukraine does not appear to be a separate country but classified as "Europe". It is obvious that the averaged indicators of this group are not close to the realities of Ukraine, and therefore – proposals for reducing food loss and waste, developed on the basis of such analytical data, can not be fully representative for our country, which required the corresponding calculations according to actual data (Babych, 2018).

The results obtained are of the utmost importance in shaping the food security policy on the basis of sustainable development of the agro-food sector in Ukraine. Firstly, it has been empirically proven, that food loss and waste results in significant economic damage and lost revenue. Secondly, the reduction of food loss and waste has positive environmental and social consequences: the expansion of physical access to food; reducing poverty and gender inequality, especially among the rural population; reduction of greenhouse gas emissions; reducing the load on water and land resources. This conclusion is especially important for agricultural producers, the vast majority of whom believe that additional profit can be obtained using extensive (through the expansion of cultivated areas) or intensive (through increased use of mineral fertilizers and plant protection products) farming methods.

The results of calculating economic losses at the stage of production are unexpected: they account for only 20.7% of the total amount in the food price chain and are significantly lower than those at the stage of sales. Such indicators arose due to the fact, that FAO attributed Ukraine to a group of European countries, where weight percentages of food loss and waste, especially cereals, milk and meat, are very low, compared to Ukraine. Such indicators correspond to the level of technology of the developed countries, but are not yet available to Ukraine: the degree of wear of fixed assets in agriculture, forestry and fisheries makes up 37.3 % in 2016 (State Statistics Service of Ukraine, 2016); 57.7 % of livestock production in 2016 was produced by households without special equipment for mechanized milking, special refrigerated milk storage cells and specialized slaughter equipment. On the other hand, Ukraine has developed and adopted relevant laws that require compliance with European norms in the production of milk and meat, including mechanized milking and special areas for slaughter of animals, which significantly reduces the rates of food and food waste at this stage and they will indeed correspond to the FAO.

Another controversial issue is the weight percentages of food and food waste identified by FAO at the consumption stage. On the one hand, Ukrainians really have a habit since the Soviet Union, when there was a total deficit, including food, to the accumulation of food "in stock", which eventually leads to its loss due to spoilage. On the other hand, the vast majority of Ukrainians cannot afford to buy surplus products due to economic constraints: low wages and pensions at European prices for most types of food, especially in the winter because of the lack of infrastructure for processing and storage of products.

In our opinion, it is these studies – the clarification of weight percentages of food loss and waste for Ukraine – should be carried out in the future.

Conclusion

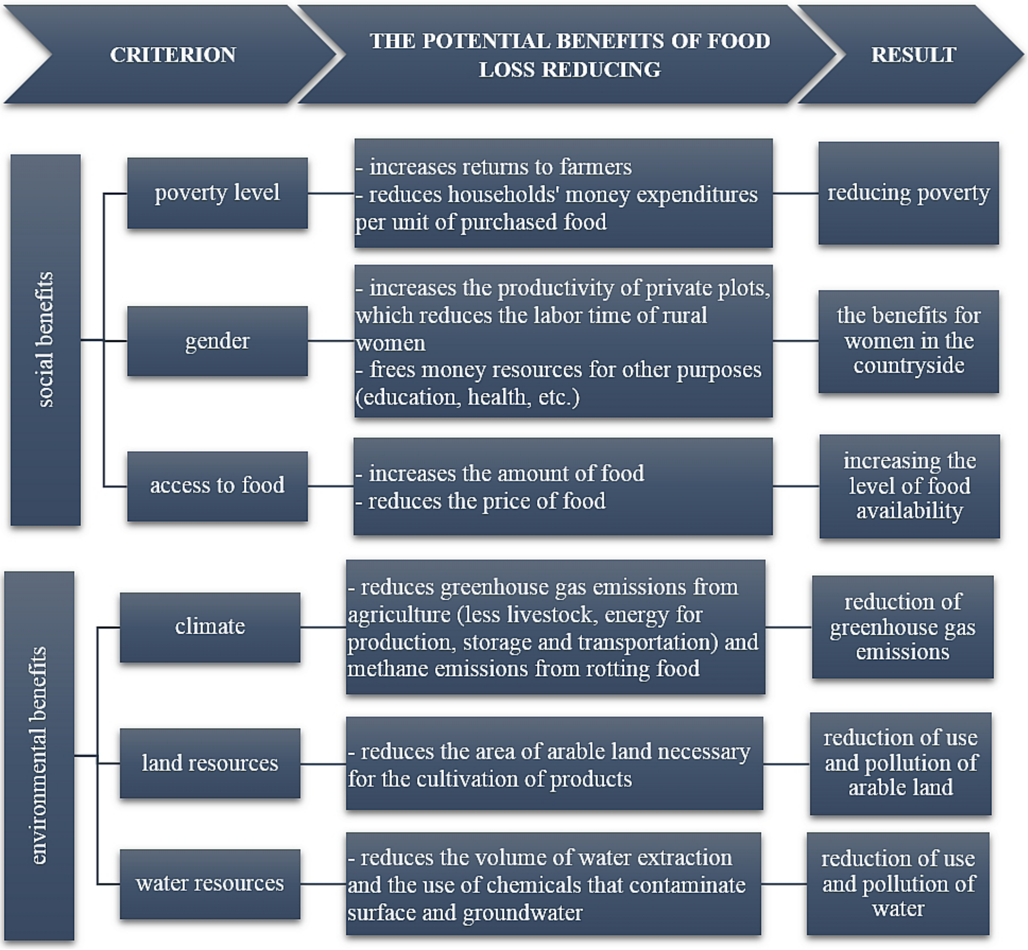
The article assesses the level of economic losses caused by food loss and waste in Ukraine. The analysis was conducted in terms of regions and product types. The author's methodological approach to assessing the impact of food loss and waste on the economic losses is based on the following principles: objectives; unity; systematic; scientific knowledge; maximum informativeness.

It has been established that the economic consequences of food loss and waste are expressed by significant economic losses, which equate to futile losses and inefficient investments, and lost revenue, which reduces the economic well-being of all subjects in the chain of food value. The sum of economic losses in Ukraine in 2016 amounted to about 991.9 million EUR, which is 2.8 % of the budget of Ukraine in 2017, and a 2224.5 million EUR unsatisfied income. The main source of economic damage and lost revenue as a result of food loss and waste in Ukraine is meat, followed by vegetables, potatoes, milk, cereals, fruits and fruits. In 2016, per 100 hectares of agricultural land, economic losses as a result of food loss and waste in Ukraine amounted to about 2.8 thousand EUR against 6.9 thousand EUR of actual profits per 100 hectares of agricultural land, which is 40.6 % of the actual profits received; and economic losses as a result of food loss and waste in Ukraine per 100 people of the population amounted to 2.5 thousand EUR, which is almost 2% of the average annual salary of employees of agricultural enterprises.

It is substantiated that ensuring the physical and economic availability of food, reducing food loss and waste can significantly reduce poverty, provide gender benefits, reduce ecosystem pressure and climate. Reducing food loss and waste can be one of those rare strategies that will have the highest effect at a minimal cost. It should be understood that the potential advantages of food waste and food by-products' reduction are not limited to additional gross output and profits. Zero loses of food waste and food by-products will provide for significant social and environmental benefits (Figure 6).

The direct effect of reduction of economic losses (resulting from food waste and food by-products) upon poverty level lowering is undeniable: in such conditions, the manufactures have their profits rising, and the consumers receive the decrease in price.

In Ukraine, unlike member states of the European Union, agricultural producers should also include households of citizens, who grow and produce food products not only for their own consumption. Currently, this category of households produces far more crops of all types (with the exception of industrial crops) compared to farms. The volume of grown potatoes, vegetables and fruits is respectively 98, 86 and 82 % of their total harvested volume. Respective indicators in livestock production are high as well: 74 % of milk, 87 % of wool and 98 % of honey from their total harvested amount in 2016 was produced by households. Taking into account the number of such households and their role in provision of the population with certain crop and livestock products, de facto they are full members



Source: own work

Figure 6: Potential benefits of reducing food loss and waste in Ukraine.

of the food market as manufacturers, but de jure they are recognized only as products' consumers. The main workers in this category are women. Thus, for women, the reduction of economic losses (resulting from food waste and food by-products) will contribute to investment into education, health and other spheres of life.

Reduction of economic losses, resulting from food waste and food by-products, will decrease the production cost. Together with an increase in products' amount and as a result of zero losses, we will receive an increase in the level of physical and economic affordability of food for the population.

In Ukraine it is far more difficult to achieve environmental benefits. The problem is that, unlike the EU countries, Ukraine is still tending to increase production rate when it comes to food security. Taking into account the fact that the level of ploughness in Ukraine is 85.6% (in 14 regions this index exceeds the average data for the country), the main source of volumes' increase is intensification, in particular the increase in introduction of chemical substances.

No global estimation of food waste and food by-products' losses as well as their environmental, social and economic consequences were carried out by domestic scientists so far. By objectively assessing the inadequate level of social responsibility of the overwhelming majority of domestic food manufacturers, the authors focus their attention on the economic consequences of food waste and food by-products' losses. At the moment, the most important task is to draw the attention of food manufacturers to the problem of food waste and food by-products. And the easiest way to achieve this is by using indicators understandable for them, namely income and profit. The next task is a reorientation from "increased production rate and increased losses" to "reduced losses and eco-efficient production".

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References

[1] Babych, M. and Kovalenko, A. (2018) “Food Security Indicators in Ukraine: Current State and Trends of Development”, *Baltic Journal of Economic Studies,* Vol. 4, No. 1, pp. 8-15. ISSN 2256-0963. DOI 10.30525/2256-0742/2018-4-1-8-15.

[2] Babych, M. (2018) “*Losses of food and food waste on the basis of creating their value*”, Poltava, CzFEND, p. 16. UDK 33 (In Ukraine).

[3] Chegere, M. J. (2018) “Post-harvest losses reduction by small-scale maize farmers: The role of handling practices”, *Food Policy*, Vol. 77, pp. 103-115. ISSN 0306-9192. DOI 10.1016/j.foodpol.2018.05.001.

[4] FAO (2011) “*Global food losses and food waste – Extent, causes and prevention*”. FAO. [Online]. Available: http://www.fao.org/docrep/014/mb060e/mb060e00.pdf [Accessed: 15 Apr. 2018].

[5] FAO (2013) “*Food Wastage Footprint: Impacts on Natural Resources*”, FAO. [Online]. Available: http://www.fao.org/docrep/018/i3347e/i3347e.pdf [Accessed: 15 Apr. 2018].

[6] Hanson, C. and Mitchell, P. (2017) “The Business Case for Reducing Food Loss and Waste”, Champions 12.3: AIHW. [Online]. Available: http://www.wrap.org.uk/sites/files/wrap/Report_The%20Business%20Case%20for%20Reducing%20Food%20Loss%20and%20Waste.pdf [Accessed: 15 Apr. 2018].

[7] Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L. and Searchinger, T. (2013) “*Reducing Food Loss and Waste. Working Paper, Installment 2 of Creating a Sustainable Food Future*”. Washington, DC: World Resources Institute. [Online]. Available: http://www.worldresourcesreport.org [Accessed: 15 Apr. 2018].

[8] Mylona, K., Maragkoudakis, P., Miko, L., Bock, A.-K., Wollgast, J., Caldeira, S. and Ulberth, F. (2017) “Viewpoint: Future of food safety and nutrition - Seeking win-wins, coping with trade-offs”, *Food Policy*, Vol. 74, pp. 143-146. ISSN 0306-9192. DOI 10.1016/j.foodpol.2017.12.002.

[9] Richards, T. J. and Hamilton, S. F. (2018) “Food waste in the sharing economy”, *Food Policy*, Vol. 75, pp. 109-123. ISSN 0306-9192. DOI 10.1016/j.foodpol.2018.01.008.

[10] SAVE FOOD (2015) "*Global Initiative on Food Loss and Waste Reduction Food and Agriculture Organization of the United Nations*", SAVE FOOD. [Online]. Available: http://www.fao.org/3/a-i4068e.pdf 25.02.2018 [Accessed: 15 Apr. 2018].

[11] Schuster, M. and Torero, M. (2016) “Toward a sustainable food system: Reducing food loss and waste", In "*2016 Global Food Policy Report*”. Washington, D.C.: International Food Policy Research Institute (IFPRI). [Online]. Available: http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/130211/filename/130422.pdf [Accessed: 15 Apr. 2018].

[12] Sheahan, M. and Barrett, C. (2017) “Review: Food loss and waste in Sub-Saharan Africa”, *Food Policy*, Vol. 70, pp. 1-12. ISSN 0306-9192. DOI 10.1016/j.foodpol.2017.03.012.

[13] Tesfaye, W. and Tirivayi, N. (2018) “The impacts of postharvest storage innovations on food security and welfare in Ethiopia”, *Food Policy*, Vol. 75, pp. 52-67. ISSN 0306-9192. DOI 10.1016/j.foodpol.2018.01.004.

[14] Zezza, A., Carletto, C., Fiedler, J., Gennari, P. and Jolliffe, D. (2017) "Food counts. Measuring food consumption and expenditures in household consumption and expenditure surveys (HCES). Introduction to the special issue", *Food Policy*, Vol. 72, pp. 1-6. ISSN 0306-9192. DOI 10.1016/j.foodpol.2017.08.007.

[15] State Statistics Service of Ukraine (2017) "*Balances and consumption of the main food products by the population of Ukraine*", State Statistics Service of Ukraine. [Online]. Available: http://www.ukrstat.gov.ua/ [Accessed: 15 Apr. 2018].

[16] State Statistics Service of Ukraine (2016) "*Agriculture, forestry and fishing. State Statistics Service of Ukraine*". [Online]. Available: http://www.ukrstat.gov.ua/ [Accessed: 15 Apr. 2018].

[17] State Statistics Service of Ukraine (2016) "*On Approval of 2010 Constant Prices for Agricultural Products to Calculate the Agricultural Productivity Index*". State Statistics Service of Ukraine. [Online]. Available: https://ukrstat.org/uk/norm_doc/2011/362/362.htm [Accessed: 15 Apr. 2018].

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Application of Exponential Smoothing Models and Arima Models in Time Series Analysis from Telco Area

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Abstract

The use of ICT has been steadily increasing in both business and social life. Apparently, the most essential communication technology today is a mobile phone. However, the use of mobile phones also has its downside, which is their impact on the environment, which is not negligible.

Despite the negative impact on the environment, few of us can imagine a life without a mobile phone. The mobile telecommunications market is one of the most important sectors of the modern economy. Analysing past developments - as well as predicting future developments - of indicators in this area plays a very important role in decision making, as in any other area of the national economy. The extrapolation methods have been the most often applied methods in the area of time series analysis and forecasting in practice. Currently, the combined methods in time series forecasting is more and more favoured. The main aim of this paper is an examination of applicability of the Box-Jenkins methodology models and the exponential smoothing models for providing extrapolation forecasts, but for past development modelling of selected indicators from the telecom area, too. Information on the indicators under study was collected on monthly and daily basis. Quality of the models selected was then assessed using the MAPE and AIC metric. In conclusion, a comparative analysis was performed of both the groups of models. The best individual models were further aggregated and quality of these was assessed using the same assessment criteria. SAS statistical system was applied for effective implementation of the analysis. The research has demonstrated that the exponential smoothing models can only be recommended for the analysis of indicators under study from the mobile telecom area. The detailed analysis has proved, anyway, a higher level of success with the combined models.

Keywords

ICT and environment, ICT and sustainable rural development, mobile telco services; time series; exponential smoothing models; Box-Jenkins methodology; combined models

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Introduction

The telecom market represents a sector developing very dynamically in not only the Czech Republic but also whole the world over. Several years have passed since the iPhone was first introduced to the world, which set a new direction for mobile technology. However, the technological revolution also has its negatives. Due to the large number of used materials for making smartphones, their environmental impact is definitely not negligible. Raw materials for smartphones are mined worldwide. However, the very manufacture of smartphones leaves the biggest carbon footprint - up to three quarters of the total emissions of the smartphones industry. In addition, the Greenpeace report (a non-governmental non-profit organization for environmental protection) suggests that the "smarter" phone you have, the more carbon footprint it leaves. Because of the average life cycle of two years, smartphones are essentially disposable.

The problem is that 85% to 95% of all carbon dioxide emissions in the first two years of using a smartphone is the production of a new mobile phone. In particular, the extraction of rare elements that every smartphone contains. In any case, by simply extending the use of the smartphone to 3 years, the carbon footprint will be greatly improved by avoiding the need to extract other rare elements. This is an important environmental knowledge.

In reality, however, servers and data centres are the largest source of carbon dioxide emissions, generating 45% of emissions within the sector by 2020. This is because every Google search or every Facebook download needs to process your computer. However, smartphones also play an important role here, as they are mobile applications that make us increasingly need non-stop running servers.

On the other hand, the use of smart phones plays an important role in economic growth and sustainable development. For sustainable development, technologies that provide open access to information are important.

The Czech Republic has for a long time been included among those European Union States with a high share of mobile networks traffic. It is just forecasting of the mobile networks traffic volumes, in the interconnection services (national and international services) in particular, what this study is dealing with. Mobile phone services and mobile phones, in particular in Indonesia, were analysed by Rafiy and Adam (2016).

For decision-making activities in any area, the quantitative information knowledge is a necessity. The quantitative information - its acquisition, transformation, transmission and use - is crucial also in the sustainable development process at all levels of decision-making in a wide variety of areas and forms. This decision-making process takes place at different geographical scales: municipalities, regional, national and international. However, decision-making at the level of smaller units is also important. The development of rural space plays a very important role in the European Union (and not only in the EU). Rural development policy affects the various sectors of the European economy. The growth of education and information in society is based on the economic and social growth of European world society. The development and use of ICT plays a very important role here. One of the objectives of sustainable rural development is to reverse rural migration. Employment stimulation, equal opportunities and, last but not least, the response to the growing demands for quality of life, health, safety, personality development and leisure.

Currently it is practically impossible to set up important economic decisions in the developed countries missing the knowledge of the basic indicators past development. Great emphasis is laid on a thorough analysis of these indicators development. The phenomenon given not only can be analysed based on the past recorded values development but its future ways can be predicted from these, too. And this is why the current path of the time series has to be modelled somehow. There are a number of areas where it is needed to apply the modern time series analysis methods. The time series theory belongs, in the area of economic indicators in particular, among the most important quantitative methods.

Out of the methods employed in the univariate time series extrapolation forecasts making of various indicators most often, are the exponential smoothing models (Corberán-Vallet et al., 2011; Billah et al., 2006; Gardner, 2006; Nimesh et al., 2014), thanks to the robustness (Cipra, 1992; Gelper et al., 2010) and simplicity of these in particular. Time series modelling and forecasting using the exponential smoothing techniques was the objective of Murat et al. (2016), too, who employed the techniques on time series data from the area of meteorology. Papic-Blagojevic et al. (2016) applied the exponential smoothing models on time series from the tourism area in Serbia, where the RMSE and BIC assessment criteria were exploited in the comparison of separate exponential smoothing models. Sbrana and Silvestrini (2014) dealt with the exponential smoothing methods problems and application of these in their study, from the area of wholesalers' inventories time series analysis in the USA. Like every method has ES also some disadvantages. Among them, there is the fact, too, that it cannot handle trends well. However, has also the advantages, such as, e.g., it produces accurate forecasts. Despite the noted shortages, the ES methods are very popular and they have been applied with success in many areas, the telecom area included. Gardner and Diaz-Saiz (2008) continued following their original work from 2006 by a new study aimed just at an analysis of indicators from the mobile telecommunications area. In particular, they dealt with the impact of cutting off a number of irrelevant older observations from the time series under study, upon the exponential smoothing models constructed quality. The Holt and damped trend methods were the objective of the study in particular. Lim et al. (2012) studied the possibility of 3G mobile subscription prediction in separate Chinese provinces, with regard to regional differences.

There are several ways of solution of univariate time series forecasting. Besides the classical trend models and adaptive models the Box-Jenkins methodology can be applied (Hindls et al., 2000). The BJ methodology is one of the modern approaches to time series analysis. It was presented in 1970 by the authors G. E. P. Box and G. M. Jenkins in their work „Time Series Analysis, Forecasting and Control". They formed the theory and methodology for time series forecasting using the so-called ARIMA models – autoregressive integrated moving average models. The main merit of theirs is setting up the principles practically applicable, e.g., in situations where the „classical" time series decomposition analysis fails.

Time series modelling and forecasting using the BJ methodology is widely exploited currently in various areas. Many authors have aimed in their studies at examining the ARIMA models in time series modelling and forecasting of various indicators. The ARIMA models have been applied with success in the telecom area, too. Bastianin et al. (2016) aimed in their study at the time series models selection strategy, incl. of the ARIMA models, and assessment of their appropriateness in time series forecasting of incoming calls on the telecom companies call centres. The forecast precision of this indicator can then in the companies facilitate reaching an optimal ratio between the operation costs incurred and the quality of services provided. Mastorocostas et al. (2012) prepared a study dealing with time series prediction of outgoing calls indicator within the University campus, using neural networks combined with fuzzy systems. Then they made a comparison with the well-known exponential smoothing models and the ARIMA models. A study with a very similar aiming was pre- pared by Hilas et al. (2006) who used the methods of seasonal decomposition, exponential smoothing and seasonal ARIMA models in forecasting national and international calls within the University campus. Actual data then were compared with 95 % confidence intervals constructed. Guo et al. (2009) dealt in their work with mobile networks traffic forecasting, using data supplied by China Mobile Communications Corporation (CMCC) Heilongjiang Co. Ltd., using the BJ methodology, seasonal ARIMA models in particular. Christodoulos et al. (2010) aimed in their research at improvement of the forecasts by a combination of two forecasting methods, see, the BJ methodology and the diffusion models. They applied the methods on time series concerning world broadband and mobile telecommunications´ penetration. Mastorocostas et al. (2014) in their work dealt with application, analysis and forecasting of time series from telecom area, where the fuzzy modelling method was applied in the studied indicators forecasting. They presumed in that work that, the model construction process is a two-phase one, where the first stage is Subtractive Clustering (SC) and then Orthogonal Least Squares (OLS) techniques follow. Findley (2005) has dealt with modelling and forecasting using the ARIMA models in general. Both methods (ES and ARIMA models) have also been used in the study by Hloušková et. al. (2018) or by Svatošová and Köppelová (2017).

In time series analysis and time series forecasting processing proper, a certain sequence of stages has been recommended and considering these, our research has prevalently been aimed at the stage of design of appropriate candidates for the modelling and extrapolation forecasts making purposes and the assessment of these, based on the assessment criteria selected.

The main aim of this work has been to perform a comparative analysis of the exponential smoothing models with the models provided by BJ methodology, and an applicability assessment of the time series models selected for past development modelling of selected indicators and for the traffic forecasting purposes in mobile networks. Subsequently we experimented with combined forecasts constructed based on a combination of both the methods analysed. Those models were combined which had been selected as the best ones in both the model groups based on the assessment criteria chosen. Data for application have been collected on monthly and daily basis and provided by the Vodafone Czech Republic, Ltd. company. In particular, these are data on traffic in the interconnect and roaming areas (national and international voice services, MMS, SMS, etc.)

Traffic forecasting in the area of mobile telecom services provision is very important for the telecom company. In this area (and not only here) no one has dealt so far with combined fore- casts construction supplying aggregated information obtained from the individual models, entering the aggregation. Wei and Yang (2012) have dealt with the forecasting methods combinations, too. Empirical studies by some authors signal promising results in the forecasts using combined methods, hence certainly it is significant to examine these chances. Contemporary methodology of time series analysis and forecasting has been developed very intensively over several recent decades and completed by new, often very sophisticated procedures, and with modifications of existing techniques. Practical applicability of these procedures has to be repeatedly and systematically verified and examined on real time series, since the time series models do not have a universal or permanent nature and have to be constructed in accordance with the properties of the indicators studied.

Materials and methods

Specification of analysed indicators and used statistical software

All in all, 72 short-term time series from the mobile telecom services have been exploited, out of which 44 daily frequency series (series of interconnection traffic – national voices services, international voice services, SMS and MMS services national and international, some special national voice services e.g. ATX services, coloured lines, emergency calls) and 28 series with monthly frequency of data collection (series of roaming traffic – voice, SMS, MMS and data services). Time series forecasting for telecom area based on daily data collection has been dealt with, e.g., by Mabert (1985), who analysed time series of numbers of calls on emergency lines.

Within this study, time series have been analysed with differing length of reference period, ranging from 89 to 273 data. Data proper on the indicators under study, i.e., the traffic volume in mobile networks, have been provided by Vodafone Czech Republic, Ltd. company.

Processing proper of the time series analysis of the indicators under study has been performed using the Time Series Forecasting System (TSFS) being a component of the SAS programme system. A part of the TSFS is the regime of automatic model selection capable of considerable acceleration of the optimal model search process for the time series analysis. The search process relies on diagnostic tests done, aimed at establishing the presence of trend, seasonality or need of logarithmic data transformation.

Time series modelling

Each of the time series studied was first automatically identified and diagnosed by means of the SAS system selection criteria. Then the 5 best models from the wide range of exponential smoothing models (adaptive models) and ARIMA models were constructed for each time series.

Based on models selected, a comparative analysis has been performed of both the model groups (the exponential smoothing models and the BJ methodology based models), considering differing frequencies and the two differing stages of time series analysis - interpolation and extrapolation.

In time series forecasting then the adaptive models have been applied with success, assuming that, for a future development extrapolation forecast construction the latest time series observations are those most valuable. Therefore, those will be assigned the highest weights and the older data either can be quite excluded from study or, they will be assigned lower weights as compared with the values obtained later. Hence, the adaptive models take aging of information into account. The weight system is formed by means of the so-called levelling constants assuming values from $< 0; 1 >$ interval. In order to find the optimal levelling constant value, the „method of trial and error“ has been applied in practice. As the optimal value such value can be chosen, which minimizes the error of estimate properly selected. The SAS statistical system, considered to be applied in this paper for efficient materialization of all the analyses needed, offers an automatic estimate of the levelling constant value.

The ARIMA models are very flexible and they can adapt quite quickly to changes over the time series. Therefore, the BJ methodology can, in particular, offer a starting point for modelling of a seasonal time series with a complex stochastic structure. In the real world there are many time series where the classical analysis models fail. The BJ methodology models just can be applied many times with success in such cases (Cipra, 1986).

Combined models

The SAS programme system is taken as one of the most perfect and most comprehensive statistical programme packets which satisfies conditions of this study, i.e., to have a really wide circle of various models available. The TSFS component facilitates construction of combined models both in the form of simple arithmetic average or weighted arithmetic average with differing weights. In our case, weighted arithmetic average has been chosen with the so-called regression weights offered, that can penalize somehow the forecasts loaded with higher forecast errors. At the same time, it is possible to aggregate the forecasts based on arithmetic averages of the original time series values of the indicators studied, or using arithmetic average of logarithms of those original values.

Assessment of models

Within many researches, the autocorrelation charts (ACF) and the partial autocorrelation functions (PACF) have been employed in order to identify best models (Mirzavand and Ghazavi, 2015). Applicability of most the time series analytical models namely depends on satisfaction of the assumption that, many of the residuals is of the so-called White noise nature, which is an uncorrelated random quantity with zero mean and constant variance (Seger and Hindls, 1993). Dissatisfaction of the assumption presents a signal for certain data modification, e.g., an adequate transformation. The ACF and PACF charts offer one of the ways for quality assessment of the time series models but it is not the only one. Just vice versa. The graphical analysis mentioned always should be completed by other tools.

In this paper of ours, the quality of models constructed has been assessed using the MAPE metric (Mean Absolute Percent Error) defined as:

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

where y_t or y'_t (t = 1, 2, . ., n) are the actual or the smoothed values of the given time series and n is the number of time series observations. Popularity of the MAPE metric use is based on its percentage expression. It is a dimensionless measure which facilitates mutual comparison of models constructed for different indicators.

Another convenient tool used in this work in order to acknowledge appropriateness of the models selected is the AIC (Akaike´s Information Criterion) defined as:

$$AIC(k) = n \ln(MSE) + 2 \qquad (2)$$

where n is the number of observations, k is the number of parameters (Bozdogan, 2000; Mirzavand and Ghazavi, 2015) and MSE is the Mean Square Error:

$$M.S.E. = \frac{1}{n}\sum_{t=1}^{1}(y_t - \hat{y}_t)^2 \qquad (3)$$

where y_t or y'_t (t = 1, 2, . ., n) are the actual or the smoothed values of the given time series and n is the number of time series observations.

The MAPE metric has been widely applied in quality assessment of the time series models constructed. For time series modelling and forecasting from the telecom area it has been used for model quality assessment by Mastorocostas and Hilas (2012), or Gardner (2006). Paul et al., (2015) used MAPE for the forecasts assessment of commodity prices in Mumbai market. The best forecasting model for the indicators studied was chosen based on the minimal AIC value.

The information criteria, among which the AIC belongs, inter alia, too, are also applicable in time series models assessment. They are applicable both for the exponential smoothing models and for the ARIMA models as well, where they find a wider use (Gardner, 2006). The Akaike information criterion was used by Ghosh et al. (2010) in the assessment of Functional-coefficient autoregressive (FCAR) model. They applied the FCAR model in modelling and forecasting of annual export lac data in India. AIC was, among others, object of a study done by Billah et al. (2006). They aimed at selection of exponential smoothing methods for time series forecasting from the area of the M3 forecasting competition. They studied 3 different approaches to the forecasting methods given selection. One of those is the approach, too, based on information criteria, such as the AIC. Bolin et al. (2015) have predicted the global sea level in their work employing the ARIMA model where the best model choice was done based on the AIC.

Results and discussion

Comparative analysis of exponential smoothing models and ARIMA models

The Table 1 shows clearly the percentages of success of both the two model groups. Considering the time series periodicity the table tells us - according to the chosen criteria - at what percentage share a model from the exponential smoothing models group ranked first and at what percentages the BJ methodology models ranked first. In this part of the paper both models for the purpose of past development modelling of the indicators under study have been constructed and assessed (interpolation) as well as models for forecasting of these (extrapolation).

It can be seen from the results obtained that, for the indicators selected concerning the numbers of minutes spent in the area of mobile telecommunications, the exponential smoothing models have been applied more often. It means, at both the stages of time series analysis, interpolation and extrapolation. Not even periodicity of the time series under study affects the comparison results of the two model groups. Based on the MAPE and AIC criteria values assessment the exponential smoothing models

INTERPOLATION			
Type of model	Daily time series	Monthly time series	TOTAL proportion
ARIMA models	38.64 %	10.71 %	27.78 %
Exponential smoothing models	61.36 %	89.29 %	72.22 %
TOTAL	100.00 %	100.00 %	100.00 %
EXTRAPOLATION			
Type of model	Daily time series	Monthly time series	TOTAL proportion
ARIMA models	50.00 %	17.86 %	37.50 %
Exponential smoothing models	50.00 %	82.14 %	62.50 %
TOTAL	100.00 %	100.00 %	100.00 %

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

Table 1: Percentage representation of models placed on the 1st place.

have presented themselves as more appropriate for the past development description at roughly 72 % and for the given indicators forecasting at about 63 %. An outstanding difference in applicability between the two model groups has been recorded in monthly time series. At the interpolation stage in particular, where the exponential smoothing models have been found more appropriate of 89.29 %. An interesting outcome has been reached when comparing the groups as to the extrapolation properties assessment where the two model groups have been represented at the same share.

Assessment of the two model groups

In the Table 2 the model groups under study have been assessed using a selected MAPE metric. Table 2 shows the absolute model number in the ARIMA model group and the exponential smoothing model group with the MAPE indicator value reached, the values of which have been expressed in interval, for greater clarity. The results have been subdivided moreover according to the fact whether the model was applied in the indicator studied past development modelling or in its extrapolation.

It is seen from the results obtained that, within both the model groups in most cases MAPE values lower than 15 % have been reached, what is expressing quality of the models for use in the time series studied analysis. The MAPE metric values moved most often within 5 - 10 % interval or, they reached values lower than 5 %. There is no borderline generally accepted for the MAPE measure. In practice it is possible to meet varying situations and the MAPE value (its height) moves just depending on the actual situation. It is possible to meet a situation where a 5 % value is required, in another case 15 % again, nevertheless a model with MAPE value about 10 % can be taken as the suitable one. The outcomes obtained show that, in the ARIMA models group the MAPE values of the models constructed fluctuated within the desirable interval up to 10 % at 78.7 %, in the exponential smoothing models group the share was 69.1 %.

The AIC criterion served an additional measure in order to confirm suitability of the models constructed, the values of this corresponded to the MAPE values in almost 97 % cases. This means, the model chosen based on the lowest MAPE value could have been constructed for the time series given, in 97 % cases according to the AIC criterion, too. Here it holds again that, a model of higher quality can reach a lower value of this assessment criterion, too.

The Table 3 is presenting an overview of the best models in the separate model groups, those having been applied in the time series analysis under study most often, again considering the two time series analysis stages – interpolation and extrapolation. Besides the model names proper, Table 3 is providing information on how many times the given model has been chosen into the group of the five best ones – position of the separate models chosen in absolute view but in the relative (percentage) share, too.

The Table 3 presents the models most often employed within a more extensive research, where always five models were selected for each time series and time series analysis stage, for the following experiment with combined models construction. These were further exploited in the construction of the aggregated forecasting models, dealt with in the following chapter.

As it concerns the models situated always on the first place, then at the interpolation stage mostly the ARIMA (0,1,1)s NOINT and the Log ARIMA (0,1,1)s NOINT from the BJ methodology model group placed themselves (of the indicators

TYPE OF MODEL	INTERPOLATION	EXTRAPOLATION	TOTAL (both analysis)
	Count of models		
ARIMA Total	20	27	47
smaller than 5	2	20	22
between 5 and 10	10	5	15
between 10 and 15	3	2	5
higher than 15	5		5
Exponential smoothing Total	52	45	97
smaller than 5	11	23	34
between 5 and 10	20	13	33
between 10 and 15	11	4	15
higher than 15	10	5	15
Grand Total	72	72	144

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

Table 2: Assessment of the models and specific MAPE values.

INTERPOLATION	TOTAL absolute number	TOTAL Proportion in %
ARIMA models - total	135	37.50%
ARIMA (0,1,1)s NOINT	18	5.00%
Log ARIMA (0,1,1)s NOINT	14	3.89%
Log ARIMA(0,1,2)(0,1,1)s NOINT	13	3.61%
Log ARIMA(2,1,0)(0,1,1)s NOINT	12	3.33%
ARIMA (2,0,0)(1,0,0)s	9	2.50%
Log ARIMA(2,1,2)(0,1,1)s NOINT	9	2.50%
Exponential smoothing models - total	225	62.50%
Seasonal exponential smoothing	34	9.44%
Log Winters method additive	27	7.50%
Log Winters method multiplicative	23	6.39%
Log seasonal exponential smoothing	22	6.11%
Seasonal dummy	20	5.56%
EXTRAPOLATION	**TOTAL absolute number**	**TOTAL Proportion in %**
ARIMA models - total	139	38.61%
ARIMA (0,1,1)s NOINT	21	5.83%
Log ARIMA(2,1,0)(0,1,1)s NOINT	15	4.17%
Log ARIMA(0,1,2)(0,1,1)s NOINT	12	3.33%
ARIMA (2,0,0)(1,0,0)s	11	3.06%
Log ARIMA (0,1,1)s NOINT	9	2.50%
Exponential smoothing models - total	221	61.39%
Seasonal exponential smoothing	30	8.33%
Log seasonal exponential smoothing	20	5.56%
Seasonal dummy	19	5.28%
Log Winters method multiplicative	17	4.72%
Log Winters method additive	15	4.17%

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

Table 3: Overview of the best models.

collected on daily basis) and the Log ARIMA (2,1,0)(0,1,1)s model (indicators with monthly frequency). Out of the group of exponential smoothing models then these were the Log seasonal exponential smoothing and the Log Winters method additive models, on both the daily and monthly frequency time series.

The outcomes of this empirical research confirm the importance of extensive work aimed at detailed analysis of the exponential smoothing models. Gardner (2006) performed a detailed research in his work, where he started from an assumption that, the exponential smoothing methods are suitable and optimal for a very general class of models, which is wider than the ARIMA models class.

Construction and assessment of combined models for the indicators studied forecasting

For most of the individual models selected results have been obtained differing from both the MAPE and AIC criteria only slightly. Therefore, construction of aggregated models was included in the analysis and subjected to experimentation, too. Analysis was limited at the aggregated models construction aimed at the extrapolation of indicators studied. Combined models were constructed always of two best individual models. Combined forecasts have been obtained for the separate time series with MAPE values as given in Table 4.

The Table 4 shows the success rate of combined models based on the MAPE metric values. The MAPE measure values are grouped into 4 groups for better presentation, same as in the Chapter 3.2. However, the success rate here is expressed in percent.

For a better comparison of the combined models with the individual models see the following table.

The Table 5 is presenting the rate of success of individual models (placed on first places) in %, based on the MAPE metric values. It is obvious from the results presented that, the combined models indisputably have got properties appropriate for the time series under study extrapolation. The quality of these exceeds the individual models chosen as the best ones for each indicator on basis of their diagnostic testing results. The results in Tables 4 and 5 show that, combined models can be successfully applied in forecasts construction of the indicators studied. MAPE values lower than 5 % have been reached for these in 63.9 % cases, regardless of the indicators´ periodicity. Such low values were obtained for the individual models constructed, all in all, in 59.7 % cases.

Regarding periodicity of the indicators collected, the combined models assessed using the MAPE criterion have shown themselves more appropriate both on basis of the indicators collected monthly (the 5% limit has not been exceeded in almost 54 % cases), as well as the indicators collected on daily basis (the 5% limit has not been exceeded in 70.5 % cases).

Table 6 offers a clear information in how many % cases the combined model, eventually the individual model is more suitable for forecasting as assessed by the MAPE measure value.

Regardless of periodicity of the indicators studied, the combining technique of the individual forecasting models has shown itself a step in the right direction. Overall, the combined models have reached lower MAPE values in almost 70 % cases.

COMBINATION of 2 best models	**peridodicity**		**TOTAL proporition in %**
	daily	**daily**	
MAPE value - smaller than 5	70.45%	53.57%	63.89%
MAPE value - between 5 and 10	13.64%	32.14%	20.83%
MAPE value - between 10 and 15	9.09%	7.14%	8.33%
MAPE value - higher than 15	6.82%	7.14%	6.95%
TOTAL	**100.00%**	**100.00%**	**100.00%**

Source: Own processing

Table 4: MAPE values of the combined models.

INDIVIDUAL MODELS	**peridodicity**		**TOTAL proporition in %**
	daily	**monthly**	
MAPE value - smaller than 5	65.91%	50.00%	59.72%
MAPE value - between 5 and 10	18.18%	35.71%	25.00%
MAPE value - between 10 and 15	9.09%	7.14%	8.33%
MAPE value - higher than 15	6.82%	7.14%	6.94%
TOTAL	**100.00%**	**100.00%**	**100.00%**

Source: Own processing

Table 5: MAPE values of individual models placed on the first places.

Evaluation	peridodicity		TOTAL proporition in % (monthly and daily time series)
	model proportion in % - daily time series	model proportion in % - monthly time series	
combination is better	65.91 %	75.00 %	69.44 %
individual model is better	34.09 %	25.00 %	30.56 %
TOTAL	**100.00 %**	**100.00 %**	**100.00 %**

Source: Own processing

Table 4: MAPE values of the combined models.

A more detailed examination of the combined forecasts has to be materialized by experimenting. It is possible to experiment with a varying number of models entering the evaluation, length of the reference period or distance of the forecast horizon.

Conclusion

No single designer, company, or government can solve the carbon footprint of contemporary technology. However, significant environmental savings can be made, among other things, by both mobile operators (such as fuel savings on business trips or by reducing gas and electricity consumption) and by consumers, i.e. individuals. They can try to save the environment, or energy, while using a mobile phone. Just follow a few basic principles.

However, mobile phones and mobile telecommunications services can help unlock the potential of rural areas and make them more attractive places to live, as well as providing high-quality internet access. Information and communication technologies and their efficient use, facilitated by better high-speed internet access, are generally considered to be a key factor for increasing productivity and fostering innovation also in rural areas.

Outcomes of the research done confirm that, both the model groups having been the objective of study, can be successfully applied in modelling and forecasting within the domain of mobile telecom services use. However, the exponential smoothing models have recorded a more frequent application in the analyses done than the ARIMA models. What concerns frequency of the data collected, the exponential smoothing models have been found better applicable both for monthly and daily data, be it at the stage of interpolation or extrapolation, as well.

Based on the analysis done, the exponential smoothing models can only be recommended for the analysis of indicators under study from the mobile telecom area. The contemporary statistical programmes facilitate construction of not only the high quality individual forecasting models but combined models, too. The practice of combination techniques has brought about very good outcomes in prognosticating. Christodoulos et al. (2011) have assessed these techniques as very beneficial ones. Deb et al. (2017) have reached a conclusion, too, in their study that, the combined techniques are much more efficient in time series forecasting. They have dealt with construction and assessment of the combined models in the buildings energy consumption. Tavakkoli et al. (2015) have applied a combination of two models from the adaptive models class in their study – specifically the Double and Holt-Winters exponential smoothing models – with the ARIMA models, and they have assessed the benefit of this approach for particleboard consumption in Iran. The outcomes of this study also confirm that, the combined techniques are more efficient and they supply better results in the mobile networks traffic forecasting. In spite of the comparatively irregular ways of development of some of the indicators under study, both the individual and combined models employed here have been subject to rather low errors of prediction.

The research could continue further towards empirical analysis of a still more extensive time series collection, experimenting with varying lengths of the reference periods or the forecasting horizons, too. Madden and Tan (2007) too, have aimed at time series forecasting from the domain of telecommunications using linear models and experimenting with varying lengths of the forecasting horizons. In their study they reached a conclusion that, for longer (more distant) forecasting horizons in case of monthly time series, the exponential smoothing models are more fitting compared with the ARIMA models, the Holt exponential smoothing model in particular. Fildes et al. (1998) compared in their study various forecasting methods, incl. of the ARIMA models, considering precision of the prognoses constructed for different forecasting horizons and they reached a result that, the ARIMA models can set up more precise extrapolation forecasts for longer forecasting horizons – up to18 periods in advance.

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References

[1] Bastianin, A., Galeotti, M., and Manera, M. (2016) "*Statistical and Economic Evaluation of Time Series Models for Forecasting Arrivals at Call Centers*". [Online]. Working Papers, 2017, Vol. 6., pp. 1–26. [Online]. Available: http://services.bepress.com/cgi/viewcontent.cgi?article=2188&context=feem. [Accessed: 15 April 2019].

[2] Billah, B., King, M. L., Snyder, R. D. and Koehler, A. B. (2006) "Exponential smoothing model selection for forecasting", *International Journal of Forecasting*, Vol. 22, No. 2, pp. 239-247. ISSN 0169-2070. DOI 10.1016/j.ijforecast.2005.08.002.

[3] Bolin, D., Guttorp, P., Januzzi, A., Jones, D., Novak, M., Podschwit, H., Richardson, L., Sé, A., Sowder, C. and Zimmerman, A. (2015) "Statistical prediction of global sea level from global temperature", *Statistica Sinica*, pp. 351-367. ISSN 10170405. DOI 10.5705/ss.2013.222w.

[4] Bozdogan, H. (2000) "Akaike's Information Criterion and Recent Developments in Information Complexity", *Journal Of Mathematical Psychology*, Vol 44, No. 4, pp. 62-91. ISSN 0022-2496. DOI 10.1006/jmps.1999.1277.

[5] Cipra, T. (1986) "*Analýza časových řad s aplikacemi v ekonomii*" (in Czech), 1st ed., Prague, SNTL/Alfa, textbook.

[6] Cipra, T. (1992) "Robust exponential smoothing", *Journal of Forecasting*, Vol. 11, No. 1, pp. 57-69. ISSN 0169-2070. DOI 10.1002/for.3980110106.

[7] Corberán-Vallet, A., Bermúdez, J. D. and Vercher, E. (2011) "Forecasting correlated time series with exponential smoothing models", *International Journal of Forecasting*, Vol. 27, No. 2, pp. 252-265. ISSN 0169-2070. DOI 10.1016/j.ijforecast.2010.06.003.

[8] Deb, Ch., Zhang, F., Yang, J., Lee, S. E. and Shah, K. W. (2017) "A review on time series forecasting techniques for building energy consumption", *Renewable and Sustainable Energy Reviews*, Vol. 74, pp. 902-924. ISSN 1364-0321.DOI 10.1016/j.rser.2017.02.085.

[9] Fildes, R., Hibon, M., Makridakis, S. and Meade, N. (1998) "Generalising about univariate forecasting methods: further empirical evidence", *International Journal of Forecasting*, Vol. 14, No. 3, pp. 339-358. ISSN 0169-2070. DOI 10.1016/S0169-2070(98)00009-0.

[10] Findley, D. F. (2005) "Asymptotic second moment properties of out-of-sample forecast errors of misspecified regARIMA models and the optimality of GLS", *Statistica Sinica*, pp. 447-476. ISSN 10170405.

[11] Gardner, E. S. (2006) "Exponential smoothing: The state of the art–Part II", *International Journal of Forecasting*, Vol. 22, No. 4, pp. 637-666. ISSN 0169-2070. DOI 10.1016/j.ijforecast.2006.03.005.

[12] Gardner, E. S. and Diaz-Saiz, J. (2008) "Exponential smoothing in the telecommunications data", *International Journal of Forecasting*, Vol. 24, No. 1, pp. 170-174. ISSN 0169-2070. DOI 10.1016/j.ijforecast.2007.05.002.

[13] Gelper, S., Fried, R. and Croux, C. (2010) "Robust forecasting with exponential and Holt–Winters smoothing", *Journal of forecasting*, Vol. 29, No. 3, pp. 285-300. E-ISSN 1099-131X. DOI 10.2139/ssrn.1089403.

[14] Ghosh, H. and Paul, R. K. (2010) "Functional coefficient autoregressive nonlinear time-series model for forecasting Indian lac export data", *Model assisted statistics and applications*, Vol. 5, No. 2, pp. 101-108. E.ISSN 1875-9068, ISSN 1574-1699. DOI 10.3233/MAS-2010-0147.

[15] Guo, J., Peng, Y., Peng, X., Chen, Q., Yu, J. and Dai, Y. (2009) "Traffic forecasting for mobile networks with multiplicative seasonal arima models", *Electronic Measurement & Instruments*, 2009, ICEMI'09, 9th International Conference, pp. 3–377, IEEE. DOI 10.1109/ICEMI.2009.5274287.

[16] Hilas, C. S., Goudos, S. K. and Sahalos, J. N. (2006) "Seasonal decomposition and forecasting of telecommunication data: A comparative case study", *Technological Forecasting and Social Change*, Vol. 73, No. 5, pp. 495-509. ISSN 0040-1625.DOI 10.1016/j.techfore.2005.07.002.

[17] Hindls, R., Hronová, S. and Novák, I. (2000) "Metody statistické analýzy pro ekonomy" (in Czech), Management press, 1st ed., 249 p. ISBN 80-85943-44-1.

[18] Hloušková, Z., Ženíšková, P. and Prášilová, M. (2018) "Comparison of Agricultural Costs Prediction Approaches", *Agris On-Line Papers in Economics and Informatics*, Vol. 10, No. 1, pp. 3-13. ISSN 1804-1930. DOI 10.7160/aol.2018.100101.

[19] Christodoulos, C., Michalakelis, C. and Varoutas, D. (2010) "Forecasting with limited data: Combining ARIMA and diffusion models", *Technological Forecasting and Social Change*, Vol. 77, No. 4, pp. 558-565. ISSN 0040-1625. DOI 10.1016/j.techfore.2010.01.009.

[20] Christodoulos, Ch., Michalakelis, CH. and Varoutas, D. (2011) "On the combination of exponential smoothing and diffusion forecasts: An application to broadband diffusion in the OECD area", *Technological Forecasting and Social Change*, Vol. 78, No. 1, pp. 163-170. ISSN 0040-1625. DOI 10.1016/j.techfore.2010.08.007.

[21] Lim, J., Nama, Ch., Kim S., Rhee, H., Lee, E. and Lee, H. (2012) "Forecasting 3G mobile subscriptionin China: A study based on stochastic frontier analysis and a Bass diffusion model", *Telecommunications Policy*, Vol. 36, pp. 858-871. ISSN 0308-5961. DOI 10.1016/j.telpol.2012.07.016.

[22] Mabert, V. A. (1985) "Short interval forecasting of emergency phone call (911) work loads", *Journal of Operations Management*, Vol. 5, No. 3, pp. 259-271. ISSN 0272-6963. DOI 10.1016/0272-6963(85)90013-0.

[23] Madden, G. and Tan, J. (2007) "Forecasting telecommunications data with linear models", *Telecommunications Policy*, Vol. 31, No. 1, pp. 31-44. ISSN 0308-5961. DOI 10.1016/j.telpol.2006.11.004.

[24] Mastorocostas, P. and Hilas, C. (2012) "A computational intelligence-based forecasting system for telecommunications time series", *Engineering Applications of Artificial Intelligence*, Vol. 25, No. 1, pp. 200-2006. ISSN 0952-1976. DOI 10.1016/j.engappai.2011.04.004.

[25] Mastorocostas, P. and Hilas, C. (2014) "SCOLS-FuM: A Hybrid Fuzzy Modeling Method for Telecommunications Time-Series Forecasting", *Informatica*, Vol. 25, No. 2, pp. 221-239. E-ISSN 1822-8844, ISSN 0868-4952.

[26] Mirzavand, M. and Ghazavi, R. (2015) "A stochastic modelling technique for groundwater level forecasting in an arid environment using time series methods", *Water resources management*, Vol. 29, No. 4, pp.1315-1328. E-ISSN 09204741, ISSN 15731650. DOI 10.1007/s11269-014-0875-9.

[27] Murat, M., Malinowska, I., Hoffmann, H. and Baranowski, P. (2016) "Statistical modelling of agrometeorological time series by exponential smoothing", *International Agrophysics,* Vol. 30, No. 1, pp. 57-65. ISSN 23008725. DOI 10.1515/intag-2015-0076.

[28] Nimesh, R., Arora, S., Mahajan, K. K. and Gill, A. N. (2014) "Predicting air quality using ARIMA, ARFIMA and HW smoothing", *Model Assisted Statistics and Applications*, Vol. 9, No. 2, pp. 137–149. E.ISSN 1875-9068, ISSN 1574-1699. DOI 10.3233/mas-130285.

[29] Papic-Blagojevic, N., Vujko, A. and Gajic, T. (2016) "Comparative analysis of exponentials smoothing models to tourists' aarivals in Serbia, *Ekonomika Poljoprivrede*, Vol. 63, No. 3, pp. 835-845. E-ISSN 2334-8453, ISSN 0352-3462. DOI 10.5937/ekopolj1603835p.

[30] Rafiy, M., Ernawati, Adam, P. and Rostin (2016) “The Demand of Services for Information Technology Industry in Indonesia", *AGRIS on-line Papers in Economics and Informatics*, Vol. 8, No. 4, pp. 125 - 132. ISSN 1804-1930. DOI 10.7160/aol.2016.080411.

[31] Seger, J. and Hindls, R. (1993) "Statistické metody v ekonomii" (In Czech) 1st ed., Prague H+H, 445 p. ISBN 80-85787-26-1.

[32] Svatošová, L. and Köppelová, J. (2017) “The Use of Combined Models in the Construction of Foodstuffs Consumption Forecasting in the Czech Republic", *AGRIS on-line Papers in Economics and Informatics*, Vol. 9, No. 4, pp. 81-89. ISSN 1804-1930. DOI 10.7160/aol.2017.090408.

[33] Sbrana, G. and Silvestrini, A. (2014) "Random switching exponential smoothing and inventory forecasting", *International Journal of Production Economics*, Vol. 156, pp. 283-294. ISSN 0925-5273. DOI 10.1016/j.ijpe.2014.06.016.

[34] Tavakkoli, A., Hemmasi, A. H., Talaeipour, M., Bazyar, B. and Tajdini, B. (2015) "Forecasting of Particleboard Consumption in Iran Using Univariate Time Series Models", Bio Resources, Vol. 10, No. 2, pp. 2032–2043. ISSN 1930-2126.

[35] Wei, X. and Yang, Y. (2012) "Robust combination of model selection methods for prediction", *Statistica Sinica*, Vol. 22, No. 3, pp. 1021-1040. E-ISSN 19968507, ISSN 10170405. DOI 10.5705/ss.2010.023.

Digital Divide of Rural Territories in Russia

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Abstract

Information and communication (ICT) technologies cause profound changes in social and economic phenomena. The initial stage of their diffusion is accompanied by complex and contradictory effects. One of these effects is the growing inequality in access to information and the newest technological achievements. The digital divide leaves vast social groups outside the progressive mainstream. Studies show that agribusiness and rural territories most severely suffer from digital discrimination. It consequently results in declining profitability and competitiveness of the agrarian sector and, furthermore, a growing gap between the quality of urban and rural life. To control the negative process, the primary task is to obtain a clear notion of the current tendencies. The study describes a qualitative method of analysis that can be used to measure the digital divide in rural territories.

Keywords

Digital divide, access to information, socioeconomic development, rural areas, agriculture's contribution to rural development.

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Introduction

Contemporary economic and social development is in many aspects depending on the diffusion of digital technologies. It is expected that innovations will stimulate revolutionary growth of productivity and, as a result, will improve the quality of life. However, the process of digital transformation is not homogeneous in time and space.

The digital divide, unequal access to information and communication technologies, has given rise to new social and economic problems. Vast rural territories in Russia are far behind urban centers in their level of digitalization. Among various factors influencing the inequality, 'it is… the location factor that can be considered the most relevant" (Šimek et al., 2011). The rural Russian population (over 37 million people) does not benefit from innovations. Only 52.5 % of the rural population uses e-government services (HSE, 2018), less than 10% are involved in e-commerce. The analysis of digital competencies in agrarian companies shows that there is a lack of specialists and modern technologies, which leads to a relatively higher level of production costs and a tendency to lose competitive advantages in the local and global markets. Without access to professional databases, newest software and information services, agrarian companies are deprived of the main factors of success (Shepherd, 2018; Štůsek et al., 2017; Vaněk et al., 2010). Agriculture serves as a key factor contributing to rural development. Unsatisfactory economic results of the agrarian sector provoke long-term negative consequences in the socioeconomic and demographic development of the rural territories. Over time the digital divide will lead to a profound disproportion of opportunities in urban and rural territories, new waves of migration, and further degradation of the agricultural provinces.

Governmental programs are aimed at preventing negative tendencies. The programs include investments in infrastructure, educational projects and other measures of support. In the last three years, the effectiveness of the programs has become a question of discussion. One of the barriers to positive results is the methodological problem of acquiring data for further analysis and decision making. Federal programs rely on average statistical data about the tempo of digital diffusion. The average indicators are attributed to large provinces with thousands of inhabitants and with a highly diverse local environment. One of the core problems is that there is no adequate system of analysis and measurement which could give a realistic vision of the variety. Numerous local areas keep degrading without proper support and investment. Effective control demands appropriate methods of measuring the level of digitalization. The purpose of the research is to improve strategic decision-making to support the socio-economic development of the rural territories and the agrarian sector.

Materials and methods

The research was focused on the problem of the digital divide in the Ryazan region of Russia. The Ryazan region lies to the south-east from Moscow. It is a comparatively large territory with a 65% share of land used for agricultural production (Table 1).

Half of the population lives in the administrative center, Ryazan. The region is divided into 25 local areas. The lowest population density among the local districts is a little more than 5.6 people per square kilometer. Statistics show the continuing formation of a mono-centered region with vast depopulated territories around the administrative center. The tendency grows stronger in the course of industrial and digital transformation. Agriculture is the main branch of regional economics. However, the level of agriculture value added per worker decreases at an average annual rate of 1.7 % since 2006.

The R&D expenditures in the agrarian sector have diminished from 5.1% to 0.1-0.05% of the gross regional product within the period of the last 15 years. Nowadays the innovations are concentrated in telecommunication and the industrial spheres, whereas the production of agricultural machinery ceased to exist in the late 90´s of the 20th century.

The access to information resources via the Internet has become the compensating mechanism for the agrarian producers. At the same time, the lack of digital competencies prevents agrarian producers from the successful implementation of advanced innovations. This leads to a further stagnation of the agricultural sphere. While the output of industrial production is expected to gain a 34% growth in 2025 due to digitalization, agriculture reduces its tempo of development.

The research of social and economic development at the scale of regional districts includes statistical analysis of various criteria. The approach reveals several faults in the traditional methodology. To understand the actual level of digitalization it is necessary to start with a study of general tendencies of development and the choice of key criteria of analysis.

Scientists and scientific institutions face the problem of evaluating digital transformation, digitalization maturity index, the Gini coefficient of Internet penetration and other characteristics of the worldwide phenomenon. Academic research of the last 10-15 years shows that the problem of the digital divide has not yet found an all-accepted solution (Yu et al., 2015). Most researchers state that such factors as the penetration of Internet technologies, digital literacy, technical competence, and other criteria show the stratification of society growing stronger and giving rise to new forms of inequality (López and Farzan, 2017). The digital divide influences the quality of life in the digital

	Region / Country	Area, sq km	Agricultural land, sq km	Agricultural land as a share of land area, %	Agriculture value added per worker in constant prices of 2010, US dollars	Population, persons
1	Czech Republic	77,220	34,890	45.2	24,739	10,625,695
2	Slovakia	48,080	18,860	39.2	52,970	5,447,011
3	*Ryazan region*	*39,605*	*25,695*	*65.0*	*31,857*	*1,114,137*
4	Switzerland	39,516	15,160	38.4	27,846	8,516,543
5	Netherlands	33,690	17,960	53.3	80,984	17,231,017
6	Belgium	30,280	13,508	44.6	65,294	11,422,068
7	Armenia	28,470	16,768	58.9	n/a	2,951,776
8	Israel	21,640	5,320	24.6	94,454	8,883,800
9	Slovenia	20,142	6,175	30.7	21,840	2,067,372

Source: Ryazan Statistics (2018), World Data Atlas (2019)

Table 1: The Ryazan region in comparison with several sample countries (2018).

economy and works as an obstacle to opportunities and development (Mossberger, 2003). The variety of approaches to estimate the digital divide is the result of the multiple basic concepts of digital competencies, or digital literacy (Chetty et al., 2018). International practices are focused either on the economic or on the social and cultural factors in their methodology of estimating the digital divide.

The digital divide in the Ryazan region appears as the result of uneven course of economic development due to such factors as quality of soil, water resources, mineral reserves, distance from the administrative center, unequal accessibility of the Internet, differences in skills and knowledge, the demographic structure of the population.

To compensate disparity in development it is necessary to take into account the specific institutional and social factors of development. The municipal authorities together with scientific institutions continue their attempts of introducing an adequate system of evaluation that will show the dynamics of digitalization in the local areas. The limitation factor is the lack of raw statistics at the scale of local areas. The federal system of evaluating informational and technological literacy and Internet access is based on the data obtained from the administrative center of the region. Each local area has individual systems of monitoring which are not integrated into one total database. The official publication of the obtained data takes two years. The system is under correction; hence the resources for this research include reports of local authorities and the database of the Ryazan Regional Statistics Bureau.

The recent research resulted in an evaluation of 10 dimensions that show the intensity of the digital divide across the local areas. The sample factors include those that illustrate the level of investments in the ICT sphere, the popularity of digital technologies in the business community, the availability of high-speed Internet access, and the level of digital competencies. The integral coefficient of inequality is at the level of 3.83. The qualitative measurement of the digital transformation of the economic and social life includes the procedure of normalization. The normalized value for each local area is calculated as X = R(x)/R(n), where R(x) is the dimension of the local area and R(n) is the target level for the region. In the research, it is assumed that the target level of digitalization in the agrarian sphere cannot be measured with the same dimension as in the industrial sphere. The target is measured as the maximum level observed in a particular period.

The target levels for the rural territories in 2018 were the following (Ryazan Statistics, 2018):

- P1, Internet users per 1000 people - 174;
- P2, small e-business companies per 10 thousand people, number of registered companies - 89;
- P3, the number of highly qualified ICT specialists - 25;
- P4, the volume of capital investment (not including federal or municipal budget investments) per 1 person, roubles - 26647;
- P5, the number of organizations using digital technologies - 24;
- P6, personal computers per 100 staff members, having access to the Internet - 12;
- P7, organizations using the Internet in e-commerce - 5;
- P8, organizations with Internet speed over 256 kilobit per second - 9;
- P9, organizations using special computer programs - 8;
- P10, organizations using special systems of cybersecurity – 16.

Average regional levels are used to estimate the gap in the digital development of particular areas. The procedure includes evaluation of the digitalization indicator (DI) which shows the relative level of ICT (information and communication technologies) diffusion. The indicator is calculated as a sum of normalized values.

Results and discussion

The acquired data about the 10 criteria makes it possible to evaluate the digitalization indicator for the 25 rural areas of the Ryazan region. The analysis shows that the dimensions vary from 0.33 to 0.53 (Table 2). Low levels of particular dimensions may serve as signals for decision-makers.

As indicated in Table 2 the digital divide between the rural and urban territories is considerable. Several exceptions are indicating the growing innovative potential in particular areas (Dronov et al., 2016).

The maximum level of the integral indicator equals 0.75 whereas the minimum is 0.31. It reveals the fact of deep inequality across the local areas. The digital divide may thus get a qualitative measure.

#	Local Areas	DI integral 2018	DI rural 2018
1	Alexandro-Nevsky	0.43	0.46
2	Chuchkovsky	0.42	0.36
3	Ermishinsky	0.40	0.46
4	Kadomsky	0.42	0.35
5	Kasimovsky	0.67	0.53
6	Klepikovsky	0.60	0.34
7	Korablinsky	0.49	0.41
8	Mikhailovsky	0.65	0.33
9	Miloslavsky	0.46	0.37
10	Pitelinsky	0.38	0.38
11	Pronsky	0.67	0.43
12	Putyatinsky	0.40	0.33
13	Ryazanskiy	0.71	0.40
14	Ryazhsky	0.53	0.44
15	Rybnovsky	0.64	0.41
16	Sapozhkovsky	0.33	0.39
17	Sarayevsky	0.58	0.43
18	Sasovsky	0.31	0.37
19	Shatsky	0.54	0.38
20	Shilovsky	0.75	0.48
21	Skopinsky	0.36	0.49
22	Spassky	0.55	0.36
23	Starozhilovsky	0.46	0.37
24	Ukholovsky	0.37	0.34
25	Zakharovsky	0.50	0.38

Source: Own research and processing

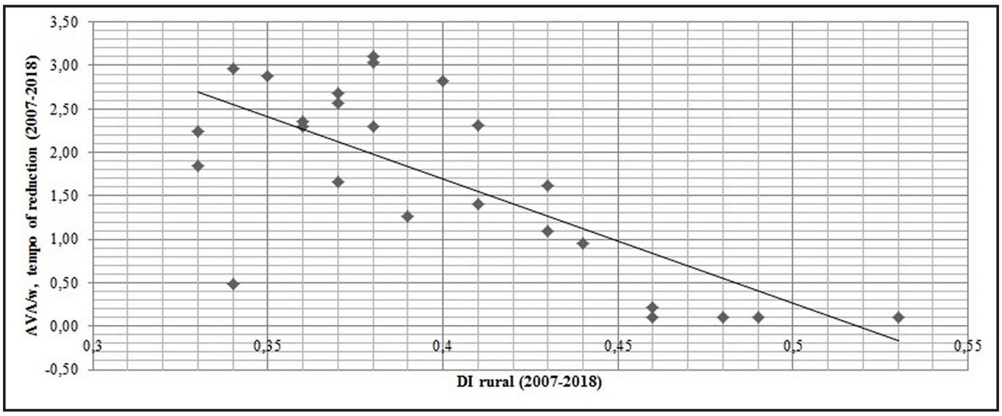
Table 2: Digitalization indicators of Ryazan rural areas compared to integral dimensions.

The integral dimension of the digital divide may include more criteria if the regional system of monitoring becomes more effective. However, the 10 dimensions estimated in this research can already prove useful for preliminary analysis.

The process of digitalization does not prominently influence either the level of profitability in the production of the raw goods or the number of companies in agriculture (within the period of observation 2007-2018). However, it is now possible to state that there is a well-observed shift in the choice of products in those areas that tend to upgrade their business with digital innovations in technology, marketing, or production organization. The statistical analyses showed a negative correlation (-0.73 on average) between the digital index and the tempo of reduction of the ‘agriculture value added per worker (AVA/w)‘, measured as the geometrical mean (Figure 1).

The total tendency to produce less added value leads to a gradual degradation of the potential for sustainable development. The state support of agriculture is still in the phase of ‘aggressive investments‘, stimulating the extensive growth of the production of the raw goods to grant food security. The analysis shows that it is necessary to change the priorities and to stimulate changes in the qualitative characteristics of the produced goods and the level of the added value. The areas of the Ryazan region with more intensive usage of digital innovations are more open to modern instruments of analysis, sources of information, new technological ideas, and more effective production management. What is more important, these areas have the potential to provide young specialists and highly qualified professionals with a proper level of life conditions.

To interpret the results of the analysis, the DI measurements may be divided into several groups including leaders, followers and slowly developing rural areas. The group of leaders is located closer



Source: own research and processing

Figure 1: Agriculture value added per worker and the digital index of the rural territories.

to the administrative center. These areas have a higher level of infrastructural and institutional development. These areas attract investors and qualified specialists. It makes the process of IT technologies diffusion more effective. The group of slowly developing areas shows a very low density of population and a lack of investments.

The multi-criteria analysis of digitalization makes it possible to work out an appropriate instrument of measurement and comparison. The list of dimensions includes data from open resources which makes the process of monitoring dynamic and effective. Such an approach may become a practical tool for analyzing tendencies and perspectives of economic and social development.

Better understanding the local diversity will improve the results of governmental programs and prevent negative tendencies in deepening the inequality between the rural and the urban population. More intensive digitalization of rural territories will create an environment of equal life opportunities and, therefore, stimulate positive economic and demographic changes in rural areas.

Conclusion

The Russian federal program of digital transformation is aimed at the rapid growth of productivity both in the industrial and agrarian spheres. However, the synergetic effect from innovations can be obtained only in case of emerging efforts of all the minor elements in the socio-economic system of the country.

A permanent monitoring of digital diffusion is an obligatory string of effective management and choice of preventive and stimulating measures. Without a new scientific approach to analytics, it is impossible to identify the barriers to progressive changes in the agrarian sector of economics. Digital agriculture changes the quality of rural life. New technologies stimulate the profitability of agribusiness and attract investments to the agrarian sector. Nevertheless, scientific research shows that digitalization may cause negative social effects, "intensify exploitation and deepen both labor and spatial marginalization" (Rotz. 2019) without an adequate system of controlling and navigating the vector of innovative development.

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References

[1] Dronov, V., Makhrova, O., Pechnikov, A. (2016) "Information inequality of districts in Ryazan oblast", In: "*The second All-Russian scientific and practical conference Incomes. Expenditures and Savings of the Russian Population: Trends and Perspectives*", ISESP RAS. Vol. 4. pp. 104-113.

[2] HSE Data Books (2018) "*Information Society Indicators in the Russian Federation*", National Research University, Higher School of Economics. [Online]. Available: https://www.hse.ru/en/primarydata/iio/ [Accessed: 3 Mar. 2019].

[3] Chetty, K., Qigui, L., Gcora, N., Josie, J., Wenwei, L., and Fang, Ch. (2018) "Bridging the digital divide: measuring digital literacy", *Economics,* Vol. 12, No 23, pp. 1-20. DOI 10.5018/economics-ejournal.ja.2018-23. DOI 10.5018/economics-ejournal.ja.2018-23.

[4] López, C. and Farzan, R. (2017) "Designing for Digital Inclusion: A Post-Hoc Evaluation of a Civic Technology", In: *Lecture Notes in Computer Science*, International Conference on Social Informatics, Socvial Informatics, pp. 572-588. DOI 10.1007/978-3-319-67217-5_34.

[5] Mossberger, K., Tolbert, C. J. and Stansbury, M. (2003) "*Virtual Inequality: Beyond the digital divide*", Georgetown University Press, ISBN-13: 978-0878409990, ISBN-10: 0878409998.

[6] Rotz, S., Gravely, E., Mosby, I., Duncan, E., Finnis, E., Horgan, M., LeBlank, J., Martin, R., Neufeld, H.T., Nixon, A., Pant, L., Shalla, V. and Fraser, E. (2019) "Automated pastures and the digital divide: How agricultural technologies are shaping labour and rural communities, *Journal of Rural Studies,* Vol. 68, pp. 112-122. ISSN 0743-0167. DOI 10.1016/j.jrurstud.2019.01.023.

[7] Ryazan Statistics (2018) "*Database of the Ryazan regional statistics*" (In Russian). [Online]. Available: http://ryazan.gks.ru/ [Accessed: 03 Mar.2019].

[8] Shepherd, M.. Turner, J. A., Small, B., and Wheeler, D. (2018) "Priorities for science to overcome hurdles thwarting the full promise of the ‘digital agriculture’ revolution", *Journal of the Science of Food and Agriculture*. E-ISSN 1097-0010. DOI 10.1002/jsfa.9346.

[9] Šimek, P., Vaněk, J., Jarolímek, J., Stočes, M. and Vogeltanzová, T. (2011) "New Version of the AGRIS Web Portal – Overcoming the Digital Divide by Providing Rural Areas with Relevant Information", *AGRIS on-line Papers in Economics and Informatics*, Vol. 3, No 4., pp. 71-78. ISSN 1804-1930.

[10] Štůsek, J., Kubata, K. and Očenášek, V. (2017) "Strategic Importance of the Quality of Information Technology for Improved Competitiveness of Agricultural Companies and Its Evaluation", *AGRIS on-line Papers in Economics and Informatics,* Vol. 9. No. 4., pp. 109-122. ISSN 1804-1930. DOI 10.7160/aol.2017.090411.

[11] Vaněk, J., Červenková, E., Jarolímek, J. and Šimek, P. (2010) "State and evaluation of information and communication technologies development in agricultural enterprises in Czech Republic", *Plant, Soil and Environment*, Vol. 56, No. 3., pp. 143-147. ISSN 1214-1178. DOI 10.17221/212/2009-PSE.

[12] World Data Atlas (2019) "Database of free data, statistics, visualization, and sharing". [Online]. Available: https://knoema.com [Accessed: 20. Sep.2019].

[13] Yu, B., Ndumu, A., Mon, L. M. and Fan, Z. (2018) "E-inclusion or digital divide: an integrated model of digital inequality", *Journal of Documentation*. Vol. 74, No. 3., pp. 552-574. ISSN 0022-0418. DOI 10.1108/JD-10-2017-0148.

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The Impact of Debt Funding Sources on Liquidity of Companies in Food Industry

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Abstract

The aim of this article is to determine the impact of debt funding sources structure on liquidity of companies in food industry in the Czech Republic from 2006 to 2016. With the purpose to fulfill the aim, we examine existence and character of relationship between the debt funding sources structure (long-term loans, short-term loans, other long-term liabilities, other short-term liabilities, debt equity ratio) and liquidity of the companies (cash ratio, quick ratio and current ratio) in food industry in the Czech Republic. The relationship between debt funding sources structure and liquidity of companies is tested through correlation analysis, Granger causality test and generalized method of moments (GMM). The liquidity of companies was positively influenced by the long-term loans in companies (cash ratio and quick ratio) in food industry in the Czech Republic. The results also indicate that there is the negative impact of other current liabilities on liquidity of companies (cash ratio, quick ratio and current liquidity) in food industry in the Czech Republic.

Keywords

Debt funding sources, generalized method of moments, Granger causality test, liquidity, long-term bank loans.

Šeligová, M. and Koštuříková, I. (2019) "The Impact of Debt Funding Sources on Liquidity of Companies in Food Industry", *AGRIS on-line Papers in Economics and Informatics*, Vol. 11, No. 3, pp. 91-104. ISSN 1804-1930. DOI 10.7160/aol.2019.110309.

Introduction

Industry is an important branch of the Czech economy and employs 38 % of all economically active inhabitants. The main industrial sector in the Czech Republic includes the chemical, engineering, food and steel industries. Other major industries are the energy, construction and consumer industries. Less important sectors are the arms industry and glass industry (which has a long tradition in the Czech Republic). Industry accounts for 38 % of the Czech economy. According to Panorama of food industry (2017), the food and beverage industry is one of the leading industries in the Czech Republic. Its significance is primarily due, to the fact that it provides for the nutrition of the population. The basic raw materials of the Czech food industry are domestic agricultural products, forestry and water products and imported raw materials. In the Czech Republic, food production and beverage production account for 2.7 % of GDP.

As stated by the Institute of Agricultural Economics and Information (2017), the production of food products in the Czech Republic belongs to the major branches of the manufacturing industry as well as to the whole of the European Union. This is mainly due to deliveries for the domestic market, which ensures the nutrition of the population through the production and sale of healthy and safe foods, which is controlled by the supervising institutions including the quality of the products. It turns out that not only the price but also the quality decides to buy a particular food. Although foreign trade in food products has a negative balance, exports have considerable importance in the complicated situation in some territories. This fact proves the quality and competitiveness of Czech food production both in the European and world markets.

Between 2007 and 2009, almost all sectors of the Czech Republic were affected by the global economic crisis. Similarly, it has also been in the manufacture of food products. According to the Ministry of Industry and Trade of the Czech Republic (2014), the Czech Republic recorded a decline in industrial output, a drop in new orders, a fall in household final consumption expenditure, a fall in investment and a rise in unemployment. After the bout of the crisis period, the Czech economy gradually revived. The revival of the Czech economy was affected by the growing consumption of households and the domestic production of food goods. The financial health of, in particular, larger companies in the food industry has boosted a higher trade margin, which has grown by almost a fifth, twice the pace for the entire manufacturing industry.

Despite the fact that the food industry has achieved favorable economic results in recent years, investments have been and are being covered by credit sources and, in part, the direct entry into capital of other business entities, both domestic and foreign. The decline in profitability combined with a high level of investment led to an increase in their indebtedness in individual businesses. The high level of indebtedness of the food industry and its continuous increase is due in particular to the growth of bank loans and liabilities to suppliers, especially agricultural holdings. The highest indebtedness rate was relatively high in sectors with low profitability, such as the dairy industry, the sugar industry, the milking industry and the starch industry. This high level of indebtedness is a risk to their own businesses, but also to their creditors, especially the primary agricultural producers who have long-term receivables. This high indebtedness raises the risk that the company will be unable to pay, which can lead to corporate bankruptcies. In order for a company to be able to pay, it must have the considerable liquidity needed to finance its investment activities and to meet its corporate obligations. On the other hand, if a company gets into liquidity problems, it can raise money through further debt (for example, bank loans).

For many years, asset liquidity in relation to the optimal level of debt or debt has been a controversial issue in financial studies. Generally in some countries liquid companies have used higher levels of debt, while in other countries these companies have been more funded by equity. Liquid companies are those companies that are able to convert their assets into cash and cover them in due time, in the required form and at the required location, with all their due liabilities at a minimum cost. Typically, these companies hold more current assets such as cash, financial assets, stocks and receivables. The relationship between liquidity and the capital structure of an enterprise may be different. Companies with a higher liquidity ratio may have a relatively higher debt ratio due to the greater ability to cover their short-term liabilities at maturity. This would lead to a positive relationship between the liquidity of the firm and its indebtedness or its debt ratio. On the other hand, enterprises with larger liquid assets may use these assets to finance their investments, which results in a negative relationship between the liquidity of the company and its leverage effect.

Stulz (1990) argues that companies may have difficulty finding new sources to fund their projects at a time when high leverage may lead to a reduction or loss of their financial flexibility. However, a certain level of debt or debt does not necessarily mean a negative phenomenon. If the debt is regularly monitored, the volume of debt is under control, and borrowed funds are used appropriately, leverage can lead to an increase in return on investment. High debt companies should invest in more liquid assets and assets that generate short-term cash flows (Peyer and Shivdasani, 2001; Ahn et al., 2006; Campello, 2003; Campello and Fluck 2005). Companies with high indebtedness will invest in safer and less risky investments or projects (Andrade and Kaplan, 1998; Eisdorfer (2008). Sufi (2009), looking at the information on whether a firm has access to credit, has found that businesses with very limited access to credit have a particularly good chance of saving cash from cash flows. This savings can be achieved through a so-called tax shield, which can be considered one of the benefits of borrowing by the company.

Morellec (2001), who believes that companies leverage a leverage effect because of the aforementioned tax shield that companies can use to their advantage, is accustomed to this claim. This idea was also supported by Graham (2000), who takes the view that most companies could leverage to obtain the corresponding tax benefits that are linked to debt burden without a clear increase in the costs associated with the financial troubled enterprise. Almeida et al. (2004) believe that the leverage effect leads companies to expect higher external financing costs in the future, leading to the use of investment towards safer projects. In addition, they also indicate another reason why companies limit their leverage. Higher leverage leads businesses to invest in safer and more liquid projects, but potentially less profitable.

For example, Al-Najjar and Belghitar (2011) looked at debt financing, which considered that a certain amount of leverage and profitability of an enterprise determined and influenced the decision to have a certain amount of the most liquid cash. In line with this idea, Baskin (1987) concludes that companies with a higher leverage effect will accumulate liquidity due to a higher probability of financial distress. In general, it is proposed that the volume of liquid or cash resources be reduced as the company's debt rises. Ferreira and Vilela (2004) suggest that firms with high levels of debt are less able to dispose of a sufficient volume of highly liquid assets. This is because they are better monitored than companies with relatively low debt or debt. Opler, Pinkowitz, Stulz and Williamson (1999) found a negative relationship between corporate debt and corporate liquidity on a sample of US non-financial corporations using panel regression analysis.

Anderson (2002) examined through regression analysis the factors influencing the holding of liquid assets. It identified the relationship between corporate liquidity and capital structure. As part of his research, he believed that if the firm relied heavily on and using high levels of debt financing, it tends to have a high level of liquid assets. The high level of debt financing tends to be associated with a high level of holding of liquid assets. The results have shown a positive relationship between the leverage effect and the liquidity of the company, where the leverage effect will increase the company's liquidity. This leads the author to identify a possible link where the high level of debt leads to high liquidity, which will lead to slow growth of the company. This resulting relationship is in line with the presence of a preventive motif of holding liquid assets in companies that maintain high leverage as a permanent feature of their capital structure. Furthermore, the negative relationship between short-term leverage and liquidity was demonstrated. The reason is that short-term debt and liquid assets can be substitutes in the sense that a company facing a low cash flow will react to this either by drawing on available liquid assets or by accumulating short-term debt or by combining both of these options.

Sharlija and Harc (2012) concluded that the negative relationship between corporate liquidity and short-term leverage is more significant than the positive relationship between corporate liquidity and long-term leverage. They believed that the more the company is liquid, the less it is indebted. The authors also believe that long-indebted companies have a larger volume of liquid assets and can be considered as more liquid. The results of the study also showed a negative relationship between cash and short-term or long-term leverage. The problem of debt funding sources and liquidity of companies has been dealt with in a number of authors in their studies. An overview of the studies dealing with similar issues, including the variables and methods used, are presented in the Table 1.

From the above-mentioned literature review, it is clear that there has been no clear impact of debt funding sources on corporate liquidity. For this reason, the aim of this article is to determine the impact of debt funding sources structure on liquidity of companies in food industry in the Czech Republic from 2006 to 2016. With the purpose to fulfill the aim, we examine existence and character of relationship between the debt funding sources structure (long-term loans, short-term loans, other long-term liabilities, other short-term liabilities, debt equity ratio) and liquidity of the companies in food industry in the Czech Republic. The relationship between debt funding sources structure and liquidity of companies will be tested through correlation analysis, Granger causality test and generalized method of moments (GMM).

In order to achieve the goal, the following research questions will be identified and evaluated:

- What is the relationship between the debt funding sources structure and liquidity of companies in food industry in the Czech Republic from 2006 to 2016?

The first part of this article will include a literature review. The second part of this article will focused on data and methodology. The third part of this article will contain results. Last part of this article will conclude results and discussion.

Authors	Methods	Variables	Results
Růčková (2014)	• correlation analysis	Return on equity, quick ratio (L2), gross domestic product	Return on equity (+/-), gross domestic product (+/-)
Růčková (2015)	• GMM method	Debt equity ratio, return on equity, current ratio (L3)	Debt equity ratio (+/-)
Šeligová (2017)	• correlation analysis • regression analysis	The share of fixed assets in total assets, return on assets, return on equity, debt equity ratio	The share of fixed assets in total assets (-), return on equity (+), debt equity ratio (-)
Šeligová (2018)	• correlation analysis • GMM method	The share of fixed assets in total assets, return on assets, return on equity, debt equity ratio, equity ratio	Return on assets (-), return on equity (+), equity ratio (+)
Kim, Mauer a Sherman (1998)	• correlation analysis • regression analysis	Growth opportunities, cash flow volatility, debt funding or debt, cash flow and bankruptcy risk	Growth opportunities (+), debt equity ratio(-)
Opler, Pinkowitz, Stulz a Williamson (1999)	• panel regression analysis	Cash, asset value, market value of a firm, science and research expenditure, capital expenditure, cash flow, net working capital, shareholder payout and leverage	Growth opportunities (+), debt (-)
Anderson (2002)	• regression analysis	Return on assets, long-term loans, medium-term loans, short-term loans, science and research expenditure, cash flow, liquidity	Long-term leverage (+), short-term leverage (-)
Mehar (2005)	• correlation analysis	Fixed assets, net profit after tax, retained earnings	Fixed assets (+), net profit (+), retained earnings (-)
Shah (2012)	• correlation analysis	Return on assets	Return on assets (-)
Šarlija a Harc (2012)	• correlation analysis	Share of retained earnings on capital, leverage	Leverage (-)
Al-Najjar (2013)	• regression analysis	Impact of the capital structure, leverage, profitability, company size, dividend policy	
Trippner (2013)	• correlation analysis	Return on assets, return on equity	Return on assets (+,-), return on equity (+,-)
Miloş (2015)	• panel regression analysis	Share of total debt on total liabilities, return on assets, share of fixed assets in total assets, size of firm	Leverage (-)

Source: own processing

Table 1: Overview of selected empirical studies related to the relationship between the funding sources structure and liquidity of companies.

Materials and methods

To determine the relationship between the debt funding sources structure and the liquidity of companies in the food industry, financial data was used, which was drawn from the Amadeus database. This database includes data from the annual reports of individual companies in Europe. To fulfill the objective of this article, data from annual reports of individual companies in food industry in the Czech Republic were selected.

To determine the relationship between debt funding sources structure and liquidity of companies, medium sized companies, large companies and very large companies were selected.

The Amadeus database divides companies by size as follows:

- A very large companies with operating revenues of more than EUR 100 million, total assets of more than EUR 200 million and more than 1 000 employees.
- A large companies with operating revenues of more than EUR 10 million, total assets of more than EUR 20 million and more than 150 employees.
- A medium-sized companies with operating revenues of more than EUR 1 million, total assets greater than EUR 2 million and more than 15 employees.
- Small companies are considered to be enterprises that do not meet the criteria set for medium-sized enterprises.

The dataset cover the period 2006-2016. All data and time series are on annual frequency. The sample of analyzed companies includes 306 companies in food industry of which 157 are medium-sized companies, 131 are large companies and 18 are very large companies. The data from Amadeus database are the basis for the application of correlation analysis, Granger causality test and generalized method of moments. On the other hand, the data used to illustrate the development of liquidity for the entire food industry in the Czech Republic was obtained from the Ministry of Industry and Trade of the Czech Republic and the Amadeus database. First, the data was processed in Microsoft Excel and then econometric software Eviews 8 was used to determine the relationship between debt funding sources structure and liquidity companies. The Amadeus database includes the division of companies only into medium-sized companies, large companies and very large companies.

Recommendation 2003/261/ European Directive defines small companies as companies with employees less than 50 employees annual turnover of less than EUR 10 million or balance sheet total of less than EUR 10 million.

For this reason, medium-sized companies can be identified to a certain extent by selecting them from the Amadeus database with small companies according to Recommendation 2003/261 / European Directive.

In order to answer the identified research question, the following variables were selected, the selection of which was based primarily on the above-mentioned literature review. The description of the variables used is shown in Table 2.

Three ratios are used to express the liquidity of the company and characterize the liquidity of the company according to the balance sheet. The company's liquidity is expressed using the cash ratio, the quick ratio or the current ratio. Derivatives characterizing the amount of short-term and long-term bank loans, the debt equity ratio indicator, and the volume of other short and long-term liabilities such as trade payables, bond liabilities, payables to employees (payables), etc., are used to express the debt financing sources structure.

Abbreviation	Description	Calculation	Calculation
L1	Cash ratio	$\frac{cash}{current\ liabilities}$	$\frac{LN\ 71\ (BS,A)}{LN\ 37(BS,L)}$
L2	Quick ratio	$\frac{current\ assets - inventories}{current\ liabilities}$	$\frac{LN\ 37 - LN\ 38\ (BS,A)}{LN\ 37\ (BS,L)}$
L3	Current ratio	$\frac{current\ assets}{current\ liabilities}$	$\frac{LN\ 37\ (BS,A)}{LN\ 37(BS,L)}$
STL	Short-term loans	$\frac{short\ term\ bank\ loans}{total\ assets}$	$\frac{LN\ 50\ (BS,L)}{LN\ 1\ (BS,A)}$
LTL	Long-term loans	$\frac{long\ term\ bank\ loans}{total\ assets}$	$\frac{LN\ 35\ (BS,L)}{LN\ 1\ (BS,A)}$
DER	Debt equity ratio	$\frac{debt}{equity}$	$\frac{LN\ 24\ (BS,L)}{LN\ 2\ (BS,L)}$
OCL	Other current liabilities	$\frac{other\ current\ liabilities}{total\ assets}$	$\frac{LN\ 46 - LN\ 50\ \ (BS,L)}{LN\ 1\ (BS,A)}$
ONCL	Other non-current liabilities	$\frac{other\ non-current\ liabilities}{total\ assets}$	$\frac{LN\ 31 - LN\ 35\ \ (BS,L)}{LN\ 1\ (BS,A)}$

Note: LN = Line Number, BL = Balance Sheet, A = Assets, L = Liabilities
Source: own proceeding

Table 2: Description of used variables.

The liquidity ratio is very important indicator because liquid company only is able to pay its payables. If the company has a sufficient amount of funds for payment of its current liabilities, the company will be liquid. An excessively high value of liquidity is usually accompanied by lower values of equity (return on equity) that is associated with a conservative approach. On the other hand, companies that have too low levels of liquidity typically use debt sources for financing their activities.

Debt equity ratio (leverage) measures debt sources to equity. The higher value of the debt equity ratio, the higher ratio of debt sources to equity. This fact can indicate a higher risk for creditors. The value of debt equity ratio 1 indicates that equity and debt sources are involved in the financing of companies in the same amount. Higher debt represents a higher level of risk of companies. On the other hand, higher debt may mean a larger volume of funding sources because the costs of external funding tend to be cheaper than costs of equity. Companies that have too low levels of liquidity typically use debt sources for financing their activities. For this reason, we can expect a negative relationship between liquidity of companies and debt equity ratio.

Table 3 shows the basic descriptive characteristics of companies in food industry in the Czech Republic, where maximum and minimum capture the maximum value and the minimum value of liquidity of companies and debt funding sources structure. The standard deviation shows a standard deviation of the value from their arithmetic mean. Median is a value that divides a series of ascending ranked results into two equally large halves.

Due to the large number of data, this data was processed into panel data by industry and period. These panel data were subsequently used in the correlation analysis, Granger causality test and Generalized Method of Moments (GMM).

According to Cohena (2014), the correlation analysis is a suitable method for the initial identification (estimation) of the functional relationship between a particular explanatory and explanatory variable. The correlation relationship can be expressed using the Pearson correlation coefficient, which may take the following form:

$$P = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y} = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\Sigma(x_i - \bar{x})^2 \Sigma(y_i - \bar{y})^2}} \quad (1)$$

Where *X* represents the mean value of the enterprise solvency matrix represented by the selected enterprise liquidity indicator, *Y* is the mean of the matrix of the values of the individual financial indicators related to the structure of the sources of financing (explanatory variables) and *n* the number of observations. Pearson's correlation coefficient is based on the calculation by entering the covariance of the variables *X* and *Y* into the numerator, and then into the denominator the product of the standard deviations of the variables *X* and *Y*, which is defined as the root of the variance of the random variables *X* and *Y*.

The resulting correlation analysis values range from -1 to 1 when the values approaching 1 indicate a positive dependence (positive linear correlation) between the analyzed variables, the values approaching -1 have a completely opposite negative relationship (negative linear correlation). The values near 0 show the mutual independence of the variables (zero linear correlation), where the dependency can´t be determined unequivocally (there is no linear dependence confirmed here, but it can be a non-linear dependence between the analyzed variables). The variables are uncorrelated in this case. According to Evans (1996) the values of the correlation coefficient in the following range indicate:

- 0 to 0.19 very weak correlation
- 0.2 to 0.39 weak correlation
- 0.4 to 0.59 middle correlation

	Maximum	Minimum	Standard deviation	Mean	Median
L1	996.93	-29.69	28.03	2.20	0.13
L2	4113.25	-139.85	82.72	6.09	1.65
L3	7736.17	-223.06	149.55	9.45	2.53
STL	0.98	-0.01	0.11	0.08	0.02
LTL	0.75	-0.07	0.14	0.13	0.05
DER	519.28	-606.50	24.33	1.97	0.89
OCL	4.26	-0.02	0.31	0.44	0.39
ONCL	2.54	-0.02	0.19	0.11	0.04

Source: own proceeding according to Amadeus Database

Table 3: Description of used variables.

- 0.6 to 0.79 strong correlation
- 0.8 to 1 very strong correlation

The statistical significance of the correlation coefficient, which can be tested at 1%, 5% and 10% significance, plays an important role in determining the relationship between variables. Using correlation analysis and the correlation coefficient, the relationship between the variables, including their resulting direction, ie whether they are positive, negative or zero correlations, can be determined. However, it is not possible to determine which variable affects another variable.

For this reason, the Granger causality test will be used to determine which variable may affect another variable. In accordance with the article, we focus using Granger causality test to determine, whether debt founding sources structure affects the liquidity of companies and which specific variables related to debt funding sources structure affect the liquidity of food companies. To determine the existence of short-term relationships between two variables, Granger's causality test, which works with stationary rows and delays used in cointegration analysis, can be used. Granger's causality takes into account that the past can influence the future. Variable X has a causal effect (in a granger sense) on Y if past X values can help explain Y.

In the case of Granger's causality, the aim is to reject the zero hypothesis that there is no causal relationship between the variables studied. Engle and Grange (1987), in their study, quantify Granger causality by the following equations (2) a (3), where Y_t and X_t represent corporate liquidity and debt funding sources structure, ε_t error or residual component, β_0 and φ_0 constants of causal equations, β_{1t}, β_{2t}, φ_{1t} and φ_{2t} intersections with axes X and Y.

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{\sigma} \beta_{1i}\, \Delta Y_{t-i} + \sum_{i=1}^{\gamma} \beta_{2i} \Delta X_{t-1} + \varepsilon_{1t} \quad (2)$$

$$\Delta X_t = \varphi_0 + \sum_{i=1}^{\gamma} \varphi_{1i}\, \Delta X_{t-i} + \sum_{i=1}^{\gamma} \varphi_{2i} \Delta Y_{t-1} + \varepsilon_{2t} \quad (3)$$

Using the correlation analysis and the correlation coefficient, the relationship between the variables can be determined. However, it is impossible to determine how strong the dependence between these variables is, and how is a causal relationship or link between them that examines the relationship between the cause and its consequences within the variables analyzed by us. By contrast, using the Granger causality test, it is only possible to determine which variable may affect another variable.

However, it is impossible to determine how strong the dependence between these variables is, and how is a causal relationship or link between them that examines the relationship between the cause and its consequences within the variables analyzed by us. For this reason, a generalized method of moments (GMM method) will be used to determine the causal relationship between the variables and to determine the dependence of the endogenous variable on the exogenous variables.

According to Prucha (2014), the problem of panel data is mainly when individual panel data are part of a shorter time series and are unsuitable for the use of least squares in terms of panel regression. According to him, the Generalized Method of Moments (GMM method) is a suitable method for examining the functional relationships between variables that are organized into such panel data.. On the other hand, the disadvantage is the fact that it is not possible to test the given data within the basic assumptions of the smallest square method, ie heteroskedasticity, autocorrelation, normality and multi-collinearity and stationarity.

In order to ensure sufficient reporting ability, all variables will be tested for their statistical significance (for significance levels of 1%, 5% and 10%). In addition, the robustness of the model will be verified using Sargan / Hansen J-test, which determines to what extent the method is capable of delivering the same results even under load by slight parameter changes. The model is robust in this regard if the results of the Sargan / Hansen test are greater than 0.05.

The relationship between the debt financing structure and the liquidity of the bonds can be expressed using the following equation, which is in line with Hall (2005):

$$L_{it} = \alpha_1 + \beta_1 * \Delta L_{it-1} + \beta_2 * X_{1it} + \beta_3 * X_{2it} + \ldots + \beta_n * X_{nit} + \varepsilon_{it} \quad (4)$$

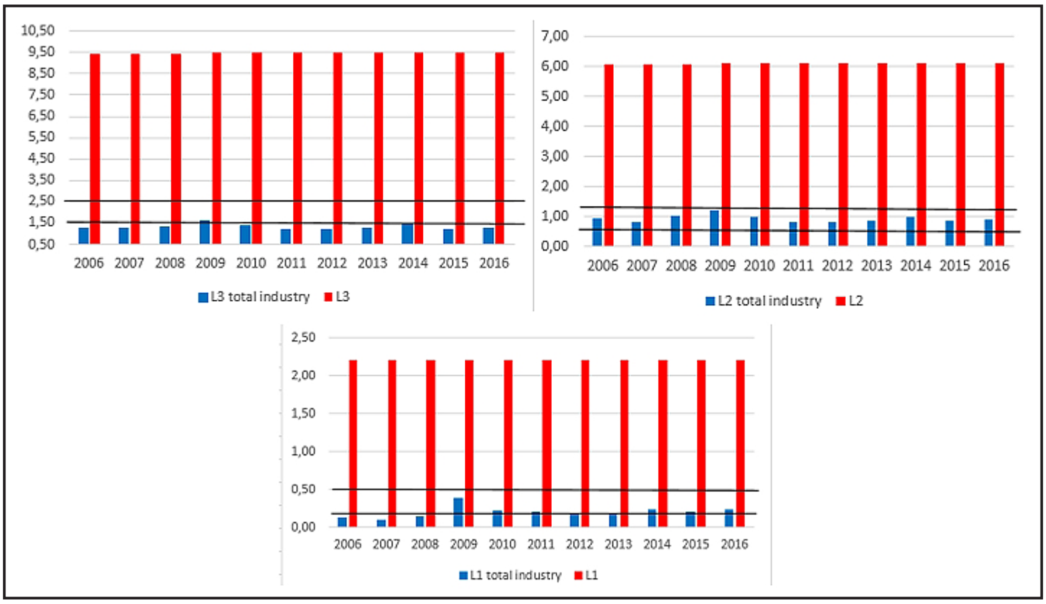
where L_{it} depicts a dependent variable that is presented through selected liquidity indicators (current ratio L_3, quick ratio L_2 and cash ratio L_1) i[th] company within the Czech Republic in time $_t$, ΔL_{it-1} is an explanatory variable that represents a delayed value L from the previous year, Xn_{it} it includes explanatory variables for which they are considered short-term loans, long-term loans, other current liabilities and other non-current liabilities. Symbols and represent the constant of the model and the residual component of the model within the generalized method of moments (GMM method).

Results and discussion

Before using the selected methods to determine the relationship between the debt funding structure and the liquidity of companies in food industry the Czech Republic, it is necessary to find out how the liquidity of companies in food industry in the Czech Republic has developed at a general level (total industry) and in our sample of analyzed companies. Data for the entire industry was drawn from the database of the Ministry of Industry and Trade of the Czech Republic.

It can be seen from Figure 1 that the liquidity (current liquidity L3, quick liquidity L2 and cash liquidity L1) of the analyzed sample of companies in food industry in the Czech Republic developed almost evenly throughout the analyzed period. The liquidity value of the analyzed companies exceeded the diametrically recommended liquidity values. If we compare these liquidity values with the values of all companies in food industry in the Czech Republic, we can say that the liquidity values (current liquidity L3, quick liquidity L2 and cash liquidity L1) of the analyzed company sample exceeded the liquidity values of all companies several times in food industry in the Czech Republic throughout the analyzed period. Regarding the trend of liquidity values of all companies in food industry in the Czech Republic, it can be stated that their liquidity values (current liquidity L3, quick liquidity L2 and cash liquidity L1) showed an alternate development trend throughout the analyzed period. Liquidity indicators (L3, L2 and L1) showed an upward trend until 2009. After this year, liquidity indicators dropped mainly due to financial crises, thanks to which businesses got into solvency problems. The Table 4 reflects the degree of interdependence of monitored parameters in food industry in the Czech Republic using correlation analysis.

It can be seen from Table 4 that a statistically significant relationship between cash liquidity and short-term loans, debt ratios, other current liabilities and other non-current liabilities has been demonstrated at a materiality level of 1 % and 5 %. The results showed a negative weak correlation



Sources: own processing from Amadeus database and Ministry of Industry and Trade of the Czech Republic

Figure 1: Development of liquidity indicators in the food industry in the Czech Republic from 2006 to 2016.

	Short-term loans	Long-term loans	Debt equity ratio	Other current liabilities	Other non-current liabilities
Cash liquidity (L1)	-0.1981*	-0.0221	-0.3443 *	-0.3630 *	-0.0741 **
Quick liquidity (L2)	-0.0535 ***	-0.0722 **	-0.5051*	-0.5337 *	-0.0867 *
Current liquidity (L3)	-0.0180	-0.0782 **	-0.5132 *	-0.5479 *	-0.0939 *

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 4: Correlation between liquidity and debt funding sources structure.

force towards neutral correlation. This means that if there is a rise in short-term loans, debt ratios, other current liabilities and other non-current liabilities, there will be a rise in cash liquidity. The correlation between the cash liquidity and the long-term loans indicator was not statistically significant.

Furthermore, the negative very weak correlation between the quick liquidity and the short-term loans, long-term loans and other non-current liabilities was demonstrated at a statistical significance level of 1 %, 5 % and 10 %. Within the debt equity ratio, other current liabilities and quick liquidity, the negative mean correlation strength was demonstrated. We can say that the decline in the debt financing sources structure will have an impact on the growth of quick liquidity. The correlation coefficient showed a negative very low correlation strength between current liquidity and long-term loans and other non-current liquidity at 1 % and 5 % level of statistical significance. On the contrary, the negative average correction force has been demonstrated between current liquidity and current liquidity and other current liabilities. Similarly, the decline in these indicators will trigger the growth of current liquidity.

Using correlation analysis we found out whether there is a linear correlation dependence between two variables. However, we are not able o determine which variable affects another variable. Using a Granger causality test, you can determine the direction in which the variables analyzed are mutually affected (Table 5).

Granger causality test	F-Statistic	Probability
DER ≠> L1	49.7244	2.00E-12
L1 ≠> DER	12.4812	0.0004
STL ≠> L1	4.96532	0.026
L1 ≠> STL	3.33838	0.0679
L1 ≠> ONCL	2.77996	0.0956
OCL ≠> L1	62.9391	3.00E-15
L1 ≠> OCL	18.4305	2.00E-05
DER ≠> L2	54.0902	3.00E-13
L2 ≠> DER	4.22397	0.04
LTL≠> L2	9.75569	0.0018
L2 ≠> LTL	4.31988	0.0379
L2 ≠> ONCL	4.51687	0.0337
ONCL≠> L2	47.5419	7.00E-12
DER ≠> L3	40.5843	2.00E-10
L3 ≠> DER	3.58992	0.0583

Source: authors' calculations

Table 5: Granger causality test between liquidity and debt funding sources structure (to be continued).

Granger causality test	F-Statistic	Probability
L3 ≠> LTL	5.52193	0.019
STL≠> L3	5.83457	0.0159
L3 ≠> ONCL	3.01005	0.0829
OCL≠> L3	30.5883	4.00E-08
L3 ≠> OCL	3.52476	0.0606

Source: authors' calculations

Table 5: Granger causality test between liquidity and debt funding sources structure (continuation).

Based on the results of the Granger Causality test, the double bond relationship between the debt equity ratio and the cash liquidity, short-term loans and cash liquidity, other current liabilities and cash liquidity has been demonstrated. As part of the unilateral bond, the effect of cash liquidity on other non-current liabilities was demonstrated. Any change in debt equity ratio and short-term loans will affect cash liquidity of food companies. Conversely, if there is a change in cash liquidity, debt equity ratio, short-term loans and other non-current liabilities will also change. With regard to quick liquidity, the mutual influence of debt equity ratio, long-term loans and other non-current liabilities on quick liquidity has been demonstrated. Changing these indicators will impact quick liquidity and vice versa.

In addition, the impact of the debt ratio, short-term loans and other current liabilities on current liquidity was demonstrated. If these indicators change, this change will also reflect current liquidity. Within current liquidity, its impact on the debt equity ratio, long-term loans, other current liabilities and other non-current liabilities has also been demonstrated. However, it should be noted that within the Granger causality, the test plays an annual delay role, where any change in the debt financing sources structure will be reflected in the company's liquidity with annual delays, and vice versa.

Using a Granger causality test, the direction in which the variables to be analysed could be influenced. However, we are not able to determine the causal relationship between the variables and determine the dependence of the endogenous variable on the exogenous variables. For this reason, the above methods were extended by the Generalized Method of Moments (GMM method) (Table 6).

The results of the GMM method showed the positive effect of long-term loans on cash liquidity (coefficient + 0.0615) on a statistical significance level of 5%. This means that

	Delayed variable	Short term loans	Long term loans	Debt equity ratio	Other current liabilities	Other non-current liabilities	J-statistic
Cash liquidity (L1)	**1.0105 ***	-0.0466	**0.0615 *****	0.0767	**-0.5233 ***	-0.0286	127.3720
Quick liquidity (L2)	**1.2564 ***	0.0112	**0.0155 *****	0.0437	**-0.2635 ***	0.0028	88.28076
Current liquidity (L3)	**1.3422 ***	0.0064	0.0087	0.0104	**-0.1894 ***	0.0099	73.27072

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 4: Correlation between liquidity and debt funding sources structure.

the growth of long-term loans will affect the growth of cash liquidity in food companies. In the case of higher debt, companies can use the tax shield that companies can use to their advantage. Companies can make money in the form of long-term loans to finance their activities or to invest in more profitable projects, which will then yield a higher yield than the cost of external financing in the form of long-term loans. Increasing indebtedness of companies in the food industry is also a risk for their creditors, especially agricultural primary production, which records long-term receivables from these companies. Table 5 shows that the positive effect of long-term loans (+ 0.155) on quick liquidity on the level of 5% of statistical significance has been demonstrated. If a company tends to become more indebted, quick liquidity will occur. These results correspond to the cash liquidity results, where a similar effect of long-term loans to quick liquidity has occurred. This is in line with Baskin (1987), which concluded that companies with higher debt would accumulate liquidity because of the higher probability of financial distress. Also, Sufi (2009) found that companies that have significantly reduced access to credit have a particularly greater chance of saving cash from cash flows. This savings can be achieved by using a so-called tax shield, which can be seen as one of the benefits of taking credit from a company. Morellec (2001), who believes that companies are in debt because of the aforementioned tax shield, which companies can use to their advantage, is in support of this claim. In his research, Anderson (2002) believed that if a company relies on a high level of debt financing for a long time, it tends to have a high level of liquid assets. This fact leads the author to identify a potential link where a high level of debt leads to high liquidity, which in turn will lead to a slow growth of the company. This resulting relationship is in line with the presence of a proprietary liquidity holding motive for companies that maintain a high level of debt as a permanent feature of their capital structure. Šarlija and Harc (2012) also believe that long-term debt companies have more liquid assets and can be considered more liquid.

Furthermore, the negative effect of other current liabilities on cash liquidity (-0.5233) on the statistical significance level was 1 %. If there is a decline in other current liabilities, there will be cash liquidity growth and vice versa. Other current liabilities include mainly payables to suppliers. In the case of companies in the food industry, they play a significant role in the obligations towards suppliers, especially agricultural holdings. At the level of statistical significance of 1 % the negative impact of other current liabilities on quick liquidity (- 0.2635) was confirmed. Growth of other current liabilities will lead to a reduction in quick liquidity. Within current liquidity, the negative effect of other current liabilities on current liquidity (- 0.1894) was confirmed at 1 % of the level of statistical significance. If there is an increase in unpaid liabilities, the current liquidity will decrease. This is in line with Ferreira and Vilela (2004), who suggest that companies with a high level of debt funds are less able to dispose of a high volume of highly liquid assets. Thus, the authors concluded that there is a negative link between debt sources of funding and the holding of highly liquid funds. Kim, Mauer and Sherman (1998) have shown a negative relationship between foreign resources and corporate liquidity in their study. Opler, Pinkowitz, Stulz, and Williamson (1999) also found similar results in their study, using a panel regression analysis to demonstrate a negative relationship between debt sources and corporate liquidity. Furthermore, the negative relationship between short-term debt resources and liquidity was demonstrated. This is because short-term debt assets and liquid assets can be a substitute in that a company facing low cash flow will respond to this either by drawing disposable liquid assets or by accumulating short-term foreign resources or a combination of both. Šarlija and Harc (2012), using Pearson's correlation coefficient, demonstrated the existence of a negative relationship between corporate liquidity and foreign funding sources. The authors of the study also concluded that the negative relationship between company liquidity and short-term foreign sources is more significant than the positive relationship between company liquidity and long-term debt sources.

The statistical significance of the results found is the J-statistic (127.3720 for cash liquidity, 88.28076 for quick liquidity, 73.27072 for current liquidity), which confirms the robustness of all three models. The effect of the other variables analysed was not statistically significant.

Using the generalized method of moments (GMM method), indicators have been identified that affect the liquidity of companies in the food industry. Research results have shown that this is an indicator of long-term loans and other current liabilities. These two indicators have the most significant impact on the company's liquidity management. Long-term loans represent the most risky loans for banks, therefore they are provided under very strict conditions. Credit risk corresponds to higher interest rates as compared to short-term loans. For businesses, however, the advantage of long-term loans lies in lower payment, which are paid over a longer period of time. Therefore, businesses are not burdened with a high outflow of funds due to a high repayment. The food industry is considered to be a diversified, largely high-turnover industry that uses long-term bank loans to further capitalize on cash. If we focus on the food industry as a whole (Figure 1), we can see that these food companies have achieved uniform liquidity values throughout the analysis period. There was only a minor fluctuation in 2009 due to the effects of the financial crisis. In general, however, the industry is not experiencing significant liquidity problems, but in many cases it is above average compared to the recommended liquidity values. The food industry is characterized by a higher level of current assets, leading to the liquidity of companies operating in the food industry. Long-term bank loans that secure the business of these companies contribute to liquidity. On the other hand, if other short-term liabilities continue to grow for these companies, this will probably jeopardize their liquidity position. An important role here is the turnover time of the commitment, which shows how long the company is able to pay its short-term liabilities. If a company pays its liabilities at longer time intervals, it means that the company rewards its money before the maturity date of its liabilities in other more profitable investments. On the other hand, this may also mean that the company has liquidity problems and is unable to pay its liabilities properly and on time.

Other current liabilities include mainly unpaid invoices, unpaid wages or unpaid taxes. Without any other current liabilities, no company can practically fail. Naturally, they arise from the normal operation of the company and from repeated business relations. Typically, they are financed by circulating assets or other operating needs. The volume of short-term capital is affected by the amount of working capital (current assets minus current liabilities) and liquidity. At the level of 1% of statistical significance, the positive ratio of the cash ratio, quick ratio, current ratio to the cash ratio, quick ratio and current ratio of the current year was shown. This means that the rise in the cash ratio, quick ratio and current ratio of the previous period increases the values of the cash ratio, quick ratio and current ratio of the current period.

Conclusion

The food industry as part of the manufacturing industry includes not only the production of food products but also the production of beverages. According to the Ministry of Agriculture (2004), the food sector, as a key element of this industry, will ensure the daily food supply of the food market. From the point of view of the standard of living, this is an important part of a consumer market with strategic importance expressing national interest that becomes urgent in crisis situations such as natural disasters etc.

The aim of this article was to determine the impact of debt funding sources structure on liquidity of companies in food industry in the Czech Republic from 2006 to 2016. With the purpose to fulfill the aim, we examined existence and character of relationship between the debt funding sources structure (long-term loans, short-term loans, other long-term liabilities, other short-term liabilities, debt equity ratio) and liquidity of the companies in food industry in the Czech Republic. The relationship between debt funding sources structure and liquidity of companies was tested through correlation analysis, Granger causality test and generalized method of moments (GMM).

The results showed that it is important for companies in the food industry to track the volume of long-term loans and the volume of other current-liabilities. The results confirmed that long-term loans have a positive effect on the cash ratio and quick ratio.

The resulting coefficients are + 0.0615 for cash liquidity and + 0.0155for quick liquidity. This means that if the long-term bank loans increase by 1 unit, the cash liquidity value increases by 0.0615 units and the quick liquidity value by 0.0155 units. The results also confirmed the negative impact of other current liabilities on the cash ratio, the quick ratio and the current ratio. The resulting coefficients are - 0.5233 for cash liquidity, - 0.2635 for quick liquidity and – 0.1894 for current liquidity. This means that if other current liabilities increase by 1 unit, the cash liquidity value drops by 0.5233 units, the quick liquidity value drops by 0.2635 units and the current liquidity drops by 0.1894 units. If the company's indebtedness is regularly monitored, the amount of the owed amount will be fully controlled by the company and the borrowed funds will be used appropriately in the production process, it will have a positive impact on corporate liquidity. On the other hand, if there is a constant increase in other current liabilities, this will reduce corporate liquidity.

The conclusion can be said, as stated by the Institute of Agricultural Economics and Information (2017), the production of food products in the Czech Republic belongs to the major branches of the manufacturing industry as well as to the whole of the European Union. This is mainly due to deliveries for the domestic market, which ensures the nutrition of the population through the production and sale of healthy and safe foods, which is controlled by the supervising institutions including the quality of the products. It turns out that not only the price but also the quality decides to buy a particular food. Although foreign trade in food products has a negative balance, exports have considerable importance in the complicated situation in some territories. This fact proves the quality and competitiveness of Czech food production both in the European and world markets.

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References

[1] Ahn, S., Denis, D. and Denis, D. (2006) “Leverage and investment in diversified firms”, *Journal of Financial Economics*, Vol. 79, No. 2, pp. 317-337. ISSN 0304-405X. DOI 10.1016/j.jfineco.2005.03.002.

[2] Anderson, R. W. (2002) “*Capital structure, firm liquidity and growth*”, Working papers research series. National Bank of Belgium. [Online]. Available: www.nbb.be/doc/ts/publications/wp/WP27en.pdf. [Accessed: 1 Feb. 2017].

[3] Andrade, G. and Kaplan, S. (1998) “How costly is financial (not economic) distress? Evidence from highly leveraged transactions that become distressed“, *Journal of Finance,* Vol. 53, pp. 1443-1493. ISSN 1540-6261.

[4] Almeida, H., Campello, M. and Weisbach, S. M. (2004) “The cash flow sensitivity of cash“, J*ournal of Finance*, Vol. 59, pp. 1777-1804. ISSN 1540-6261. DOI 10.1111/j.1540-6261.2004.00679.x.

[5] Al-najjar, B. and Belghitar, Y. (2011) “Corporate cash holdings and dividend payments: Evidence from simultaneous analysis“, *Managerial and Decision Economics*, Vol. 32, No. 4, pp. 231-241. ISSN 1099-1468. DOI 10.1002/mde.1529.

[6] Baskin, J. (1987) “Corporate Liquidity in Games of Monopoly Power“, *The Review of Economics and Statistics*, Vol. 69, No. 2, pp. 312-319. ISSN 1530-9142. DOI 10.2307/1927239.

[7] Campello, M. (2003) “Capital structure and product markets interactions: evidence from business cycles“, *Journal of Financial Economics*, Vol. 68, pp. 353-378. ISSN 0304-405X. DOI 10.1016/S0304-405X(03)00070-9.

[8] Campello, M. and Fluck, Z. (2005) “Product Market Performance, Switching Costs, and Liquidation Values: The Real Effects of Financial Leverage“, University of Illinois. Working paper.

[9] Cohen, J. and Cohen, P. (2014) “*Applied Multiple Regression/Correlaion Analysis for the Bevaioral Sciences*“, 2nd ed., Psychology Press. ISBN 0-89859-268-2.

[10] Eisdorfer, A. (2008) “Empirical evidence of risk-shifting in financially distressed firms“, *Journal of Finance*, Vol. 63, pp. 609-637. ISSN 1540-6261. DOI 10.2139/ssrn.686435.

[11] Engle, R. F. and Granger, W. C. (1987) “Co-integration and Error Correction: Representation, Estimation, and Testing“, *Econometrica*, Vol. 55, No. 2, pp. 251-276. ISSN 1468-0262. DOI 10.2307/1913236.

[12] Evans, J. D. (1996) “*Straightforward statistics for the behavioral sciences*“, Pacific Grove, CA: Brooks/Cole Publishing Company. ISBN 978-0534231002.

[13] Ferreira, A. and Vilela, S. (2004) “Why do firms hold cash? Evidence from EMU Countries“, *European Financial Management*, Vol. 10, No. 2, pp. 295–319. ISSN 1468-036X. DOI 10.1111/j.1354-7798.2004.00251.x.

[14] Graham, J. (2000) “How big are the tax benefits of debt?“, *Journal of Finance*, Vol. 55, pp. 1901-1941. ISSN 1540-6261. DOI 10.1111/0022-1082.0027.

[15] Hall, A. R. (2005) “*Generalized Method of Moments (Advanced Texts in Econometrics)*“, Oxford: University Press. ISBN 0-19-877521-0.

[16] Institute of Agricultural Economics and Information (2017) “*Panorama of the Food Industry 2016*“, Prague: Ministry of Agriculture. ISBN 978-80-7434-387-2.

[17] Kim, C. S., Mauer, D. C. and Sherman, A. E. (1998) “The determinants of corporate liquidity: Theory and evidence“, *Journal of Financial and Quantitative Analysis*, Vol. 33, No. 3, pp. 335-359. ISSN 0022-1090. DOI 10.2307/2331099.

[18] Mehar, A. (2005) “Impacts of equity financing on liquidity position of a firm“, Applied Financial Economics, Vol. 15, pp. 425–438. ISSN 1756-6916. DOI 10.1080/0960310042000314197.

[19] Miloş, M. C. (2015) “Capital Structure Determinants. Evidence from the Romanian Listed Companies“, *Analele Universitatii 'Eftimie Murgu' Resita,* Fascicola II. Studii Economice, pp. 129-134. ISSN 1584-0972.

[20] Ministry of Agriculture (2014) “*The concept of food industry in the Czech Republic for the period after the accession of the Czech Republic to the EU (2004–2013)*“, [Online]. Available: http://eagri.cz/public/web/file/3045/_16452_32655_Koncepce_potravinarstvi__2004_2014__1_.pdf. [Accessed: 28 July 2018].

[21] Morellec, E. (2001) “Asset liquidity, capital structure, and secured debt", *Journal of Financial Economics*, Vol. 61, pp. 173-206. ISSN 0304-405X. DOI 10.1016/S0304-405X(01)00059-9.

[22] Opler, T., Pinkowitz, L., Stulz, R. and Williamson, R. (1999) “The determinants and implications of corporate cash holdings“, *Journal of Financial Economics*, Vol. 52, No. 1, pp. 3-46. ISSN 0304-405X. DOI 10.1016/S0304-405X(99)00003-3.

[23] Peyer, U. and Shivdasani, A. (2001) “Leverage and internal capital markets: evidence from leveraged recapitalizations“, *Journal of Financial Economics*, Vol. 59, pp. 477-516. ISSN 0304-405X. DOI 10.1016/S0304-405X(00)00094-5.

[24] Prucha, I. R. (2014) “Instrumental Variables/Method of Moments Estimation“, In: Fisher, M. M. and Nijkamp, P. eds. "*Handbook of Regional Science*", Heidelberg: Springer. ISBN 978-3-642-23430-9. DOI 10.1007/978-3-642-23430-9_90.

[25] Růčková, P. (2014) "Vztah rentability, likvidity a hrubého domácího produktu v podmínkách České republiky", *Český finanční a účetní časopis*, Vol. 1, pp. 140-147. ISSN 1802-2200. (In Czech). DOI 10.18267/j.cfuc.388.

[26] Růčková, P. (2015) "Vliv likvidity a rentability na využití zdrojů financování ve zpracovatelských podnicích v zemích V4", *Acta academica karviniensia*, Vol. 15, No. 3, pp. 69-79. ISSN 1212-415X. DOI 10.25142/aak.2015.032.

[27] Shah, P. (2012) "Evaluation of Profitability and Liquidity Relationship through Multivariate Working Capital Analysis", *A Management Journal*, Vol. 3, No. 2, pp. 177-198. ISSN 0378-7206.

[28] Stulz, R. (1990) "Managerial discretion and optimal financing policies", *Journal of Financial Economics*, Vol 26, No. 1, pp. 3-27. ISSN 0304-405X. DOI 10.1016/0304-405X(90)90011-N.

[29] Sufi, A. (2009) "Bank lines of credit in corporate finance: an empirical analysis", *Review of Financial Studies*, Vol. 22, No. 3, pp. 1057-1088. ISSN 1465-7368. DOI 10.1093/revfin/hhm007.

[30] Šarlija, N. and Harc, M. (2012) "The impact of liquidity on the capital structure: a case study of Croatian firms", *Business Systems Research*, Vol. 3, No. 1, pp. 30-36. ISSN 1847-9375. DOI 10.2478/v10305-012-0005-1.

[31] Šeligová, M. (2017) "The Effect of Selected Financial Indicators on Liquidity of Companies in Selected Sectors in the Czech Republic", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 65, No. 6, pp. 2085-2091. ISSN 1211-8516. DOI 10.11118/actaun201765062095.

[32] Šeligová, M. (2018) "The Impact of Funding Sources on Corporate Liquidity in Energy Sector in the Czech Republic and Slovak Republic", *Scientific Papers of the University of Pardubice – Series D*, Vol. 25, No. 42, pp. 223-234. ISSN 1804-8048. DOI 10.3846/cbme.2017.116.

[33] Trippner, P. (2013) "Analysis of Financial Liquidity Management in the Enterprise and its Impact on the Profitability", In: Stavárek, D. and P. Vodová (ed). In: *Proceedings of 14th International Conference on Finance and Banking. Karviná*: Silesian University, School of Business Administration, pp. 494-501. ISBN 978-80-7248- 939-8.

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Indicators' Dynamics of Irrigated Agriculture by Federal Districts of Russia

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Abstract

Currently, up to 80% of agricultural land needs watering in the Russian Federation. Therefore, the state of irrigated agriculture affects the efficiency and effectiveness of the country's food sector. The subject of this article is the studying of the basic indicators' dynamics of irrigated agriculture (total irrigated area, its condition: good, satisfactory and unsatisfactory, costs per hectare of irrigated area and actually watered area) and their interrelations in all federal districts of the Russian Federation for 2013-2016.

Methods of economic and statistical analysis were used in the work, in particular, analysis of the time series, correlation and cluster analyses.

As a result of the studying, it was established that the state and development of irrigated agriculture in the Russian Federation is unstable and cannot be regulated solely by climatic factors.

Keywords

Irrigated agriculture, irrigated area condition, cost per hectare of irrigated area, correlation analysis, cluster analysis.

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Introduction

One of the most important tasks of the subprogramme "Development of Land Reclamation for Agricultural Land of Russia for 2014-2020" is increasing the productive potential of irrigated land (Direction, 2013). Expansion of irrigated areas, improvement of their condition, improvement of irrigation technology and quality of management of irrigated areas increases productivity and reduces the payback period of funds invested in irrigated land use, contributes to increasing the competitiveness of irrigated areas (Jamin et al., 2011).

The studying over the long-term period of the development trends of irrigated agriculture and its economic and statistical analysis makes it possible to identify untapped development drivers, determine the points of economic growth of irrigated agriculture and increase its efficiency, which will allow not only meeting the needs of the population in agricultural production, but also increase the country's export capacity (Chernova and Gilina, 2009).

Compared with the other industrialised countries, the Russian Federation is located in an unfavorable climate zone for agriculture, which sharply reduces the competitiveness of agriculture, hinders the development of other sectors of the national economy, and causes an increased need for government support. In droughty, as well as in excessively wet years, the possibilities of highly productive varieties of crops, innovative technologies of their cultivation, and even progressive farming systems are not realised.

However, the territory of the Russian Federation is not homogeneous in terms of agricultural production and irrigated agriculture. It is necessary to distinguish regions that provide the maximum return on investment in irrigated land. Such territories as the SFD can be attributed as the most favorable from the point of view of natural climatic factors and ensuring the maximum effect from the investment in irrigated agriculture (Ugryumova, et al., 2018).

In all countries of the world with developed agriculture, the state allocates budget funds for the implementation of policies aimed at the rational using of water and other types of resources, through the modernisation and reconstruction of irrigation systems, the introduction of new environmentally friendly and resource-saving irrigation techniques, and optimisation of planning processes. (Klimova, 2013) The high costs of forming and expanding the fund of irrigated lands require not only careful monitoring, but also taking into account all factors affecting the optimal spending of funds. It is also necessary to counter government the destabilizing effects of the market environment.

The difficult situation in irrigated agriculture of the Russian Federation and the changing conditions of the socio-economic environment require detailed analysis, factors affecting the development and effectiveness of irrigated agricultural production. Allocation of the most characteristic and typical processes in irrigated agriculture of the country will allow the formation of specialised clusters of the Russian Federation's regions and work out unified methods of socio-economic impact with respect to them, increasing their competitiveness (Alahtaeva, 2011).

The methods of statistical analysis make it possible to identify the causal interrelationships of the processes in irrigated agriculture, to determine the main trends of its development in the Russian regions and to analyse them taking into account all-Russian changes in the economy and legislation. These studies simultaneously make it possible to specify the prospects for the development of irrigation technology and technology, and, therefore, have an impact on the intensification of the development of agricultural production.

Similar surveys are carried out in other countries of the world using irrigated agriculture. So, for example, drip irrigation technologies are a serious area of research and development in one of the most agricultural-oriented countries in the world - India (Raut et al., 2014). In countries which are experiencing increased demand for water, particular importance is given to researching water reuse opportunities.

Glazyev argues that only 14 of the 85 subjects of the Russian Federation are net- food producers, and the remaining 71 act as net-consumers. This ratio reveals the special role of the regions that bear the main burden of the country's food supply. (Glazyev, 2016).

The aim of this article is the studying of the basic indicators' dynamics of irrigated agriculture (total irrigated area, its condition: good, satisfactory and unsatisfactory, costs per hectare of irrigated area and actually watered area) and their interrelations in all federal districts of the Russian Federation for 2013-2016.

Materials and methods

The authors of the article use materials from the Department of Land Reclamation of the Agriculture's Ministry of the Russian Federation, methods of economic and statistical analysis, in particular, the analysis of time series, correlation analysis, cluster analysis.

The authors conducted an economic and statistical analysis of the following basic indicators of irrigated agriculture:

X_1, X_2, X_3 are the specific weights of irrigated lands, respectively, in good, satisfactory and unsatisfactory condition (%);

X_4 - the total cost per hectare of irrigated land (thousand rubles);

X_5 - specific weights of actually watered areas (%);

X_6 - the total area of irrigated land (thousand hectares)

by federal districts of Russia in 2013-2016 (Table 1).

In Table 2 the chain increments of these indicators for 2014-2016 are given.

From the Table 2 it follows:

- increasing of the total area of irrigated land with an increasing trend of costs per hectare of irrigated area was observed in the Central Federal District (2016), North Caucasian Federal District (2014), Volga Federal District (2014,2016), Siberian Federal District (2015), and with decreasing trend of expenses - in the Central Federal District (2014, 2015), the North-West Federal District (2014), the Southern Federal District (2016), the Ural Federal District (2016), the Volga Federal District (2015) and the Siberian Federal District (2014);
- decreasing of the proportion of areas in an unsatisfactory condition with an increasing trend of costs per hectare of irrigated area was observed in the SFD (2015), PFD (2016), FEFD (2015), and in a decreasing cost trend - in the CFA (2014-2015), the North-West Federal District (2014), the North Caucasian Federal District (2015), the Southern Federal

Year	Federal District	X_1, %	X_2, %	X_3, %	X_4, thousand roubles	X_5, %	X^6, thousand hectares
2013	Central	50.89	24.18	24.93	74.97	17.53	473.949
	Northwestern	10.79	51.22	37.98	50.61	2.58	17.373
	North Caucasus	46.67	23.74	29.59	32.31	44.79	925.506
	Southern	57.27	20.47	22.26	51.46	53.53	1111.451
	Volga	64.6	30.21	5.19	31.01	52.27	806.496
	Ural	57.47	32.55	9.98	39.30	16.92	132.082
	Siberian	50.36	39.19	10.45	47.56	47.42	498.605
	Far Eastern	50.42	23.25	26.33	172.38	21.61	113.292
2014	Central	51.18	24.08	24.73	40.05	17.54	480.054
	Northwestern	7.21	58.37	34.42	45.86	4.39	17.660
	North Caucasus	41.23	23.92	34.86	45.37	42.48	1023.165
	Southern	57.80	20.19	22.01	36.01	38.97	1111.064
	Volga	67.68	12.05	20.27	31.95	47.82	885.537
	Ural	53.14	35.66	11.20	22.83	17.12	120.182
	Siberian	50.80	40.63	8.57	16.65	47.20	499.801
	Far Eastern	51.55	21.28	27.17	24.56	22.03	113.292
2015	Central	52.37	23.77	23.86	31.10	13.57	482.568
	Northwestern	7.59	56.69	35.72	40.19	2.84	16.772
	North Caucasus	41.49	23.71	34.81	35.43	50.41	1017.944
	Southern	57.00	21.43	21.57	62.94	33.77	1110.441
	Volga	67.60	27.68	4.73	27.26	40.76	898.505
	Ural	52.72	36.05	11.24	25.72	17.97	120.098
	Siberian	49.46	41.53	9.01	83.29	38.56	499.807
	Far Eastern	52.42	23.04	24.54	169.36	15.90	113.286
2016	Central	43.63	30.80	25.58	52.65	12.09	484.900
	Northwestern	7.59	54.90	37.51	47.57	0.00	16.772
	North Caucasus	41.24	23.79	34.97	31.77	48.75	1013.949
	Southern	57.61	20.82	21.56	40.64	34.28	1110.471
	Volga	67.78	27.56	4.67	29.62	24.26	904.5247
	Ural	52.78	35.97	11.26	21.18	17.39	120.508
	Siberian	47.98	43.06	8.97	43.66	37.05	499.173
	Far Eastern	47.30	23.23	29.47	36.13	17.47	113.286

Source: compiled by the authors based on data from the Ministry of Agriculture of the Russian Federation

Table 1: Basic indicators of irrigated agriculture by federal districts of the Russian Federation for 2013-2016.

Federal District	Indicator	Chain increments		
		2014	2015	2016
CFD	X_1,%	0.29	1.19	-8.74
	X_2,%	-0.1	-0.31	7.03
	X_3,%	-0.2	-0.87	1.72
	X_4, thousand roubles	-34.92	-8.95	21.55
	X_5,%	0.01	-3.97	-1.48
	X_6, thousand hectares	6.105	2.514	2.332

Source: compiled by the authors based on data from the Ministry of Agriculture of the Russian Federation

Table 2: Chain increments of indicators X_1, X_2, X_3, X_4, X_5 and X_6 in the federal districts of the Russian Federation for 2014-2016 (to be continued).

Federal District	Indicator	Chain increments		
		2014	2015	2016
NWFD	X_1,%	-3.58	0.38	0
	X_2,%	7.15	-1.68	-1.79
	X_3,%	-3.56	1.3	1.79
	X_4, thousand roubles	-4.75	-5.67	7.38
	X_5,%	1.81	-1.55	-2.84
	X_6, thousand hectares	0.287	-0.888	0
NCFD	X_1,%	-5.44	0.26	-0.25
	X_2,%	0.18	-0.21	0.08
	X_3,%	5.27	-0.05	0.16
	X_4, thousand roubles	13.06	-9.94	-3.66
	X_5,%	-2.31	7.93	-1.66
	X_6, thousand hectares	97.659	-5.221	-3.995
SFD	X_1,%	0.53	-0.8	0.61
	X_2,%	-0.28	1.24	-0.61
	X_3,%	-0.25	-0.44	-0.01
	X_4, thousand roubles	-15.45	26.93	-22.3
	X_5,%	-14.56	-5.2	0.51
	X6, thousand hectares	-0.387	-0.623	0.03
PFD	X_1,%	3.08	-0.08	0.18
	X_2,%	-18.16	15.63	-0.12
	X_3,%	15.08	-15.54	-0.06
	X_4, thousand roubles	0.94	-4.69	2.36
	X_5,%	-4.45	-7.06	-16.5
	X_6, thousand hectares	79.041	12.968	6.0197
UFD	X_1,%	-4.33	-0.42	0.06
	X_2,%	3.11	0.39	-0.08
	X_3,%	1.22	0.04	0.02
	X_4, thousand roubles	-16.47	2.89	-4.54
	X_5,%	0.2	0.85	-0.58
	X_6, thousand hectares	-11.9	-0.084	0.41
SFD	X_1,%	0.44	-1.34	-1.48
	X_2,%	1.44	0.9	1.53
	X_3,%	-1.88	0.44	-0.04
	X_4, thousand roubles	-30.91	66.64	-39.63
	X_5, %	-0.22	-8.64	-1.51
	X_6, thousand hectares	1.196	0.006	-0.634
FEFD	X_1,%	1.13	0.87	-5.12
	X_2,%	-1.97	1.76	0.19
	X_3,%	0.84		4.93
	X_4, thousand roubles	-147.82	144.8	-133.23
	X_5,%	0.42	-6.13	1.57
	X_6, thousand hectares	0	-0.006	0

Source: compiled by the authors based on data from the Ministry of Agriculture of the Russian Federation

Table 2: Chain increments of indicators X_1, X_2, X_3, X_4, X_5 and X_6 in the federal districts of the Russian Federation for 2014-2016 (continuation).

District (2014, 2016), the Volga Federal District (2015), and the Siberian Federal District (2014, 2016);

- increasing of the proportion of actually watered areas with an increasing trend of costs per hectare of irrigated area was observed in the UFO (2015), and with a decreasing trend in costs - in the Central Federal District (2014), North-West Federal District (2014), North-Caucasian Federal District (2015), South Federal District (2016), UFO (2014) and the Far Eastern Federal District (2014, 2016).
- Considering that the proportion of actually watered areas also depends on climatic conditions, the dynamics of irrigated agriculture can be considered positive if the total area of irrigated land increases and the proportion of areas in an unsatisfactory condition decreases. Thus, the positive dynamics of irrigated agriculture in 2014 was observed in the Central Federal District, North-Western Federal District and Siberian Federal District, in 2015 - in the Central Federal District and Volga Federal District, and in 2016 - in the Southern Federal District and Volga Federal District.
- The Table 3 shows the linear coefficients of pair correlation of costs per 1 hectare of irrigated areas and the rest of the analyzed factors by federal districts. At the same time, a positive coefficient indicates a direct relationship (with an increase in the values of one indicator, the values of the other increase), and a negative coefficient indicates an inverse relationship (with an increase in the values of one indicator, the values of the other increase).

The analysis (Table 3) leads to the following conclusions:

- the dependence of the proportion of areas in good condition on the cost of 1 ha direct in the Northwestern Federal District, UFD and Far Eastern Federal District, in other districts it is inverse, while it is strong in the SFD and UFD, noticeable in the NWFD, moderate in the PFD, SFD and DFD, weak in CFD;
- the dependence of the proportion of areas in satisfactory condition on the cost of 1 ha direct in the Central Federal District, North-Caucasian Federal District, Southern Federal District, North-Eastern Federal District and Far Eastern Federal District, in other districts it is reverse, while it is strong in North-West Federal District, Southern Federal District and Volga Federal District, noticeable in the North-Western Federal District, Volga Federal District and Far-Eastern Federal District, weak in the Central Federal District and Siberian Federal District;
- the dependence of the proportion of areas in an unsatisfactory condition on the cost per 1 ha direct in the Central Federal District, North-West Federal District, North Caucasus Federal District, Volga Federal District and Siberian Federal District, in other districts it is reverse, while it is strong in the Volga Federal District and Far Eastern Federal District, moderate in the Volga Federal District, North Caucasus Federal District, moderate North Volga Federal District and weak in the SFD and SFD;
- the dependence of the proportion of actually watered areas on the cost of 1 ha is direct in the Central Federal District, Southern Federal District and Volga Federal District, it is reversed in other districts, while it is noticeable in the SCF and SFD, moderate in the Central Federal District, Volga Federal

Factor	Federal districts							
	CFD	NWFD	NCFD	SFD	PFD	UFD	SFD	FEFD
X_1	-0.23	0.67	-0.42	-0.99	-0.32	0.97	-0.35	0.46
X_2	0.15	-0.69	0.82	0.80	-0.56	-0.96	0.17	0.59
X_3	0.59	0.61	0.4	-0.21	0.67	-0.97	0.2	-0.78
X_5	0.36	-0.24	-0.63	0.03	0.43	-0.47	-0.56	-0.17
X_6	-0.69	0.44	0.48	-0.22	-0.45	0.97	0.07	-0.03

Source: compiled by the authors based on data from the Ministry of Agriculture of the Russian Federation

Table 3: Linear correlation coefficients of costs per 1 ha of irrigated area and analysed factors.

District, Volga Federal District, is weak in the SFD;

- the dependence of the total irrigated area on the cost per 1 ha is direct in the Northwestern Federal District, North Caucasus Federal District, UFD and SFD, in other districts it is reverse, while it is strong in UFD, noticeable in the Central Federal District, moderate in the Northwest Federal District, North Caucasian Federal District, Volga Federal District, weak in the Southern Federal District and is absent in the SFD and FEFD.

As a result of the cluster analysis performed by the k-means method in the SPSS statistical package on the basis of the state indicators for 2013-2016, three clusters of federal districts were formed, the cluster profiles of which (average values of indicators in federal districts located in one cluster) are given in (Table 4).

Results and discussion

First of all the conducted cluster analysis confirmed the steady position of the federal districts in the four-year retrospective analysis, which testifies to the well-established positioning of these territories in irrigated agriculture.

These findings are fully correlated with previous studies conducted and published by the authors, devoted to the analysis of the using of irrigated land in the Federal Districts of the Russian Federation (Ugryumova et al., 2018).

Analysis (Table 4) showed that during the studying period from 2013 to 2016 the federal districts of the 1st cluster (North Caucasus Federal District, the Southern Federal District and the Volga Federal District) occupied the first places, the districts of the 2nd cluster (the Central Federal District and the Siberian Federal District) ranked second, and the districts of the 3rd cluster (the North-West Federal District, the Volga Federal District and the Far Eastern Federal District) occupied third position in irrigated agriculture. It should be noted that all districts with positive dynamics of irrigated areas, except for the North-West Federal District, were included in the 1st and 2nd clusters.

2013	**Clusters**			**2014**	**Clusters**		
	1	2	3		1	2	3
	NCFD SFD PFD	CFD SFD	NWFD UFD FEFD		NCFD SFD PFD	CFD SFD	NWFD UFD FEFD
Cluster Profiles							
Indicators	**Average values**			**Indicators**	**Average values**		
X_1	56.18	50.63	39.56	X_1	55.57	50.99	37.30
X_2	24.81	31.69	35.67	X_2	18.72	32.36	38.44
X_3	19.I	17.69	24.76	X_3	25.71	16.65	24.26
X_4	38.26	61.27	87.43	X_4	37.78	28.35	31.08
X_5	50.20	32.48	13.70	X_5	43.09	32.37	14.51
X_6	947.82	486.28	87.58	X_6	1006.59	489.93	83.71
2015	**Clusters**			**2016**	**Clusters**		
	1	2	3		1	2	3
	NCFD SFD PFD	CFD SFD	NWFD UFD FEFD		NCFD SFD PFD	CFD SFD	NWFD UFD FEFD
Cluster Profiles							
Indicators	**Average values**			**Indicators**	**Average values**		
X_1	55.36	50.92	37.58	X_1	55.54	45.81	35.89
X_2	24.27	32.65	38.59	X_2	24.VI	36.93	38.03
X_3	20.37	16.44	23.83	X_3	20.40	17.28	26.VIII
X_4	41.88	57.20	78.42	X_4	34.01	48.16	34.96
X_5	41.65	26.VII	XII.24	X_5	35.76	24.57	XI.62
X_6	1008.96	491.19	83.39	X_6	1009.65	492.04	83.52

Source: compiled by the authors based on data from the Ministry of Agriculture of the Russian Federation

Table 4: Federal District Clusters and their Cluster Profiles.

Conclusion

The state and development of irrigated agriculture in the Russian Federation is unstable and cannot be regulated solely by climatic factors (in particular, the quality of federal and regional government, the size and structure of financial flows, etc.) affect the development of irrigated agriculture. Strong enough on the development of irrigated agriculture is influenced by the material and technical condition of the existing equipment and its level of wear[1].

The cost per hectare of irrigated area across federal districts is highly differentiated and is not always effective regardless of the area's climatic conditions.

Throughout 2013-2016 the North Caucasus Federal District, the Southern Federal District and the Volga Federal District were the leaders, and the Northwestern Federal District, the Ural Federal District and the Far Eastern Federal District were outsiders in irrigated agriculture.

It is necessary to improve the existing and develop new methodological approaches to managing the economic development of irrigated agriculture, justifying federal and regional funding for irrigated agriculture, and developing proposals for improving the efficiency of investment in irrigated agriculture of private land users of the Russian Federation.

[1] Ugryumova, A. A., Zamakhovsky, M P, Kapustina, T. A. (2018) "Technological safety of agriculture in regions with land reclamation agriculture", *National interests: priorities and security*, Vol. 14, No. 2, pp. 221 - 235.

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References

[1] Alahtaeva, N.M. (2011) "Justification of the cluster policy in order to develop agricultural production in the regions", *Herald of the Krasnodar State Agrarian University*, No. 10. [Online]. Available: https://cyberleninka.ru/article/v/obosnovanie-provedeniya-klasternoy-politiki-s-tselyu-razvitiya-selskohozyaystvennogo-proizvodstva-v-regionah [Accessed: 16 Jan. 2019].

[2] Glazyev, S.Y. (2016) "О продовольственной безопасности России" (in Russian), Report of the group of experts of the Izborsky Club under the leadership of Academician of RAS S. Y. Glazyev. [Online]. Available: http://www.dynacon.ru/content/articles/1725. [Accessed: 15 Jan. 2019].

[3] Jamin, J.-Y., Bouarfa, S., Poussin, J.-C. and Garin, P. (2011) "Irrigated agriculture facing new challenges", *Cahiers Agricultures*, Vol. 20, No. 1-2, pp. 10-15. ISSN 1166-7699. DOI 10.1684/agr.2011.0477.

[4] Klimova, N. V. (2013) "Features of the regulatory impact of the state on agribusiness in foreign countries", *Scientific journal KubGAU*, No. 90 (06). [Online]. Available: https://cyberleninka.ru/article/v/osobennosti-reguliruyuschego-vozdeystviya-gosudarstva-na-agrobiznes-v-zarubezhnyh-stranah [Accessed: 25 Jan. 2019].

[5] Direction (subprogram) (2019) "Development of Land Reclamation for Agricultural Lands of Russia for 2014–2020" (approved by the Decree of the Government of the Russian Federation by October 12, 2013 N 922). [Online]. Available: http://ivo.garant.ru/#/document/70210644/paragraph/5468590:2 [Accessed: 1 Feb. 2019].

[6] Raut, S. M., Agarwal, P. K., Singh, O. P. (2014) "Economic viability of drip irrigation in cotton in Jalna district of Maharashtra, India", *Annals of Agri Bio Research,* Vol. 19, No. 2, pp. 316-320. ISSN 0971-9660.

Ugryumova, A. A., Zamakhovsky, M. P., Pautova, L. E., Tyurina, L. M. (2018) "Analysis of the potential's using of irrigated agriculture on the example of the Southern Federal District", *Regional Economics: Theory and Practice*, Vol. 16, No. 11 (458), pp. 2075-2091. E-ISSN 2311-8733, ISSN ISSN 2073-1477. DOI 10.24891/re.16.11.2075.

[7] Ugryumova, A. A., Olgarenko, D. G., Zamakhovsky, M. P. (2018) "The analysis of the main factors of the irrigated agriculture in the federal districts of the Russian Federation", *International Multidisciplinary Scientific GeoConference SGEM*, Vol. 18, No. 5.3, pp. 831-838. ISBN 978-619-7408-48-5. ISSN 1314-2704. DOI 10.5593/sgem2018/5.3/S28.106.

[8] Chernova, T. V., Gilina, T. G. (2009) "Economic-statistical study of factors affecting the regional productivity of agricultural production", *Regional Economics: Theory and Practice*, Vol. 11, No. 104, pp. 62-67. [Online]. Available: https://cyberleninka.ru/article/v/ekonomiko-statisticheskoe-izuchenie-faktorov-vliyayuschih-na-regionalnuyu-proizvoditelnost-selskohozyaystvennogo-proizvodstva [Accessed: 30 Jan. 2019].

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