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Drivers of ROE and ROA in the Czech Food Processing Industry in the Context of Market Concentration

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Abstract

The paper investigates the effects of sectoral determinants on profitability of the Czech food processing industry over the period of years 2003-2014. Large micro-level sample (N = 10,509) for 12 years and across 9 food subsectors in the Czech Republic was utilized to create a sectoral panel dataset, which was used in the empirical analysis. As for the methods, regression models with fixed effects were employed. Sectoral profitability served as the dependent variable in regressions and it was operationalized by two variables, i.e. ROA and ROE. Both profitability indicators revealed the same influence of investigated determinants. Obtained results reported positive influence of higher market concentration on sectoral profitability, and also the increase of productivity was associated with the increase of ROA and ROE. It was confirmed that high indebtedness affects the profitability negatively. Contrary to the expectations, the effect of the import penetration on the profitability was not proved.

Keywords

Industry profitability, return on assets (ROA), return on equity (ROE), market concentration, regression analysis, the Czech food industry.

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Introduction

The firm profitability is a critical issue for shareholders, firm management, and from the national point of view also for the policy makers, since increasing economic activity is positively related to the economic growth in the Czech Republic (Dvouletý, 2017). Shareholders are interested in the firm profitability, since it influences the value of their firm and their investments in the long run. The firm management is responsible for the increasing profits that, in the long run, contribute to maximization of the firm value. Furthermore, the profitability of particular industries is relevant to policy makers to be able to adopt appropriate economic measures with respect to industrial policy.

As emphasized by Polok et al. (2016), the contemporary global, turbulent and unpredictable environment forces the need to investigate the factors influencing the profitability to maintain the competitiveness. Recent empirical contributions investigated the factors of performance in a number of studies (e.g. Lopez-Valeiras et al., 2016; Maier, 2016; Hirsch et al., 2014; Machek and Špička, 2014; Janda et al., 2013; Sivathaasan et al., 2013), nevertheless, the Czech food processing industry has not received adequate interest yet. Therefore, the purpose of our study is to contribute to the literature on this issue through filling in the gap in the existing research.

Generally, the food industry is one of the most important sectors in the economy due to its great significance for economic and environmental development and also for the social welfare (FoodDrink Europe, 2016), which makes the agribusiness firms' competitiveness to be important factor of continuous economic growth (Zouaghi et al., 2016). It is also a strategic sector in relation to ensuring the population's diet (Ministry of Agriculture of the Czech Republic, 2015). The food industry as the connecting link between the producer of primary agricultural commodities and the final consumer affects, to a large extent, the competitiveness of primary agricultural production in the region and can act as a catalyst for the development of the region.

Nowadays, significant structural changes take place in the agribusiness sector – many authors emphasize the increase of market concentration and effectiveness growth (e.g. Kaditi, 2013; Sckokai a kol., 2013; González and Kujal, 2012), which is related to the changes of firms' structure and is evident especially in the food processing industry and retail sector (Hanf and Belaya, 2008; Dries et al., 2004 or Weiss and Wittkopp, 2005). Retail chains with high concentration of business activities gained considerable market power and have a decisive role in the development of food commodity verticals, as confirmed by, e.g. Lloyd et al. (2015) or the OECD (2014). Globalization processes give the agribusiness development a transnational dimension and substantially change the territorial allocation of food production. As stated by Saitone and Sexton (2017), the growing concentration of food processors and retailers, which was the subject of interest to advocates of the structure-conduct-performance (SCP) paradigm especially in the second half of the 20th century (Conner et al., 1985; Marion, 1986), is due to its impact on market power and the overall performance of the agri-food system on the front burner also today (e.g. Adjemian et al., 2016; Hirsch et al., 2014; Kaditi, 2013; Setiawan et al., 2012).

Openness of the economy and the increasing globalization mean for the Czech food processing firms not only undisputable advantages, but also much more competitive pressure than in the past. While in the past, food and raw agricultural materials mostly of the Czech origin were used for the food production, nowadays there are widely used raw materials from EU and other countries, as stated by Fuksa (2010). Also the commodity structure has changed after the entry into the EU towards the apparent growth of the share of finalized products with high value added (Svatoš and Smutka, 2012), which emphasize the key role of the food industry within the commodity verticals and networks particularly in relation to the competitiveness of the whole agri-food chin.

Nowadays, also the level of technology and implementation of innovations has become an indispensable precondition of competitiveness of the Czech food processing industry, since it significantly affects the productivity, which is nowadays of great interest to economists and managers (Lefebvre et al., 2015).

The above mentioned facts justify the timelessness and validity of the analysis focused on the key industry drivers of profitability of the Czech food processing sectors, since understanding the relationship between the structural changes on the food market and the profitability of the Czech food industry, is a key point when determining the effective industry policy. Moreover, the results of this study are relevant not only to policy makers with respect to the economic and industrial policy (Dvouletý, 2017), but have implications also for food managers and investment analysts evaluating the external environment changes.

The aim of our study is to test empirically the effect of the key industry factors on the profitability of the Czech food processing sectors in the period of years 2003-2014. Except market concentration as the main factor of our interest, the analysis includes also the impact of the market size, import penetration, productivity and leverage on two indicators of profitability – Return on Assets (*ROA*) and Return on Equity (*ROE*). We estimate the set of econometric models with fixed effects, which allows us to interpret separately the impact of the determinants on the profitability over the time and across the particular sectors keeping other factors constant.

The structure of our paper is as follows. First, the review of scientific literature related to the issue of market concentration and performance is presented. It is followed by the description of the methodological approach, including data and variables used for the analysis. In the next section, we present and discuss the results of the regression analysis. Finally, the conclusions are made.

Literature review

The assessment of the impact of industry factors, particularly the market concentration, as well as other structural variables such as the intensity of advertising and promotion, capital requirements, import competition, size of firms, industry growth or risk level, has been the subject of a number of research studies (e.g. Sivasubramaniam and Kara, 2015; Bothwell et al., 1984; Setiawan et al., 2012; Collins and Preston, 1966; Dickson, 2005). The analyses are based on economic literature usually using the econometric approach to investigate the relationship between market structure and performance.

The assessment of market concentration is different from the firm perspective, industry perspective and also from the national economy point of view. On one hand, there are arguments that promote positive effects of higher market concentration due to the distribution of fixed costs for a larger number of products, due to the repetition of certain activities and also due to the concentration of research, marketing, financial transactions and the use of managerial skills, which affects the competitiveness of the company (Ginevičius and Čirba, 2007). On the other hand, high market concentration usually means the existence of a monopoly or dominant firm in an industry that may be related to market power and, more likely, anticompetitive behaviour of firms in the market with negative impact on small businesses and consumers (Kaditi, 2013), since large companies have considerable bargaining power and ability to influence the economic policy and government decision-making through corruption or social threats to unemployment, influence public opinion, etc. (Adams and Brock, 1986; Dicken, 2011). As pointed out by Curry and George (1983) or Hausman and Parker (2010), a clear assessment of market concentration is a complex and controversial issue.

The main finding of the previously published studies is the positive relationship between market concentration and performance, as higher market concentration usually means higher prices (e.g. Schmalensee and Willig, 1989; Newmark, 2004; Setiawan et al, 2012; Hirsch et al., 2014). It can be assumed that performance will tend to be higher in highly concentrated markets, where a large share of the industry output is attributable only to a few companies, than to less concentrated markets or industries with competitive structure (Viscusi et al., 2005).

As highlighted by Newmark (2004), it is appropriate to put an indicator of market size in the price-concentration analysis, since prices change not only depending on various size of firms, which is reflected in market concentration indicators, but also on the number of firms in the industry. The restrictive effect of competition (measured by the number of competitors) on the profit margins of enterprises was demonstrated e.g. by Hersch et al. (1994) in the transitive economies of Hungary, Poland and the former Czech and Slovak Federal Republic (CSFR).

In connection with the structural characteristics affecting the performance of industries, it is also appropriate to examine the impacts of the growing openness of the market, for example through the import competition. Considering the link between import competition and firm profitability, there are two different effects that may result from greater market openness – first, the rise in imports leads to sharper competition in the domestic market, and secondly, openness to foreign supply markets makes it possible to increase the availability of cheaper raw materials or intermediate products (Kasahara and Rodrigue, 2008). In general, increased competition may pose a threat to domestic businesses in the industry as well as the opportunity. Negative impacts of import penetration on the Austrian manufacturing industry was found out by Onaran (2011), while Olper et al. (2013) demonstrated across 25 European countries and 9 food industries over the 1995–2008 period that an increase in import penetration is systematically positively related to the productivity growth.

In the view of the heterogeneity model developed by Melitz and Ottaviano (2008), the increase of import competition due to the trade liberalization should induce a selection process from low to high productivity firms resulting in the productivity growth of the industry. At the same time, the similar selection may induce also by market size, as mentioned by Olper et al. (2013). This shows the interdependence of various structural characteristics and their effects on the industry performance, and motivates researchers to include the productivity indicators among the tested industry factors when addressing the effects of structural characteristics on the industry performance. According to Jorgenson et al. (2014), an increase in productivity and thus the profitability growth is often generated by product and process innovations. In view of the fact that new investments are usually connected with higher capital use leading to higher indebtedness, the disunited results on both negative and positive impacts on profitability were researched by many authors (e.g. Daher and Le Saout, 2015; Sivathaasan et al., 2013; Chaddad and Mondelli, 2013; Hirsch et al., 2014).

The debate on the relationship between industry performance and structural characteristics, which should offer an advice upon the economic and competition policy, still remains non-consensual, and therefore, the issue continues to be open.

Materials and methods

In this section we introduce our collected sample and methodological approach. We are particularly interested in the determinants of industry performance and the influence of the market concentration.

Sample

The empirical analysis has been conducted with usage of the dataset of the enterprises operating in the Czech food processing industry, i.e. the subsectors between CZ-NACE 101 and CZ-NACE 110 drawn from the database Albertina – Gold Edition (Bisnode, 2015), and covers the period from 2003 to 2014. The units of analysis were individual food subsectors, where the subsector CZ-NACE 104 (manufacture of vegetable and animal oils and fats) was excluded in order to provide relevant data. During the analysed period significant structural change took place in this subsector, which caused sharp fluctuations of this subsector profitability and market concentration – till 2008 there was only one large company in this subsector with the high market share (48.5% in 2003), whose financial results were worsening during 2003-2008. The bad financial situation of this company resulted in the bankruptcy of the company and its transformation into new enterprises, which led to temporary decrease of both subsector profitability and market concentration. Explaining the changes in the profitability of this subsector through the analysed determinants would be misleading, since the sharp fluctuations in profitability did not occur depending on the evolution of the sub sectoral characteristics, but due to the bankruptcy of one largest enterprise in the subsector.

The sample of the accounting data of enterprises is made out of 10,509 observations across 12 years and 9 food subsectors in the Czech Republic; namely CZ-NACE 101 – Production, processing, preserving of meat and meat products, CZ-NACE 102 – Processing and preserving of fish and fish products, CZ-NACE 103 – Processing and preserving of fruit and vegetables, CZ-NACE 105 – Manufacture of dairy products, CZ-NACE 106 – Manufacture of grain mill products, starches and starch products, CZ-NACE 107 – Manufacture of bakery and farinaceous products, CZ-NACE 108 – Manufacture of other food products, CZ-NACE 109 – Manufacture of prepared animal feeds, CZ-NACE 110 – Manufacture of beverages. The sample includes also small enterprises with 0-19 persons employed (49% observations in the sample) that are in the Czech food processing industry represented in a large number, which increases the representativeness of the sample. These firm data were used for particular subsectors when calculating the concentration indicators, which are of the main interest of our study.

The other three data sources were utilized. First, the data published by the Ministry of Agriculture in the regularly published publication Panorama of the Food Industry of the Czech Republic (Ministry of Agriculture of the Czech Republic, 2008, 2015) – this source was employed for the determination of the remaining indicators used in the presented analysis and also for identification of the total sales of individual subsectors when calculating the market concentration indicator CR4. Second, the data published by the Czech Statistical Office (Czech Statistical Office of the Czech Republic, 2016) – the value added was expressed at comparable prices based on the producer price indices for particular subsectors of the Czech food industry (the year 2005 = 100). Third, the numbers of enterprises in individual food subsectors in 2003-2007 were supplemented from Eurostat (European Commission, 2016) as they have been published by the Ministry of Agriculture of the Czech Republic only since 2008 (Ministry of Agriculture of the Czech Republic, 2008, 2015).

Variables

Two indicators were used to measure the profitability of subsectors – return on assets (*ROA*) and return on equity (*ROE*). *ROA* measures the company management ability to generate profits from total assets of the company regardless of the way of funding, ROE reflects the return to shareholders on their equity, and are calculated as follows (Megginson et al., 2008):

$$ROA_j = \frac{EBIT_j}{Total\ Assets_j} \times 100$$

$$ROE_j = \frac{EAT_j}{Equity_j} \times 100$$

where *j* denotes the subsector of the Czech food industry, i.e. CZ-NACE 101 to 110, except for CZ-NACE 104.

Since the market structure is characterised by the number of firms in an industry and the size distribution of companies, the measures of concentration and the number of firms in the subsectors are used to describe the market structure – the Concentration Ratio of four largest firms in the market (*CR4*), the Herfindahl-Hirschman Index (*HHI*), and the number of firms (*NF*).

The concentration indicators represent independent variables in models and are calculated by the following formulas (Viscusi et al., 2005):

$$CR4 = \sum_{i=1}^{4} S_i$$

$$HHI = \sum_{i=1}^{n} (S_i)^2$$

where S_i denotes the individual market share, i.e. the percentage of the *i*-th firm calculated as the production of the company divided by the sum of production of all firms in the subsector, *n* denotes number of firms in the subsector, for which *HHI* is calculated. We used the sales data, i.e. sales of own products and services, because they explain more about the market share than the output. For the concentration indicators it is valid that the higher they are, the higher market power is concentrated among the largest firms therefore positive coefficients in models are expected.

Number of firms (*NF*) in particular subsectors is expected to have a negative sign of the parameter in models, since larger markets with a large number of firms can be considered as a more competitive environment, which implies smaller ability of the firms to influence the price on the market.

Import penetration ratio (*IMP*) is a measure of the importance of imports in the domestic country and shows the extent to which the demand for goods or services is being met by foreign producers rather than domestic production. The formula is as follows (Lindner, 2001):

$$IMP_{it} = \frac{M_{it}}{Y_{it} + M_{it} - X_{it}}$$

where *i* denotes each of the nine subsectors of the Czech food and drink industry and *t* denotes the year, M_{it} and X_{it} are, respectively, the total imports and exports of the subsector *i* in the year *t*, and Y_{it} is the total production of the subsector *i* expressed by the total sales of own products and services. Since the international trade increases the competitive pressure (Kalínská et al., 2010), the import competition should reduce overall market share of large companies in the industry, and due to the increase in imports, decrease the market shares of large domestic firms. Therefore, the negative relationship between profitability and import penetration is expected, i.e. the negative sign of estimated parameter in models.

Since the production efficiency is significantly influenced by the productivity, two proxies for productivity, namely labour productivity (*Labour_Productivity*) and personal cost per value added (*PersCost_VA*), were included in models as independent variable to test their impact on the profitability (Hayes et al., 1988). They are calculated as follows:

$$Labour\_Productivity_j = \frac{Value\ Added\ in\ comparable\ prices_j}{Number\ of\ Employees_j}$$

$$PersCost\_VA_j = \frac{Labour\ Cost_j}{Value\ Added_j} \times 100$$

where *j* denotes the subsector of the Czech food industry, i.e. CZ-NACE 101 to 110, except for CZ-NACE 104.

As emphasised by Saitone and Sexton (2010), nowadays, the food processing firms face severe competition due to the changing market conditions (such as increased market concentration in retailing, emphasis on the dimensions of product quality and food safety, and changes in worldwide distribution and geographic location of production and processing), which forces them to increase the productivity by keeping steady labour force and increasing overall output. Is can be assumed that higher productivity causes the increase of profits, as investigated e.g. by Athanasoglou et al. (2005). Given the design and interpretation of the productivity indicators, the *Labour_Productivity* indicator is expected to have positive impact on profitability, whereas the *PersCost_VA* indicator the negative impact.

Given the fact that indebtedness is an important variable for understanding the profitability (Simon-Elorz et al., 2015), we use the debt ratio (*Leverage*) calculated by the following formula (similarly to the previous studies, e.g. Clayton, 2009; Lopez-Valeiraz, 2016; Chandrapala and Knápková, 2013) as independent variable:

$$Leverage_j = \frac{Total\ Liabilities_j}{Total\ Assets_j} \times 100$$

where *j* denotes the subsector of the Czech food industry, i.e. CZ-NACE 101 to 110, except for CZ-NACE 104. Since the debts in the capital structure provide benefits to the firm as well as increase the financial distress costs, it is difficult to determine the relationship between indebtedness and profitability ratios, i.e. the sign of the parameter in models. On the one hand, the interests mean the tax reduction, but on the other hand, the interests are obligations and as such they can incur the financial distress to the firm.

Before moving to the methodological approach, we present the descriptive statistics for the variables of interest, which are reported in Table 1.

Variable/Statistics	Mean	SD	Min	Max	N
ROA	6.7396831	3.4552748	-4.8387882	15.482057	108
ROE	9.6966256	8.4777807	34.239597	41.153664	108
CR4	39.270157	19.618538	12.577329	96.238654	108
HHI	928.15055	1286.4564	85.455134	6332.1207	108
NF	728.58333	850.02504	15	3,036	108
IMP	42.727938	27.324315	8.9975684	115.00251	108
Labour_Productivity	610.99249	294.61539	215.48077	1266.9048	108
PersCost_VA	56.076266	13.290135	25.426469	88.04782	108
Leverage	55.727831	11.611146	34.742969	91.038824	108

Source: STATA 14; authors' elaboration

Table 1: Descriptive statistics.

Empirical approach

Our sample consists of a panel of nine subsectors of the Czech food industry for the period of years 2003-2014. To study determinants of sectoral profitability and to achieve main goal of our research, we implement multivariate regression analysis of panel data, which was used for example in the study by Setiawan et al. (2012) or Dickson (2005). Regression analysis allows us to analyse the impact of the sectoral determinants (independent variables), especially market concentration, on the profitability of the subsectors (dependent variables). Profitability is represented by two different profitability indicators of the subsectors, i.e. *ROA* and *ROE*. Market concentration is represented also by two different indicators, i.e. *CR4* and *HHI*. Other determinants include number of firms in particular subsector (*NF*), import penetration (*IMP*), indebtedness (*Leverage*), and we also use two ways, how to measure productivity, i.e. labour productivity (*Labour_Productivity*) and personal cost per value added (*PerCost_VA*). According to Verbeek (2012) we need to begin with the test of stationarity of the individual variables, then we need to choose the most appropriate estimation technique and finally, our estimated models need to fulfil econometric assumptions.

In our study, we used the programme STATA 14 to estimate all presented outcomes. To test stationarity, Levin, Lin & Chu test for the panel data (Levin et al. 2002) was conducted for each of the variables, which proved that all of the variables are stationary. As for the estimation technique, we could choose pooled OLS, random effects or fixed effects approach. Based on the results of Hausman test, we have decided to use fixed effects estimator. Our econometric models were therefore estimated with the fixed effects and with robust standard errors, which are consistent against the consequences of autocorrelation and heteroscedasticity. To evaluate level of collinearity and to detect potential threat of multicollinearity, we used correlation matrices and Variance Inflation Factors (VIF) test. This high level of collinearity was observed between *Labour_Productivity* and *PersCost_VA*, and between *CR4* and *HHI*. As a remedy, these variables had to be put into the regression models separately. In the presented models, collinearity among the independent variables was found to be below the generally accepted threshold. All estimated models were found to be statistically significant and the Goddess of fit (R^2) informs us that the share of explained variance of the dependent variables in our estimated models is quite good and comparable with the previously published studies (Verbeek, 2012). Since all assumptions were fulfilled, we might proceed towards interpretation of obtained results.

Results and discussion

The final models are presented in Table 2. Statistical significance of independent variables is reported conventionally. The results show, that the market concentration, productivity and indebtedness have significant effect on both *ROA* and *ROE* in all estimated models.

The market concentration variables (*CR4* and *HHI*) have statistically significant positive effect on *ROA* and *ROE*, which indicates that during the period of observation, i.e. 2003-2014, the increase in market concentration in the Czech food processing market (documented by Blažková, 2016) was associated with higher profitability of food subsectors. This result corresponds with the majority of previous studies, e.g. Dickson (2005), Setiawan et al. (2012) or Hirsch et al. (2014), and also with our assumptions related to the ongoing changes in the commodity verticals, i.e. increasing retail concentration as the subsequent vertical stage (*CR5* indicator was 14.45% in the Czech food processing industry in comparison with 45.50% in the Czech retail sector in 2013). It can be assumed that higher market concentration on the food processing market may generate better bargaining position of food processors towards retailers.

As stated by Newmark (2004) or Hersch et al. (1994), the structure of the industry can be assessed not only by the size distribution of firms on the market, i.e. by the market concentration indicators, but also by the number of firms on the market. Contrary to our expectations, the positive sign of the coefficient for *NF* variable was observed in all models. Regarding the fact that the coefficients were not statistically significant, we cannot make any conclusions about the impact of the number of firms on profitability of the Czech food processing industry. There are several large firms in the Czech food processing industry reporting high profits, but on the other hand, very small firms are represented in large numbers that can be successful and profitable from the regional point of view or due to the discovering and occupying of the market niches. Therefore, the number of firms in the sector is not considered as an important determinant of profitability in the Czech food processing industry.

As seen from Table 2, the import penetration ration (*IMP*) is not statistically significant driver of profitability in the Czech food processing industry. Moreover, the sign of its coefficient is differing in particular estimated models. Thus, it has to be concluded that the impact of import penetration on profitability was not confirmed, and although the import competition was increasing on the Czech food market during 2003-2014, the impact on the firm profitability was not observed. When considering the linkage between import penetration and the profitability, two different effects could be at work behind the openness of the market – first, imports lead to sharper competition in the domestic market, and second, the openness to foreign supply markets enables the availability of cheaper intermediates (Kasahara and Rodrigue, 2008). Hence, the increased import penetration may represent a threat for firms in the industry as well as the opportunity.

To investigate the effects of productivity on the *ROA* and *ROE* indicators, two variables

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Independent/Dependent	*ROA*	*ROA*	*ROA*	*ROA*	*ROE*	*ROE*	*ROE*	*ROE*
CR4	**0.0737*** -0.0195**	**0.0874*** -0.0222**			**0.137*** -0.0334**	**0.161*** -0.041**		
HHI			**0.000745*** -0.000207**	**0.000814*** -0.000242**			**0.00132** -0.000407**	**0.00142** -0.000454**
NF	0.000794 -0.00177	0.00136 -0.00165	0.000477 -0.00143	0.000842 -0.0012	0.00216 -0.003	0.00312 -0.00268	0.00149 -0.00235	0.00203 -0.00182
IMP	-0.00264 -0.0262	0.0142 -0.0352	0.0196 -0.0292	0.0395 -0.0398	-0.0179 -0.043	0.0105 -0.0636	0.0223 -0.0466	0.0547 -0.0694
Labor_Productivity	**0.00513** -0.00154**		**0.00639** -0.00253**		**0.00946*** -0.00256**		**0.0117** -0.00466**	
PersCost_VA		**-0.0802*** -0.0201**		**-0.0871** -0.035**		**-0.139** -0.0449**		**-0.149* -0.0676**
Leverage	**-0.160*** -0.0282**	**-0.147*** -0.0343**	**-0.149*** -0.0332**	**-0.134** -0.0424**	**-0.176*** -0.0506**	**-0.154** -0.0511**	**-0.156** -0.0584**	**-0.131* -0.0668**
Observations	108	108	108	108	108	108	108	108
R^2	0.455	0.425	0.408	0.344	0.354	0.318	0.299	0.226
Adjusted R^2	0.359	0.324	0.304	0.229	0.24	0.198	0.176	0.09
AIC	393	398.7	401.9	412.9	538.3	544.2	547.1	557.8
BIC	414.5	420.2	423.3	434.4	559.8	565.7	568.6	579.3

Note: Standard errors are in parentheses, *** stat. significance at 1% level, ** stat. significance at 5% level, * stat. significance at 10% level.
Source: STATA 14; authors' elaboration

Table 2: Model table.

were employed in models – labour productivity (*Labour_Productivity*) and personal cost per value added (*PersCost_VA*). All coefficients were found to be statistically significant, and according to our expectations, the increased labour productivity led to higher profitability of the Czech food processing industry in 2003-2014, and the impact of the increase of personal cost per value added was negative, which shows that the investments in the technology and innovations generate positive effects through the increased level of productivity.

As mentioned above, increased innovation activity and investments in new technologies are usually connected with the increased capital needs, which may be manifested in the higher indebtedness causing the risk of the firm due to the possible troubles with paying of interests and risks of getting into the bad financial situation. On the other hand, the risk theory suggests that firms with higher risk should on average achieve higher profits (Roeser, 2012). In our analysis, the effect of higher indebtedness (*Leverage*) was not favourable and caused statistically significant decrease of profitability in all estimated models. It would be better to use combined sources to fund the firm activities in the Czech food processing industry and to decrease debts to a lower lever that would not affect the financial autonomy of firms and would increase the assets' ability to generate higher profits.

Conclusion

The aim of this paper was to investigate the determinants influencing the profitability of the Czech food processing industry, which is nowadays the key issue to maintain the competitiveness on the global and constantly changing markets, and which responds to the lack of related studies in the Czech food environment. Our main focus, when assessing the impact of industry factors on the differentiation of sector performance, was on the effects of key structural characteristics such as market concentration, increase of import competition and related changes in productivity of the subsectors.

Data for the analysis drawn from more databases were formed into the panel dataset, which covers 12-year period across 9 subsectors of the Czech food processing industry. The econometric models with fixed effects were estimated to empirically study the relationship between profitability and structural indicators, productivity and related indebtedness of the food subsectors.

It was statistically confirmed that increase in market concentration in the Czech food processing industry led to the increase in sectoral profitability, which is in line with the results of previous published studies (e.g. Kaditi, 2013; Setiawan et al., 2012a; Dickson, 2005). It confirms better market position of concentrated food processors relative to the retail in the Czech Republic regardless whether it is the consequence of efficiency or market power. Also the sectoral productivity is an important determinant of profitability, as proved by the conducted analysis, therefore policies and firm strategies should be focused on innovations of processes or products, since the innovation capabilities contributes to the sectoral profitability through lower production cost or superior products. The negative relationship was found between the profitability and the indebtedness that corresponds with Goddard et al. (2005), Chaddad and Mondelli (2013), Hirsch et al. (2014) or Chandrapala and Knápková (2013). On the other hand, this result contradicts the theory of risk (Roeser, 2012). This result shows the suitability to reduce the debts of the Czech food processing firms to generate higher profits. Although the import competition is still increasing after the entry of the Czech Republic into the EU, the impact on the sectoral profitability was not observed and statistically proved.

The study should provide a basis for the public policy makers, food managers and for further analytical research focused on all levels of the food commodity chain in the Czech Republic, since to investigate the performance in the whole chain, including possible effects of industry specific attributes on the firms' profitability, would be important and challenging aim for the further research. From a methodological perspective, future research should test, whether the industry related determinants are the same, when using different measures of profitability.

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Assessing the Agricultural Competitive Advantage by the RTA index: A Case Study in Vietnam

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Abstract

This study aims to measure static and dynamic competitive advantages of Vietnam's agricultural sectors by employing the relative trade advantage index (RTA). The dynamics of RTA indicators are tested in three ways: OLS method, Markov matrix, and trend analysis. The results show that Vietnam, generally, obtains the strong competitive advantages in crop sectors and fishery sectors whilst it incurs the weak competitive advantages in livestock sectors and processed food sectors. The regression model suggests that the country has the convergent pattern in agricultural competitive advantages, the Markov matrix proves the relative stabilities of the RTA values, and the trend analysis indicates that Vietnam obtains the RTA gaining trends in 12 agricultural sectors while it has the RTA losing trends in 28 agricultural sectors.

Keywords

Vietnam, agriculture trade, competitive advantage, RTA, dynamics.

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Introduction

In the new era of the economic globalization and competition, farmers, enterprises, sectors, and nations have to enhance their capacity to compete in the open domestic and international trade markets for maintaining and improving their market share, income, growth, and social welfare. Participation in international trade is important to explore the ways of improving efficiency and international competitiveness. This study focuses on the agricultural trade performance of Vietnam where the agricultural sectors play important roles in the social and economic conditions. In particular, the sectors contribute to 17.7 percent of the GDP, account for 17 percent of the total export and 48 percent of total employment in 2014 (WB, 2017; GSO, 2017).

Though achieving advantage from the natural environment, fertile soil, and abundant water resource Vietnam's agricultural sectors face the problems of domination of small-scale farms, negative impact on the environment, cultivation land conversion towards urbanization and industrialization, new challenges from climate changes, increasing input costs, and low productivity. These challenges require the government and enterprises to restructure the sectors. The conventional economic wisdom proposes that the country should utilize its scarce resources and specialize in producing agricultural commodities that have stronger competitive advantages and might create higher added values (Yu et al., 2010). Competitiveness[1] is a central concept in stimulating policy discussions by policy makers, politicians, researchers and it is widely employed in economic and business research from different points of view but there is little agreement on its definition (Bojnec and Ferto, 2009). There are various frameworks to assess the competitiveness according to five main disciplines: (1) economic indicators; (2) trade performance measures; (3) determinants of competitiveness; (4) multidimensional frameworks; and (5) benchmarking and value chain performance. Various empirical frameworks have been proposed to evaluate the competitive advantage based on trade data. The strength of the approaches is that they encompass both demand and supply simultaneously and take into account the marketing, tax, transport and other costs (Frohberg and Hartman, 1997).

This study aims to measure the competitive

[1] This study defines the concept of competitiveness as the international trade performance and would not differentiate the concept from competitive advantage and comparative advantage.

advantages of the agricultural sectors in Vietnam over the period 1997-2014 by employing the relative trade advantage (RTA) index suggested by Vollrath (1991). The paper focuses on analyzing the dynamics of the RTA indicators in three ways: OLS method, Markov matrix, and trend analysis. The research results in both academic and practical contributions. First, the study broadens the empirical competitive advantages analysis by using the RTA index in case of Vietnam and employing the different tools to identify the dynamics of these RTA indicators. Second, the results will provide the critical indicators of agricultural competitive advantages for government in making the policy and enterprises in building the business strategy.

The rest of the paper is organized as the following: Section 2 provides the literature review in international economics, trade performance indices as the foundation for solving the research questions; Section 3 explains the methods and the data used in this article; Section 4 presents and discusses the empirical results; and Section 5 concludes the research findings.

Literature review

The concept of competitiveness in classical international economic theory is synonymous with the competitive advantage of a nation and based on the concepts of the absolute advantage of Smith (1776) and the comparative advantage of Ricardo (1817). Cost, productivity, and price are the fundamentals of the concepts. According to Smith, absolute advantage is the export of the lower labor cost goods to partner countries and the import of the higher labor cost goods from the partners. Ricardo, broadly, explains the benefit from the international trade for countries if they export goods or services when producing at relatively lower labor costs and import goods or services when producing at relatively higher labor costs. Despite the criticism of limitations, the classical theory of international trade is certainly useful to explain the reasons why international trade happens and how international trade increases the welfare of countries in trade. The several empirical frameworks, backed by the classical international economic theory, are proposed by scholars to measure the competitive advantage and specialization of a country in an export commodity such as the revealed comparative advantage, the relative trade advantage, the normalized revealed comparative advantage, and the Lafay index.

When the data of cost, price, and productivity for every specific commodity and sector is not available, the measure of comparative advantage based on "revealed" data is the best option. Balassa (1965) proposes the index of "revealed" comparative advantage (RCA) based on the classical theory of international trade and adjusted from Liesner's (1958) first utilization. This index uses the revealed data of export to calculate the ratio of a country's export share of one commodity in the international market to the country's export share of all other commodities. Balassa argues that comparative advantage is revealed in relatively high shares of export markets and comparative disadvantage is revealed in relatively low shares of export markets. The market shares have to be compared with others to evaluate which country or commodity is comparative advantage and disadvantage (Gorton et al., 2000). The Balassa index, however, has limitations and it has been modified into different frameworks and employed in different ways. The main limitations of Balassa's index are criticized as follows: (i) it serves as export specialization index; (ii) the index is static and does not present the dynamics of comparative advantage over time; (iii) it does not include import data; (iv) the distribution of the RCA index is asymmetric and non-normal; (v) its range from 0 to + ∞ has problematic matters to interpret and compare; (vi) it double counts the data of a country and a commodity; and (vii) the index indicates the success in exporting in the world market. The exports, however, can come from incentives and the incentives explain competitiveness, not comparative advantage (Vollrath, 1991; Kreinin & Plummer, 1994; Dalum et al., 1998; Proudman and Redding, 2000; Benedictis and Tamberi, 2004; Hoen and Oosterhaven, 2006; Bojnec and Ferto, 2015).

Scholars have modified the RCA and suggested alternative measures to deal with the limitations while still covered the value of the RCA's economic implication. Vollrath (1991) suggests the relative trade advantage (RTA) that is calculated as the difference between the relative export advantage (RXA), which is similar to the RCA index, and the relative import advantage (RMA). The major difference between the RCA and Vollrath's indices are explained as follows: (i) the RXA and RMA eliminate country and product double counting; (ii) it considers all traded goods and all countries rather than subgroups and referring to global trade intensity; (iii) it uses export and import data and, therefore, encompasses both the relative supply and relative demand dimensions; (iv) the RTA value is in (-∞, 0, +∞), that avoids the asymmetric problem of the RCA values; (v) the index is more close to real competitive advantage than the RCA when abstracting from distortionary influence; (vi) the RTA is more consistent with the actual world phenomenon of two-way trade (Vollrath, 1991; Ferto and Hubbard, 2003; Worz, 2005; Banterle and Carraresi, 2007; Crescimanno and Galati, 2014). The RTA, however, is in contrast to the RCA when: (i) the RXA is smaller than the unity but higher than the RMA, thus the RTA is higher than zero and shows competitive advantage whilst the RCA shows comparative disadvantage; (ii) the RXA is higher than the unity but smaller than the RMA, thus the RTA is smaller than zero and proves a competitive disadvantage whilst the RCA indicates a comparative advantage.

Vollrath (1991) proposes two more indices of international trade competitiveness: the relative export advantage - REA which is formulated by the logarithm of the export competitive advantage (lnRXA) to deal with the asymmetric problem of the RCAs' distribution and the revealed competitiveness - RC that is the difference between logarithm of the export competitive advantage and the logarithm of import competitive advantage (lnRXA - lnRMA). The RC, however, requires the existence of a country exporting and importing the same commodity and it is very sensitive to the small values of exports and imports.

The RTA has been employed in several empirical studies to analyze the competitive advantages and trade performances of sectors in different countries (Havrila and Gunawardana, 2003; Mosoma, 2004; Asciuto et al., 2008; Camanzi et al., 2012; Maksymets and Lonnstedt, 2016).

Materials and methods

This study employs the RTA index (Vollrath, 1991) to measure the competitive advantage of agricultural sectors in Vietnam. The index is calculated as the difference between the relative export advantage (RXA) and the relative import advantage (RMA). The Vollrath's indices are formulated as follows:

Relative export advantage (RXA):

$$RXA_j = \left\{\frac{X_j}{X_t}\right\} \div \left\{\frac{X_{wj}}{X_{wt}}\right\}$$

Relative import advantage (RMA):

$$RMA_j = \left\{\frac{M_j}{M_t}\right\} \div \left\{\frac{M_{wj}}{M_{wt}}\right\}$$

Relative trade advantage (RTA):

$$RTA_j = RXA_j - RMA_j$$

where, X_j and X_t represent the country's export of product *j* and all commodities; X_{wj} and X_{wt} denote the world's export of product *j* and all commodities; *M* is the import and it is presented similarly to *X*, respectively. It is noted that t and w indicate the rest of commodities (excludes j) and the rest of countries (excludes the country under study). The value of RTA is between -∞ and +∞ and the competitive-advantage-neutral point is zero. The values of RTA may be positive in the case of the competitive advantage and negative in the opposite situation. The RXA shows a competitive advantage when it is greater than 1 and a competitive disadvantage when the values are between 0 and 1 (similar to the RCA). This study uses the quartile method (Hinloopen & Marrewijk, 2001) to identify the degree of competitive advantage and group the RTA indicators into four classes including the competitive disadvantage, the weak competitive advantage, the medium competitive advantage, and the strong competitive advantage.

According to Hinloopen and Marrewijk (2001) and Bojnec and Ferto (2008), there are at least two types of stability: (i) the stability of the distribution of the trade performance indices from one period to the next; (ii) the mobility of the value of the RTA indices for particular sectors every year of the full period. This paper, moreover, uses the trend analysis to analyze the third type of the RTA dynamics: (iii) the trends of the RTA values over the period and in the future.

Following Dalum et al. (1998) and Sharma and Dietrich (2007), the first type of the RTA indicator dynamics is analyzed using OLS method presented by Hart and Prais (1956) and first utilized by Cantwell (1989) in the context of specialization. The values of the RTA indicators are in (-∞, 0, +∞) thus it eliminates the asymmetric problem that violates the assumption of normality of the error term in the regression analysis and makes the t-statistics unreliable. The regression model of competitive advantage dynamics can be presented as follows:

$$RTA_j^{t2} = \alpha + \beta RTA_j^{t1} + \varepsilon_j$$

where t_1 and t_2 are the initial year and the final year respectively, *j* is the agricultural sector under study, α is a constant, β is a regression coefficient, and ε_j is a residual term. The RTA at time t_2 for agricultural sector *j* is the dependent variable and tested against the independent variable of the RTA at time t_1

for agricultural sector j. Dalum et al. (1998) affirm that the method is one of comparing two cross-sections or cross-countries at two points in time and there is no factor of time in the observations. In this study, it is assumed that regression is linear in parameters and the residual ε_j is normal identically distributed ($\varepsilon_j \sim$ n.i.d.(0, σ)).

The interpretation of the regression results is as follows. The $\beta = 1$ corresponds to an unchanged pattern of the competitive advantage from t_1 to t_2. If $\beta > 1$, the country tends to be more competitive in the groups where the competitive advantages are strong and to be less competitive in the groups where the competitive advantages are weak. On the other hand, if $0 < \beta < 1$, sectors with initial weak RTAs increase over time, while sectors with initial strong RTAs decrease. If $\beta = 0$, then there is no relation between the RTAs in the two periods. If $\beta < 0$, the competitive advantage positions of the groups are reversed. Those RTAs initially below the average value are above the average in the next year, and vice versa.

According to Dalum et al. (1998) and Cantwell (1989), another feature of the regression analysis is to test whether the degree of specialization changes over time and $\beta > 1$ is not a necessary condition for growth in the overall specialization pattern. The variance of the RTA indicators at year *t2* is denoted by $(\sigma_{t2})^2$ then:

$$(\sigma_{t2})^2 = \beta^2(\sigma_{t1})^2 + \sigma_\varepsilon^2$$

where, β^2 is the square of regression coefficient, $(\sigma_{t1})^2$ is the variance of the RTA indicators at year $t1$, and σ_ε^2 is the variance of the error term. The determination coefficient R^2 is defined as:

$$R^2 = 1 - \frac{\sigma_\varepsilon^2}{(\sigma_{t2})^2} = ((\sigma_{t2})^2 - \sigma_\varepsilon^2)(\frac{1}{(\sigma_{t2})^2})$$

combining these two above equations, we have:

$$(\sigma_{t2})^2 - \sigma_\varepsilon^2 = \beta^2(\sigma_{t1})^2 = R^2(\sigma_{t2})^2$$

rewriting this equation to present the relationship between the variance of the two distributions:

$$\frac{(\sigma_{t2})^2}{(\sigma_{t1})^2} = \frac{\beta^2}{R^2}$$

this equation can be simplified to:

$$\frac{\sigma_{t2}}{\sigma_{t1}} = \frac{|\beta|}{|R|}$$

where, R is the correlation coefficient from the regression model and σ^2 is the variance of the dependent variable. The dispersion of a given distribution is unchanged when $\beta = R$. If $\beta > R$ (equivalent to the increase in the dispersion), then the degree of the RTA rises. If $\beta < R$ (equivalent to the decrease in the dispersion), then the degree of competitive advantage falls.

The second type of mobility and stability of the RTA value for a particular agricultural sector is assessed in two ways. First, following the empirical method utilized first by Proudman and Redding (2000), and then used by Brasili et al. (2000), Ferto (2007), this study employs the one-step Markov chains to analyze the probability of transition among four classes in term of its moving from an initial class to other classes in one-step of moving (moving within two adjacent years) and the persistence of stability in the initial class.

In a second way, the paper utilizes a mobility index to analyze the mobility degree of the RTA values. The index identifies the degree of mobility throughout the entire distribution of the RTA indicators and facilitates direct cross-sectors comparisons over the full period. The index *M*, following Shorrocks (1978), assesses the trace of the transition probability matrix. This *M* index, thus, directly captures the relative and medium magnitude of diagonal and off-diagonal terms, and the equation of *M* index can be shown as follows:

$$M = \frac{n - tr(P)}{n - 1}$$

where, *M* is Shorrocks index, *n* is the number of classes, *P* is the transition probability matrix, and *tr(P)* is the trace of *P*. A higher value of *M* index states greater mobility and a zero value of *M* index shows perfect immobility.

The paper, moreover, uses the trend analysis to examine and predict the RTA trend of a particular agricultural sector over the full period 1997-2014. This tool identifies the RTA gaining, losing, or maintaining trends in an agricultural sector based on comparing the change of the RTA values over time. The time trend model is presented as follows:

$$RTA_{j,t} = \alpha_j + \beta_j t + \varepsilon_{j,t}$$

where, α_j is a constant; β_j is the regression coefficient showing the RTA trend; t is the time index; and $\varepsilon_{j,t}$ is a residual term. Vietnam's RTA in agricultural sector j can be considered stable if the estimated β_j is close to zero (this study uses the significance level of 10 percent). The value of $\beta_j > 0$ indicates a trend in gaining the competitive advantage while the value of $\beta_j < 0$ means a trend in losing the competitive advantage.

This study follows the definition of EU (2007) and WTO in the Revision 3 of the Standard International Trade Classification (SITC Rev. 3) to define the "agricultural commodities" as to cover the codes of 0 + 1 + 21 + 22 + 231 + 24 + 261 to 265 + 268 + 29 + 4. The trade data for this study is mainly extracted from the United Nations Comtrade based on the SITC Rev. 3. The SITC Rev. 3 offers five levels of commodity aggregation such as 1-digit sections down to 2-digit divisions, 3-digit groups, 4-digit subgroups and 5-digit items. This paper calculates the RTA indicators at 2-digit with 21 agricultural product divisions and at 3-digit with 61 agricultural commodity groups over the period 1997 – 2014. The paper defines the concept of "commodity division and commodity group" as "sector" for more effective presentations.

Results and discussion

Measuring the competitive advantages by RTA index

Analysis of competitive advantage at 2 digits

The 2-digit analysis states that crude rubber, fish, coffee, cork and wood, cereals, vegetables and fruit are the top competitive sectors of Vietnam in the world market with high world market shares (WMS). The RTA indicator shows a different result for the top competitive sectors. The country, in both 2014 and in the average of the period 1997-2014, obtains the strongest competitive advantages in crude rubber, fish, coffee, vegetables and fruit, and cereals sectors. The cereal sector significantly losses the competitiveness in 2014 in comparison with the average of the period 1997-2014. Vietnam, generally, has the competitive advantages in nine agricultural export commodity divisions in both 2014 and the average of the period 1997-2014 (Table 1).

Analysis of competitive advantage at 3 digits

The analysis at 3-digit level is useful to understand the competitive advantage of the more specific agricultural sectors in particular and to compare with economic indicators such as price, productivity and profit. The analysis result of agricultural relative trade advantage at 3-digits level (Table 2) shows that, in 2014, Vietnam obtains the strongest

Code	Commodity	**WMS** (2014)	**RTA** (2014)	**RTA** (1997-2014)
23	Crude rubber	10.18%	12.86	18.60
03	Fish, crustaceans, mollusc	5.73%	6.72	11.99
07	Coffee, tea, cocoa, spices	5.05%	6.38	9.14
05	Vegetables and fruit	1.72%	1.45	1.72
04	Cereals, cereal preprtns.	1.82%	0.58	4.53
41	Animal oils and fats	1.07%	0.56	0.21
06	Sugar, sugr.preptns, honey	0.75%	0.29	-0.24
12	Tobacco, tobacco manufact	0.63%	0.13	-0.39
11	Beverages	0.25%	0.11	0.03
24	Cork and wood	2.22%	-0.08	-0.53
01	Meat, meat preparations	0.04%	-0.16	0.05
43	Animal, veg.fats, oils, nes	0.10%	-0.45	-0.52
42	Fixed veg. Fats and oils	0.25%	-0.82	-1.24
02	Dairy products,bird eggs	0.10%	-0.84	-0.92
09	Misc.edible products etc	0.50%	-0.94	-0.01
29	Crude animal, veg.materl.	0.22%	-1.04	-0.15
21	Hides, skins, furskins, raw	0.04%	-1.15	-0.61
22	Oil seed, oleaginus fruit	0.03%	-1.24	0.38
00	Live animals	0.03%	-1.56	-0.20
08	Animal feed stuff	0.58%	-4.25	-4.38
26	Textile fibres	0.30%	-7.80	-3.90
	Max		**12.86**	**18.60**
	Average		**0.42**	**1.60**
	Competitive divisions		**9**	**9**

Source: own calculation (2017)

Table 1: The competitive advantage of Vietnam's agricultural sectors at 2-digit level.

Code	Commodity	**WMS** (2014)	**RTA** (2014)	**RTA** (1997-2014)
246	Wood in chips, particles	14.98%	21.79	12.03
075	Spices	14.30%	19.27	19.73
042	Rice	11.39%	15.85	44.99
231	Natural rubber, etc.	10.18%	13.02	18.70
071	Coffee,coffee substitute	9.27%	12.47	18.90
037	Fish etc.prepd,prsvd.nes	7.25%	9.64	5.98
036	Crustaceans,molluscs etc	7.75%	8.62	25.72
034	Fish,fresh,chilled,frozn	4.25%	4.57	6.08
265	Vegetable textile fibres	3.24%	4.11	5.13
074	Tea and mate	2.93%	3.52	7.33
057	Fruit,nuts excl.oil nuts	2.67%	2.24	3.00
035	Fish,dried,salted,smoked	1.20%	1.40	4.83
054	Vegetables	1.59%	1.37	1.07
046	Meal,flour of wheat,msln	1.21%	1.22	-3.42
245	Fuel wood, wood charcoal	1.06%	1.06	3.98
058	Fruit,preserved,prepared	0.85%	0.97	1.81
122	Tobacco, manufactured	0.78%	0.82	0.27
411	Animal oils and fats	1.07%	0.57	0.19
062	Sugar confectionery	0.83%	0.43	0.16
056	Vegtables,prpd,prsvd,nes	0.47%	0.29	0.41
024	Cheese and curd	0.00%	-0.10	-0.13
012	Other meat, meat offal	0.08%	-0.15	0.14
043	Barley, unmilled	0.00%	-0.26	-0.27
011	Bovine meat	0.00%	-0.27	-0.10
292	Crude veg.materials, nes	0.23%	-0.28	0.01
048	Cereal preparations	0.37%	-0.38	-0.31
212	Furskins, raw	0.00%	-0.42	-0.06
268	Wool, other animal hair	0.00%	-0.43	-0.19
431	Animal,veg.fats,oils,nes	0.10%	-0.44	-0.62
264	Jute,oth.textl.bast fibr	1.32%	-0.54	-0.98
091	Margarine and shortening	0.01%	-0.72	-1.11
098	Edible prod.preprtns,nes	0.54%	-0.95	0.08
023	Butter,other fat of milk	0.00%	-1.11	-1.34
261	Silk	0.18%	-1.16	-12.10
222	Oilseed(sft.fix veg.oil)	0.01%	-1.31	0.29
022	Milk and cream	0.18%	-1.37	-1.59
211	Hides,skins(ex.furs),raw	0.07%	-1.53	-0.81
422	Fixed veg.fat,oils,other	0.17%	-1.54	-1.68
121	Tobacco, unmanufactured	0.23%	-1.57	-1.96
001	Live animals	0.03%	-1.57	-0.20
041	Wheat, meslin, unmilled	0.00%	-1.81	-2.17
247	Wood rough,rough squared	0.34%	-2.59	-2.68
248	Wood, simply worked	0.64%	-2.71	-1.44
291	Crude animal materls.nes	0.22%	-4.17	-0.81
081	Animal feed stuff	0.58%	-4.29	-4.22
044	Maize unmilled	0.09%	-4.51	-1.42
263	Cotton	0.17%	-12.87	-5.88
	Max		**21.79**	**44.99**
	Average		**1.22**	**2.24**
	Competitive groups		**27**	**28**

Source: own calculation (2017)

Table 2: The competitive advantage of Vietnam’s agricultural sectors at 3-digit level (selected).

competitive advantage in wood in chips; spices; rice; natural rubber; and coffee with the RTA values of 21.79, 19.27, 15.85, 13.02, and 12.47, respectively. The world market share in 2014 also indicates the similar results for the top competitive agricultural sectors. Vietnam, in 2014, achieves the competitive advantages in 27 agricultural sectors. Based on the classification of the RTA values into four groups by quartile method (Table 5), the country has seven strong competitive advantage agricultural sectors, four medium competitive advantage agricultural sectors, and 16 weak competitive advantage agricultural sectors.

Vietnam, generally, has strong competitive advantages in crop sectors such as spices, rice, coffee, tea, fruit & nut, and vegetables; and fishery sectors such as crustaceans and fish whilst the country has weak competitive advantages in livestock sectors such as live animal, meat, and eggs & birds; and processed food sectors such as chocolate, cheese, butter, and other processed meat & foods (Table 2).

The average values of the RTA indicators for the full period 1997 - 2014 show that rice is the strongest competitive advantages sector with the value of 44.99. The next strong competitive sectors in period average are crustaceans and molluscs; spices; coffee; and natural rubber. There are significant variations between the RTA values in 2014 and in period average. This indicates the relative change of the RTA indicators at 3-digit level over time.

Analyzing the dynamics of the RTA indicators

The changes of the RTA indicators between 1997 and 2014

The variation of the RTA values between 1997 and 2014 shows Vietnam's changes in positions of competitive advantages. There are 33 competitive agricultural sectors in 1997 and only 27 competitive agricultural sectors in 2014. The country obtains the increase of the competitive advantages in 22 agricultural sectors but losses the decrease of the competitive advantages in 39 agricultural sectors. The top increasing agricultural sectors are wood in chips; meal, flour of wheat; and fish etc. prepared, preserved. The top decreasing agricultural sectors are rice; crustaceans, molluscs; and cotton. Notably, crude animal material; eggs, birds, yolks; jute, other textile bast fibres; oil-seeds, soft fixed vegetable oils; and edible products and preparations move from strong competitive advantages class to competitive disadvantages class (Table 3).

The general pattern of the RTA indicators by the OLS method

The estimation results for the RTA indicators over three periods result in the values of $0 < \beta < 1$ and values of $\beta/R < 1$ (Table 4). The results indicate that Vietnam, in general, has the convergent pattern in the agricultural competitive advantage. In other words, the country loses the competitive advantage in the initial strong competitive agricultural sectors whilst it gains the competitive advantage in the initial weak competitive agricultural sectors. The values of $0 < \beta < 1$ also prove the process of de-specialization in Vietnam's agricultural export competitiveness. The possible explaination for the result is that: Vietnam's agricultural competitive advantage pattern is based on natural resources with the primary agricultural products thus the country's increases in the productions and exports of the strong competitive advantage sectors result in the utilization of higher opportunity cost resources. Therefore, the competitive advantages of these sectors decrease. On the other hand, the resources of the new and weak competitive advantage sectors are still abundant with lower opportunity cost. Therefore, the competitive advantages of these sectors increase. This result is consitent with the traditional economic theory explaining that a country tends to decrease the competitive advantage in a product when it increases the specialization and exports the product to the world market

Top Increase	Top Decrease	Strong to Weak	Strong to No
Wood in chips, particles	Rice	Fuel wood, wood charcoal	Crude, animal,material
Meal,flour of wheat	Crustaceans, molluscs	Fruit,preserved, prepared	Eggs, birds, yolks
Fish,etc.prepd, prsvd.nes	Cotton	Fish, dried,s alted, smoked	Jute, oth.textl.bast fibre
Animal,veg.fats, oils,nes	Crude animal materls		Oilseed (sft.fix veg.oil)
Tobacco	Tea and mate		Edible, prod. preprtns, nes

Source: own analysis (2017)

Table 3: The changes of the RTA indicator ranks between 1997 and 2014 (selected).

1997 - 2005			2006-2014			1997 - 2014		
β	*R*	*β/R*	*β*	*R*	*β/R*	*β*	*R*	*β/R*
0.72	0.88	0.82	0.52	0.81	0.65	0.29	0.63	0.46

Source: own calculation (2017)

Table 4: The OLS estimation results for the RTAs indicators over three periods.

The mobilities and stabilities of the RTA indicators by Markov matrix

The RTA values are classified into four groups including competitive disadvantage, weak competitive advantage, medium competitive advantage, and strong competitive advantage. The boundary of competitive and uncompetitive groups is remained (the RTA neutral value is 0) and the authors then divide the RTA values into 3 classes of weak, medium and strong advantages by quartile method (Table 5). Let p_{ij} (*i, j* = 1, 2, 3, 4) denotes a one-step transition probability, that is the transition probability for the agricultural sectors which are in class "*i*" of year "*t*" moving to class "*j*" of year "*t*+1".

Categories	Interpretation	RTA values
Class 1	Competitive disadvantage	≤ 0
Class 2	Weak competitive advantage	≤ 1.41
Class 3	Medium competitive advantage	≤ 7.48
Class 4	Strong competitive advantage	> 7.48

Source: own calculation (2017)

Table 5: The classification of the RTA values and the interpretations by quartile method.

The stabilities and mobilities of the RTA values are investigated by using the Markov transition probability matrix and mobility index for yearly values of the RTA indicators from 1997 to 2014. The diagonal elements of the Markov matrix show the probability of remaining persistently in the initial class. The other elements of the Markov transition probability matrix provide further information on the mobility of the RTA values. Specifically, they show the probabilities of moving from one class to another from the year "*t*" to the year "*t*+1". There is a 4x4 matrix with 1,037 observations.

The result indicates that the high probabilities of the RTA indicators remain in their initial class (high diagonal elements) in which the uncompetitive sectors (in class 1) and the strong competitive sectors (in class 4) maintain the highest probabilities and the most stable. In other words, the groups with initial competitive disadvantage seem to stay uncompetitive whilst the groups with initial strong competitive advantage maintain to be strongly competitive. The average probability of stability in initial class is 84.07 percent whilst the average probability of mobility to other classes is only 5.31 percent. There is no sector moving from class 4 backwards class 1 and class 2, and from class 2 forward class 4. The probabilities of closer movings are higher than the probabilities of longer moves between classes. The M-Shorrocks of 0.21, generally, presents a relatively low degree of mobility between classes in the matrix (Table 6).

Table 6 also presents total probability (empirical ergodic) distribution and long run probability (implied ergodic) distribution. The total run and the long run distributions are relatively similar and this means that the Markov matrix accurately captures the underlying distribution of the RTA indicators (Hinloopen and Marrewijk, 2001). The difference between total run and long run probabilities confirms that the shares of uncompetitive and weak competitive sectors increase whilst the medium and strong competitive sectors decline in the long future.

The trends of the RTA indicators

The result of the RTA indicator trend analysis during the period of 1997–2014 shows that Vietnam has the RTA gaining trends in 12 agricultural sectors with $\beta > 0$ whilst the country incurs the RTA losing trends in 28 agricultural sectors with $\beta < 0$. Vietnam achieves the most RTA growing trends in wood in chips; meal, flour of wheat; fish.prepared, preserved; vegetable textile fibres; and fish, fresh, chilled, frozen during this period. This suggests that the country continues to obtain the stronger competitive advantage in these agricultural sectors in the future. During the same period, Vietnam has the most RTA losing trends in rice; crustaceans, molluscs; coffee, coffee substitute; natural rubber; and tea and mate. The country will continue to incur the weaker competitive advantage in these agricultural sectors in the future (Table 7).

	Obs: 1,037	1	2	3	4
M-Shorrocks	1	91.94	6.99	0.9	0.18
0.21	2	18.14	78.06	3.8	0
Average stability	3	6.56	12.30	73.77	7.38
84.07	4	0	0	7.5	92.5
Average mobility	Total	54.39	23.05	10.9	11.67
5.31	Long run	58.70	23.55	8.19	9.56

Source: own calculation (2017)

Table 6: The M-Shorrocks and Markov transition matrix for the RTA values.

Code	Commodity	β	p-value	R^2
246	Wood in chips, particles	1.50	0.00	0.88
046	Meal,flour of wheat,msln	0.99	0.00	0.62
037	Fish etc.prepd,prsvd.nes	0.43	0.00	0.67
265	Vegetable textile fibres	0.31	0.02	0.28
034	Fish,fresh,chilled,frozn	0.29	0.01	0.36
122	Tobacco, manufactured	0.17	0.00	0.54
411	Animal oils and fats	0.12	0.00	0.61
081	Animal feed stuff	-0.22	0.00	0.63
035	Fish,dried,salted,smoked	-0.29	0.03	0.27
075	Spices	-0.31	0.06	0.21
263	Cotton	-0.31	0.00	0.55
291	Crude animal materls.nes	-0.32	0.00	0.83
074	Tea and mate	-0.40	0.00	0.77
231	Natural rubber, etc.	-0.45	0.01	0.37
071	Coffee,coffee substitute	-0.47	0.01	0.32
036	Crustaceans,molluscs etc	-1.53	0.00	0.57
042	Rice	-3.03	0.00	0.78
	Gaining trend sectors	**12**		
	Losing trend sectors	**28**		

Source: own calculation (2017)

Table 7: The top gaining and losing trends of the RTA indicators (selected).

Conclusion

The study shows that Vietnam, in 2014, obtains the competitive advantages in 27 agricultural sectors and the competitive disadvantages in 34 agricultural sectors. The strongest competitive sectors are wood in chips, spices, rice, natural rubber, and coffee. The country, generally, has strong competitive advantages in crop sectors such as spices, rice, coffee, tea, fruit & nut and vegetables; and fishery sectors such as fish and crustaceans whilst it is clearly uncompetitive in livestock sectors such as live animal, meat, eggs & birds; and processed food sectors such as chocolate, cheese, butter, and other processed meat & foods.

The OLS estimation indicates that Vietnam has the convergent pattern in agricultural competitive advantages. In other words, the country decreases the competitiveness in the initial strong competitive sectors whilst it increases the competitiveness in the initial weak competitive sectors. The Markov matrix presents that the RTA indicators stay stable over time, especially the uncompetitive and strong competitive sectors, with the average stability probability of 84.07 percent while the average mobility probability is only 5.31 percent. The M-Shorrocks of 0.21 also shows a relatively low degree of mobility. The RTA trend analysis shows that Vietnam has the RTA gaining trends in 12 agricultural sectors and the RTA losing trends in 28 agricultural sectors and these trends will continue in the future.

The research results allow to recommend that

Vietnam needs to maintain the competitive advantage degrees and ranks of the important agricultural sectors such as rice, crustaceans, fish, tea and mate, rubber, and coffee which have lost competitive advantages significantly over the period 1997-2014 by planning cultivated areas, enriching product qualities, improving production productivities, and enhancing the global market linkages. The country should also shift its agricultural competitive advantage pattern from the primary and low value-added agricultural sectors to the processed food and high value-added sectors based on high technologies, large-scale productions, vertical and horizontal linkages, and global value chains.

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The Export Competitiveness of Global Cocoa Traders

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Abstract

Export competitiveness is an important indicator in the analysis of international trade flow, however, in empirical studies on agriculture it is often neglected. In this article we aim to analyse export competitiveness of global cocoa producers and to test the stability of the Balassa index as well as to identify the determinants behind different country performances. On a product basis, we have not found any article analyzing the competitiveness of cocoa in international trade. Our paper draws global cocoa trade data from the period 1992 to 2015. Results suggest that global cocoa trade is highly concentrated with Cote d'Ivoire, Ghana and Indonesia obtaining the highest comparative advantages in 1992-2015. However, duration and stability tests indicate that trade advantages have weakened for the majority of the countries concerned.

Keywords

Export competitiveness, cocoa trade, determinants, development.

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Introduction

Competitiveness is one of the most used and abused word in economics, containing many kinds of different interpretations. One strand of the literature combines international trade theories with those of macro level competitiveness and argues that competitiveness of nations can be interpreted and measures via trade based indices. Balassa (1965) was one of the early supporters of this theory, elaborating his famous index of revealed comparative advantages. Since this seminal work, a vast amount of literature is dedicated to the analyses of revealed comparative advantages of global trade.

Despite the apparent importance of the topic, however, the number of papers dealing with trade of agri-food products are relatively small compared to those dealing with industrial products. The main reason is probably that agricultural markets are usually assumed to be perfectly competitive. The article analyses export competitiveness in global coca trade – this approach, at least to our knowledge, is currently missing from the literature. This paper, therefore, contributes to the existing literature in three ways. First, it applies the theory of export competitiveness on an agricultural product group. Second, it analyses a product which is important from a development economic perspective as cocoa is mainly produced and exported by developing countries. Third, the article aims to identify the factors lying behind export competitiveness.

The article is structured as follows. Section 2 presents an overview of the empirical literature, followed by a demonstration of methodology and data used. Section 4 summarizes the descriptive statistics of global cocoa trade, identifying key players and products. Section 5 describes the export competitiveness patterns of the major exporters together with stability tests. Section 6 concludes.

Empirical evidence

There has been considerable research towards improving the understanding of competitiveness in economics. As the evolution of the concept suggests, it has different meanings in different places and times – mainly due to the lack of a universally accepted definition. At the micro-economic (firm) level, the understanding of competitiveness is pretty straightforward – it is "the ability of firms to consistently and profitably produce products that meet the requirements of an open market in terms of price [and] quality" (Domazet, 2012, p. 294-295). Competitiveness at the firm level is closely related to the long-run profit performance of the firm and higher return on investment for owners (Yap, 2004). Wijnands et al. (2008, p. 3), similarly defines firm competitiveness as the "ability toproduceproducts/servicesthatpeoplewillpurchase over those of competitors".

In comparison, at the macro-economic level, competitiveness is much more poorly defined. Probably the most widely accepted definition today is the one given by the World Economic Forum (WEF) (2015, p4.), defining national competitiveness as 'set of institutions, policies and factors that determine the level of productivity of a country'. It is interesting, however, that an earlier WEF report identified competitiveness as 'the ability of a country to achieve sustained high rates of growth in GDP per capita' (WEF, 1996). This old definition reflects the early thinking on competitiveness, though GDP per capita is used even today as an index measuring competitiveness in WEF's reports. On the whole, national competitiveness is the ability of a nation to create and maintain a conducive environment for its firms to prosper (Bhawsar and Chattopadhyay, 2015). Competitiveness is measured on the open market, against other nations. Further, we can also say that competitive nations are economically successful, and have rising incomes or living standards.

As stated in the introduction, the analysis of export competitiveness of agricultural and food products is limited in the international literature. In a regional context, Ndayitwayeko et al. (2014) analyzed the comparative advantage of the Eastern and Central African (EAC) coffee sector and revealed that EAC countries, though to a diminishing extent, had comparative advantage in global coffee exports from 2000 to 2012, with Uganda and Kenya leading the group. Akmal et al. (2014) analyzed the competitiveness of Pakistan's basmati rice exports and found that the country was losing its position to world markets in one of its biggest export products, calling for a change in its trade strategy. Astaneh et al. (2014) searched for comparative advantage in Iran's stone fruits market and found that the country had strengthened her competitive positions, though it lacked comparative advantage in the majority of the years analyzed.

Bojnec and Fertő (2015) analyzed the competitiveness of agri-food exports of European countries, and found majority of countries and products to have an advantage globally. The most successful nations in this regard were the Netherlands, France and Spain. The article also predicted a more long lasting advantage for Western-European countries, compared to Eastern-European ones. Fertő (2008) analyzed the evolution of agri-food trade patterns in Central European Countries and found the trade specialization across the region to be mixed. For particular product groups, greater variation was observed, with stable (unstable) patterns for product groups with comparative disadvantage (advantage). Török and Jámbor (2013) also analyzed he agri-food trade patterns of New Member States, and highlighted that almost all countries experienced a decrease in their comparative advantage after the EU accession, though it still remained at an acceptable level for most cases.

McLean et al. (2014) investigated regional integration in the Caribbean and found many countries and products to have a comparative advantage and potential to prosper. Korinek and Melatos (2009) analyzed revealed comparative advantages of MERCOSUR countries and found margarine, vegetable oils and coffee as the most competitive products in 1988 to 2004. In particular, Brazil and Argentina are leaders in comparative advantage in beef, both in fresh and preserved form.

In North America, Málaga and Williams (2006) found a lack of comparative advantage in agricultural and food export in Mexico. At the product group level, however, results suggested vegetables and fruits to have competitive positions. However, this competitiveness was decreasing for vegetables and increasing for fruits with time. Sarker and Ratnasena (2014) analyzed the comparative advantages of Canadian wheat, beef and pork sectors between 1961 and 2011, and found only the wheat sector to be competitive.

In a product-based context, Van Rooyen et al. (2010) used relative trade advantage indices to assess the competitive performance of the South African wine industry. Anderson (2013) analysed the comparative advantage of the Georgian wine industry with the Comparative Advantage Index and found high potentials, mainly in the European and Asian markets. Lakkakula et al. (2015) investigated the global trade competitiveness of rice by applying a shift-share analytical framework on global rice export data from 1997 to 2008 and found geographical structure and performance effects playing a crucial role in global rice export competitiveness. Bojnec and Fertő (2014) searched for the export competitiveness of the European dairy products on global markets and found different potentials by region and by the level of processing, suggesting that export competitiveness of the higher level of processed milk products for final consumption can be significant for export dairy chain competitiveness on global markets. However, we have not found any article analyzing the export competitiveness of global cocoa traders.

Materials and methods

As discussed in the theoretical framework, probably the most well-known index analyzing export competitiveness of nations is Revealed Comparative Advantage (RCA), calculating the proportion of a country's share of exports for a single commodity to the exports of all commodities and the similar share for a group of selected countries, expressed by Balassa (1965) as follows:

$$\mathrm{RCA_{ij}} = \left(\frac{X_{ij}}{X_{it}}\right) \Big/ \left(\frac{X_{nj}}{X_{nt}}\right) \quad (1)$$

where, X means export, i indicates a given country, j is a given product, t is a group of products and n is the group of selected countries. Hence, a revealed comparative advantage (or disadvantage) index of exports can be calculated by comparing a given country's export share by its total exports, with the export share by total exports of a reference group of countries. If RCA > 1, a given country has a comparative advantage compared to the reference countries, or in contrast, a revealed comparative disadvantage if RCA < 1.

Vollrath (1991) suggested three different specifications of revealed comparative advantage in order to eliminate the disadvantages (coming from asymmetric values) of the Balassa index. The first is the relative trade advantage (RTA) index, calculated as follows:

$$\mathrm{RCA_{ij}} = \left(\frac{X_{ij}}{X_{it}}\right) \Big/ \left(\frac{X_{nj}}{X_{nt}}\right) \quad (2)$$

where, RCA means the original Balassa index cited above and RMA stands for the revealed import advantage index, calculated by using import instead of export values in equation 1. The second approach of Vollrath is to calculate the natural logarithm of the Balassa index:

$$\mathrm{lnRXA_{ij}} = \ln(\mathrm{RCA_{ij}}) \quad (3)$$

The third approach is to measure the differences in logarithms of RXA and RMA indices as follows:

$$\mathrm{RC_{ij}} = \ln(\mathrm{RCA_{ij}}) - \ln(\mathrm{RMA_{ij}}) \quad (4)$$

where, RC is the revealed competitiveness index. In order to treat the asymmetric value problem of the Balassa-index, Dalum et al. (1998) transformed B index as follows, thereby creating the Revealed Symmetric Comparative Advantage (SRCA) index:

$$SRCA_{ij} = \left(RCA_{ij} - 1\right) / \left(RCA_{ij} + 1\right) \quad (5)$$

The SRCA takes values between -1 and 1, with values between 0 and 1 indicating a comparative export advantage and values between −1 and 0 a comparative export disadvantage. Since the SRCA distribution is symmetric around zero, potential bias is avoided (Dalum et al, 1998).

Proudman and Redding (1998) propose a weighted version of the RCA index (WRCA) for an individual product by taking the arithmetic mean of a country's RCA scores:

$$WRCA_{ij} = \frac{RCA_{ij}}{\frac{1}{N}\sum_{j-1}^{N} RCA_{ij}} \quad (6)$$

where, N is the total number of products. For a product, if its RCA value is greater than the average RCA value across all products, we would say country j has a comparative advantages in product i.

Hoen and Oosterhaven (2006) suggest another transformation of the original index as follows:

$$NRCA_{ij} = \frac{X_{ij}}{E_i E_j X_{ij}} - \frac{\left(E_i X_{ij}\right)\left(E_j X_{ij}\right)}{\left(E_i E_j X_{ij}\right)^2} \quad (7)$$

where, ARCA is the additive revealed comparative advantage index. If ARCA > 1, the country has a comparative advantage in the product concerned, and if ARCA < 1 then it will have a comparative disadvantage.

Yu et al. (2010) adopted an alternative measure to assess the dynamics of comparative advantage. The Normalised Comparative Advantage (NRCA) index is defined as follows:

$$NRCA_{ij} = \frac{X_{ij}}{E_i E_j X_{ij}} - \frac{\left(E_i X_{ij}\right)\left(E_j X_{ij}\right)}{\left(E_i E_j X_{ij}\right)^2} \quad (8)$$

Where X_{ii} represents actual exports and $\left(E_i X_{ij}\right)\left(E_j X_{ij}\right)$ stands for the comparative-average-neutral level in exports of commodity j for country i. If NRCA > 0, a country's comparative advantage on the world market is. The distribution of NRCA values is symmetric, ranging from -1/4 to +1/4 with 0 being the comparative-advantage neutral-point.

Although there are many pros and cons of the above mentioned indices, the paper concentrates on the original RCA index as it excludes imports, which are more likely to be influenced by policy interventions. Moreover, the high correlation given amongst the various indices above for our sample as well as paper size and interpretation constraints are further reasons to choose the RCA index.

The paper also checks the stability and duration of the RCA index in two steps. First, Markov transition probability matrices are calculated and then summarized by using the mobility index, evaluating the mobility across countries and time. Second, following Bojnec and Fertő (2008), survival function S(t) can be estimated by using the non-parametric Kaplan–Meier product limit estimator, pertaining to the product level distribution analysis of the SRCA index. Following Bojnec and Fertő (2008), a sample contains n independent observations denoted (t_i; c_i), where $i = 1, 2, \ldots, n$, and ti is the survival time, while c_i is the censoring indicator variable C (taking on a value of 1 if failure occurred, and 0 otherwise) of observation i. It is assumed that there are m < n recorded times of failure. We denote the rank-ordered survival times as t(1) < t(2) < … < t(m). For the purpose of our analysis let n_j indicate the number of subjects at risk of failing at $t(j)$ and let d_j denote the number of observed failures. The Kaplan–Meier estimator of the survival function is then (with the convention that ˆS(t) = 1 if t < t(1)) as follows:

$$\hat{S}(t) = \prod_{t(i)<t} \frac{n_j - d_j}{n_j} \qquad (9)$$

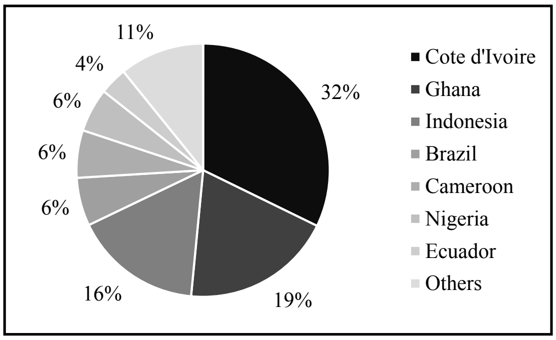
In order to calculate indices above, the article uses the World Bank WITS software based on COMTRADE, an international trade database developed by the United Nations at the HS six digit level as a source of raw data. The list of cocoa products can be found in the appendix. The chapter works with trade data for the period of 1992 to 2015.

However, we are aware that the methodology above has a number of limitations. First, trade data is not fully reliable due to various reasons. These include the following: trade values may not necessarily sum up to the total trade value for a given country dataset; countries may not necessarily report their trade values for each and every year; trade data may differ by the selection of classification; and imports reported by one country may not coincide with exports reported by its trading partner. Second, Balassa-based indices are sensitive to zero values (see equation 1, for instance). Third, outliers in results get omitted, dropping inconsistent indices and some useful data. However, based on the literature review and previous empirical works, our results well fit into past findings.

Results and discussion

The history of cocoa goes back to Mexico. Initially, cocoa was used by the Mayans as a local currency and in religious rituals, but they also prepared it as a drink. In the Age of Exploration, Spanish traders brought it to Europe and it was considered as a new medicine and an important caffeine source. The Spanish kept the secret for themselves and thereby created the biggest privilege in cocoa trading. When Europeans started to get to know and like it, its demand rised rapidly. To keep up with the increasing demand, European countries (Great-Britain, Germany and France) created their own plantations on their own lands, including their colonies too – this is where the history of African cocoa beans started (Coe and Coe, 2013).

As Figure 1 shows, global cocoa production is highly concentrated by country.



Source: own composition based on FAO database (2016)

Figure 1: Cocoa bean production, 2014, in percentage of total cocoa production.

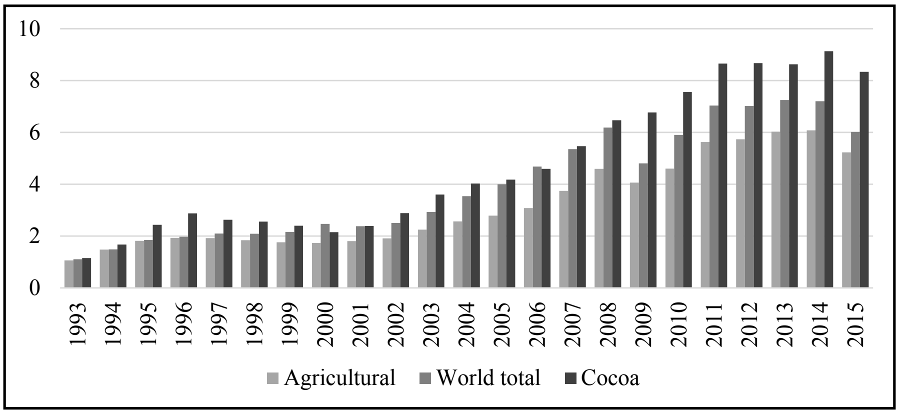
The reason is quite simple - the area where cocoa can be grown is limited as cocoa tree requires high temperature, humidity and sunshine. In 2014 the biggest producer countries were Cote d'Ivoire, Ghana, Indonesia, Brazil, Cameroon, Nigeria and Ecuador – these countries gave almost 90% of global cocoa production. Despite the fact that cocoa comes from America, currently two-third of the production takes place in Africa.

As Figure 1 suggests, producers are mainly developing countries, where farmers grow cocoa beans on small lands. However, volatile and low prices make the cocoa market unpredictable, causing hard times for farmers. In order to help them and to keep cocoa production alive, a huge number of associations were founded globally. In 2013/14, Fair Trade organisations paid almost 11 million dollars premium for the producers, 37% of which was invested in the improvement of production and quality (Fairtrade, 2016).

In line with production changes, global cocoa export has been continuously increasing in the previous 20- 25 years (Figure 2). In this period, global cocoa export increased ten times in current prices - cocoa export in 1992 was 5 billion US dollars, while in 2014 this value increased to 46 billion dollars (although some decrease was observable in 2015). Meanwhile, total exports of the world increased by 6-7 times (from 2.5 trillion to $ 15 trillion dollars), while global agricultural exports increased 4-5 times (from 230 billion to 1,2 trillion dollars). Consequently, global cocoa export has increased to a greater extent than agricultural or total export growth from 1992 to 2015.

The analysis of global cocoa trade by country gives further insights to the trends above. Ten countries with diverse locations gave the majority of global cocoa trade in the period analysed with changing concentration patterns (Table 1). Basically, two kinds of countries can be differentiated here. On the one hand, some typical cocoa producer countries (Cote d'Ivoire, Ghana) are on the list, while on the other hand, some typical processors or re-exporters (Netherlands, Belgium, Germany) can also be seen. Note that producers are from the developing world and are mainly located in Africa, while processors and re-exporters are mainly located in Europe and North-America. Concentration of the TOP10 cocoa exporters has been quite stable over the period analysed – roughly two third of global cocoa export is given by these countries.

By combining biggest producers and exporters, the case of Cote d'Ivoire and Ghana should be highlighted. According to WITS data, cocoa



Source: Own composition based on World Bank WITS database (2016)

Figure 2: The evolution of global export of cocoa, agricultural and total products, 1993-2015 (1992=1).

1992-1997		1998-2003		2004-2009		2010-2015	
Netherlands	12%	Cote d'Ivoire	12%	Netherlands	12%	Germany	12%
Cote d'Ivoire	12%	Netherlands	11%	Germany	11%	Netherlands	11%
Germany	11%	Germany	9%	Cote d'Ivoire	10%	Cote d'Ivoire	9%
France	9%	Belgium	8%	Belgium	9%	Belgium	7%
Ghana	5%	France	7%	France	6%	France	5%
United Kingdom	5%	United Kingdom	4%	Ghana	4%	Nigeria	4%
Italy	4%	United States	4%	Italy	4%	Ghana	4%
United States	3%	Indonesia	3%	Indonesia	4%	United States	4%
Indonesia	2%	Ghana	3%	United States	3%	Italy	3%
Switzerland	2%	Canada	3%	Canada	3%	Poland	3%
TOP10	65%		65%		64%		63%

Source: own composition based on World Bank WITS database (2016)

Table 1: Top cocoa exporters in the world, 1992-2015, in percentage of total cocoa export.

export gave 30% and 14% of total export and 62% and 52% of agricultural export in the period analysed, respectively. This makes their economies highly dependent on agricultural exports – a typical case for many developing countries.

The product structure of global cocoa exports is also worth to be investigated (Table 2). In 2010-2015, the most traded cocoa export products were other cocoa-based food preparations, cocoa beans and cocoa butter, altogether giving 58% of global cocoa exports, suggesting a high level of concentration. The product structure of global cocoa exports has changed little over time. Concentration of these products are also high by country – for instance, Cote d'Ivoire, Ghana, Nigeria, Indonesia and Cameroon exported 75% of world's cocoa beans in 2011-2015. It is almost the same situation with cocoa butter or cocoa powder, coming from relatively few countries. The same situation is true for the processing: the largest processors – as the Cargill, ADM and Barry Collebaut, gave 41% of global cocoa processing in 2014. Moreover, 89% of the confectioner's market was comprised by 5 companies – Mars, Molendéz International, Nestlé, Hershey's and Ferrero (Potts et al., 2014).

Export competitiveness of global cocoa traders

The export competitiveness of global cocoa traders is analysed by the original Balassa index due to high correlations (not presented here) among different Balassa-based indices described in the methodology section. It is obvious that Cote d'Ivoire and Ghana had the highest Balassa indices in the period analysed, while three countries out of the ten biggest exporters had a comparative disadvantage in 2010-2015 (Table 3). Ghana experienced the biggest fall in the period analysed, while the majority of the countries show quite stable competitive patterns based on exports.

Products	1992-1997	1998-2003	2004-2009	2010-2015
Other food preparations, containing cocoa	24.5%	25.4%	27.0%	27.2%
Cocoa beans	18.7%	24.0%	21.6%	20.4%
Cocoa butter, fat and oil	14.0%	11.0%	12.7%	10.7%
Chocolate & other food preparations containing cocoa; more than 2kg	6.0%	8.9%	10.4%	9.5%
Chocolate and other food preparations containing cocoa; filled, 2kg or less	15.7%	9.5%	8.8%	8.9%
Chocolate and other food preparations containing cocoa; not filled, 2kg or less	11.2%	9.0%	7.8%	7.4%
Cocoa paste, not defatted	4.0%	5.2%	5.2%	6.8%
Cocoa; powder, (without sugar)	4.1%	5.3%	4.8%	6.4%
Cocoa paste, defatted	0.5%	0.4%	0.4%	1.0%
Cocoa shells and other cocoa wast	0.3%	0.5%	0.7%	0.9%
Cocoa; powder, (with sugar)	1.0%	0.8%	0.8%	0.7%

Source: own composition based on World Bank WITS database (2016)

Table 2: Export of cocoa products in the world, 1992-2015, in the percentage of the total cocoa export.

Country	1992-1997	1998-2003	2004-2009	2010-2015
Netherlands	6.57	5.96	5.36	5.17
Germany	1.70	1.27	1.40	1.96
Cote d'Ivoire	174.50	206.63	209.95	175.52
Belgium	n.a.	2.43	2.34	2.56
France	1.80	1.90	1.93	1.88
Ghana	110.12	165.03	90.71	42.20
United States	0.51	0.58	0.56	0.54
Italy	0.68	0.57	0.75	0.99
Indonesia	4.58	5.38	4.99	5.99
United Kingdom	1.32	1.39	1.42	0.86

Source: own composition based on World Bank WITS database (2016)

Table 3: Balassa indices by period, 1992-2015.

When analysing export competitiveness by product, further specialisation patterns become available (Table 4). It is apparent that cocoa shells, beans, paste and butter had the highest comparative advantages among product groups. Consequently, countries exporting these products had the highest comparative advantages, while concentrating on the export of other cocoa products have not proved to be beneficial. It is also evident here that indices for raw materials are much higher than for processed products, showing high potentials for developing countries in global cocoa exports.

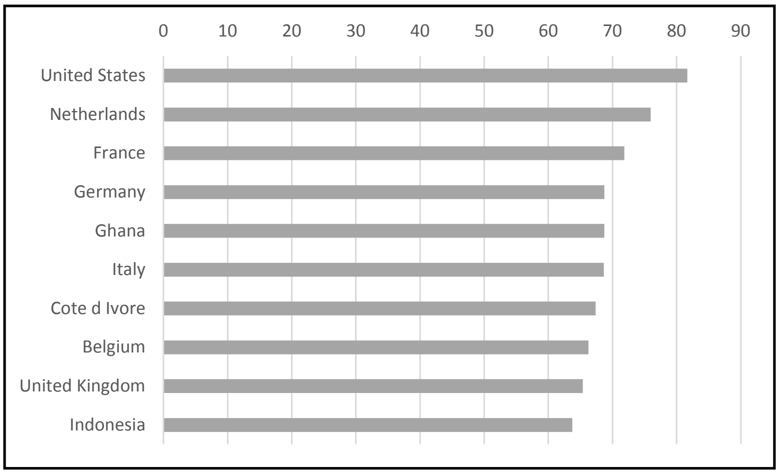
By combining exporters and products, it is also clear that producers like Cote d'Ivoire or Ghana had the biggest export competitiveness for raw cocoa materials. Conversely, distributor countries (Netherlands, Belgium or the UK) generally do not have as high (or do not have any) comparative advantage as producers, though their market positions are better.

The degree of mobility in Balassa indices is estimated by using the mobility index based on the Markov transition probability matrices (Figure 3). Results show a relatively low mobility of the Balassa index in global cocoa trade for the United States, the Netherlands and France, suggesting stable patterns of comparative (dis)advantages. Besides these countries, almost 70% of product groups with a comparative advantage remained persistent for Germany, Ghana and Italy, while lowest mobility measures pertained to Cote d'Ivoire, Belgium, United Kingdom and Indonesia, implying changing competitive potentials. In other words, these latter countries have experienced bigger changes in their cocoa export competitiveness than other countries listed.

Product	1992-1997	1998-2003	2004-2009	2010-2015
Cocoa beans	62.94	132.21	113.39	72.32
Cocoa shells	66.85	138.14	120.01	96.92
Cocoa paste, not defatted	15.96	56.82	53.56	42.11
Cocoa paste, defatted	11.47	40.31	22.13	7.70
Cocoa butter, fat or oil	13.43	23.77	18.47	16.92
Cocoa powder without sugar	3.75	8.54	10.14	7.70
Cocoa powder with sugar	1.57	3.17	1.44	5.08
Chocolate and other food containing cocoa, >2kgs	2.02	3.35	6.90	4.55
Chocolate and other food containing cocoa, filled, ≤2kgs	2.68	2.11	1.65	1.80
Chocolate and other food containing cocoa, not filled, ≤2kgs	1.24	1.48	1.70	2.28
Chocolate and other food containing cocoa, n.e.c.	1.75	1.90	1.94	2.27

Source: own composition based on World Bank WITS database (2016)

Table 4: Balassa indices for TOP10 cocoa exporters by product, 1992-2015.



Source: own composition based on World Bank WITS database (2016)

Figure 3: The mobility of Balassa indices, 1992-2015, by country, %.

Year	Survivor function	Belgium	Cote d Ivore	France	Germany	Ghana	Indonesia	Italy	Netherlands	United Kingdom	United States
1992	0.9909	1.0000	1.0000	1.0000	0.9924	1.0000	0.9659	1.0000	0.9886	1.0000	0.9621
1993	0.9811	1.0000	1.0000	1.0000	0.9846	1.0000	0.9392	1.0000	0.9808	0.9763	0.9317
1994	0.9653	1.0000	1.0000	0.9835	0.9724	1.0000	0.9159	0.9628	0.9727	0.9561	0.8932
1995	0.9469	1.0000	0.9827	0.9707	0.9597	1.0000	0.8881	0.9253	0.9643	0.9313	0.8545
1996	0.9258	1.0000	0.9648	0.9575	0.9467	0.9773	0.8599	0.8874	0.9555	0.9059	0.8157
1997	0.905	1.0000	0.951	0.9437	0.9285	0.9539	0.8352	0.8492	0.9464	0.8842	0.7767
1998	0.8831	1.0000	0.9366	0.9294	0.9098	0.9346	0.8099	0.8149	0.9320	0.8574	0.7335
1999	0.8585	0.9679	0.9165	0.9145	0.8855	0.9146	0.7969	0.7757	0.9221	0.8345	0.6904
2000	0.8351	0.9404	0.9009	0.8989	0.8553	0.8990	0.7833	0.7360	0.9168	0.8060	0.6551
2001	0.8103	0.9005	0.8845	0.8826	0.8242	0.8827	0.7643	0.6959	0.9113	0.7767	0.6273
2002	0.7840	0.8596	0.8615	0.8654	0.7921	0.8827	0.7494	0.6552	0.8935	0.7515	0.5865
2003	0.7533	0.8175	0.8314	0.8472	0.7588	0.8518	0.7232	0.614	0.881	0.7305	0.5455
2004	0.7162	0.7804	0.7999	0.828	0.7243	0.7808	0.6904	0.5721	0.8610	0.6918	0.5083
2005	0.6813	0.7352	0.7669	0.8074	0.6884	0.7486	0.6504	0.5296	0.8468	0.6632	0.4663
2006	0.6466	0.6884	0.7320	0.7854	0.6634	0.7146	0.6149	0.491	0.8314	0.6330	0.4197
2007	0.6107	0.6467	0.695	0.7616	0.6299	0.6929	0.5715	0.4514	0.8146	0.5947	0.3773
2008	0.5739	0.6026	0.6635	0.7357	0.6012	0.6535	0.5325	0.4155	0.7961	0.5541	0.3344
2009	0.5366	0.5635	0.6290	0.7070	0.5778	0.6026	0.491	0.3723	0.7857	0.5109	0.2997
2010	0.4968	0.5208	0.5909	0.6749	0.5516	0.5570	0.4538	0.3272	0.7738	0.4645	0.2588
2011	0.4525	0.4734	0.5479	0.6258	0.5315	0.5063	0.4126	0.2855	0.7598	0.4054	0.2165
2012	0.3990	0.4196	0.4981	0.5831	0.4953	0.4258	0.3657	0.2401	0.7252	0.3409	0.1722
2013	0.3386	0.3561	0.4226	0.5124	0.4652	0.3484	0.3103	0.1892	0.7032	0.2686	0.1304
2014	0.2709	0.2751	0.3266	0.4426	0.4230	0.3484	0.2398	0.1204	0.6713	0.1953	0.0771
2015	0.1798	0.1501	0.2375	0.3219	0.3461	0.3484	0.2398	0.0438	0.4882	0.1065	0.014

Source: own composition based on World Bank WITS database (2016)

Table 5: Kaplan-Meier survival rates for Balassa indices and tests for equality of survival functions in global cocoa trade, by most exported product, 1991–2015.

Regarding the duration of revealed comparative advantages in global cocoa exports, the non-parametric Kaplan–Meier product limit estimator was estimated. As described in the methodology section, equation 9 was run on our panel dataset and results confirm that in general the survival times are not persistent over the period analysed (Table 5). Survival chances of 99% at the beginning of the period fell to 1-49% by the end of the period, suggesting that a generally fierce competition exists in global cocoa trade. Results vary by country, though the highest survival times exist for the Netherlands and the lowest for the United States (processors of cocoa products). The equality of the survival functions across the top 10 countries can be checked using two non-parametric tests (Wilcoxon and log-rank tests). Results of the tests show that the hypothesis of equality across survivor functions can be rejected at the 1% level of significance, meaning that similarities in the duration of comparative advantage across most important global cocoa exporters are absent (Table 5). On the whole, results suggest cocoa processing countries have had higher probabilities of retaining their original competitive positions than cocoa producers.

Conclusion

The article analysed the competitiveness of global cocoa traders between 1992 and 2015 and reached a number of conclusions. First, our results indicate that global cocoa trade has been continuously increasing in the previous 25 years with a high concentration on both the export and import sides by country and by product. Germany, the Netherlands and Cote d'Ivoire were the biggest cocoa exporters in the world in 2010-2015, while the United States, Germany and the Netherlands were leading the line in global cocoa imports. Most traded products were other cocoa based food preparations, cocoa beans and cocoa butter, altogether giving 58% of global cocoa trade in 2010-2015, suggesting a high level of concentration (TOP10 products gave 93% in the same period).

Second, our results also suggest that the Netherlands, Germany and Cote d'Ivoire had the highest comparative advantages in the period analysed, while at the product level, cocoa beans and cocoa shells led the line. It seems evident that countries concentrated on the export of these products were the most competitive in global cocoa markets.

Third, duration and stability tests indicated that trade advantages had weakened for the majority of the countries concerned. Research in the future might check other products and variables to extend these results and make them more valid.

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Appendix

Product code	Description
180100	Cocoa beans, whole or broken, raw or roasted
180200	Cocoa shells, husks, skins and other cocoa wast
180310	Cocoa paste, not defatted
180320	Cocoa paste, wholly or partly defatted
180400	Cocoa butter, fat and oil
180500	Cocoa; powder, not containing added sugar or other sweetening matter (without sugar)
180610	Cocoa; powder, containing added sugar or other sweetening matter (with sugar)
180620	Chocolate & other food preparations containing cocoa; in blocks, slabs or bars weighing more than 2 kg or in liquid, paste, powder, granular or other bulk form in containers or immediate packings, content exceeding 2 kg
180631	Chocolate and other food preparations containing cocoa; in blocks, slabs or bars, filled, weighing 2 kg or less
180632	Chocolate and other food preparations containing cocoa; in blocks, slabs or bars, (not filled), weighing 2 kg or less
180690	Chocolate and other food preparations containing cocoa; n.e.c. in chapter 18 (other …)

Source: own composition based on World Bank WITS database (2016)

Appendix 1: Cocoa product codes and associated descriptions at the HS6 level.

Business Process Modelling Languages

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Abstract

This paper summarizes the current knowledge of business process modelling languages, which is increasingly important also in the agri-food industry. It describes the history of business process modelling, currently mostly used alternatives – UML, BPMN, EPC and recaps their strengths and features in which they outperform the others. As demonstrated all three notations can adequately model business processes. They do however differ in some specific features. In some aspects, each of the languages always outperforms the others. Important is that except of some general objective features where the languages differ, there is also a lot of subjective perception of how the single notations perform.

Keywords

Business Process Modelling, UML, BPMN, EPC.

Kožíšek, F. and Vrana, I. (2017) "Business Process Modelling Languages", *AGRIS on-line Papers in Economics and Informatics*, Vol. 9, No. 3, pp. 39 - 49. ISSN 1804-1930. DOI 10.7160/aol.2017.090304.

Introduction

Business process management (BPM) is an important topic for any organization nowadays. For each business goal, an organization has a set of activities, which must be undertaken. Business Processes are then a way to organize these activities and understand their interdependencies. (Weske, 2012; Pradabwong et al., 2015)

Importance of BPM is also increasingly seen in the agri-food industry. As Verdouw (2010) discusses one of the drivers for improved business process management is the market changes. Agri-food companies need to be increasingly flexible in the demand-driven supply chains.

Wolfert (2010), Vorst (2005) and Novák (2016) claim that the increasing demands of government, consumers and business partners are driving agri-food companies towards more knowledge based operations, where ICT and BPM play an important role.

As discussed by Panagacos (2012) BPM in an organization has more functions and benefits which it can achieve:

- Function analysis – evaluates different activities executed by different parts of organization,
- Service analysis – identifies manual processes for possible automation,
- Process analysis – assesses end-to-end processes to identify improvements,
- Information analysis – defines the flow of information between stakeholders and optimizes it,
- Workflow analysis – assesses data workflow between systems.

This article describes the different modelling languages and their strengths for different purposes. Three most common business-modelling languages were used – Business Process Modeling Notation (BPMN), Unified Modelling Language (UML) and Event-Driven Process Chains (EPC). Example of a deliver-to-order process from a fruit farm is taken to show the main differences the modeling notations have.

In the first chapter the history of business process modeling languages is briefly described. In the following chapters two, three and four individual modelling languages UML, EPC and BPMN are described with their specific features. In the fifth chapter conclusion and account for future work is described.

Materials and methods

The research has started with an analysis of available business process modeling notations. From these notations those most frequently used were chosen, namely UML Activity diagram, BPMN and EPC.

Further literature review was conducted to identify the criteria to compare these notations. The adequacy of the notations in agri-food industry was further analyzed on a use case of fruit farm process deliver-to-order. As a secondary source of data for analysis, a review of published research materials was used.

History of business process modeling languages

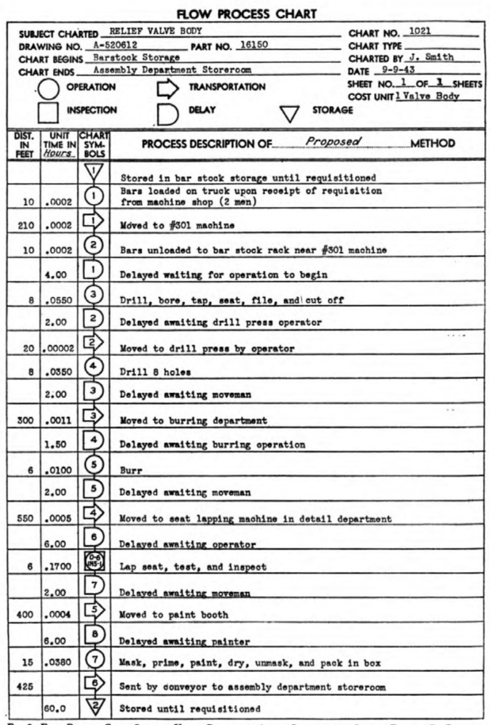
Panagacos (2012) argues that the first attempts to depict the organizational processes happened already in the time of ancient Egypt who adopted primitive forms of workflow systems used for engineering purposes.

However, when talking about the business process management in the modern time, then it is related to the attempt of permanent improvement of how business works. Therefore, Taylorism, Total Quality Management, Just In Time Management or Six Sigma initiatives are those which led to the need for a good business process modelling tool (Panagacos, 2012; Soare, 2012) (Figure 1).

In the early 20th century appeared a new management discipline of Scientific Management. It is represented mainly by the work of Frederick Winslow Taylor. He describes basic principles on how a good manager should improve his business. This included work simplification, time and motion studies and systematic work on improving the way in which the work is done.

It was another author Frank B. Gilbreth (Gilbreth, 1921) in 1921 who published his article Process Charts. Gilbreth intention was to introduce a tool, which could visualize a process in manufacturing. This is what he saw as a basis for further process improvement. He introduced a wide set of symbols. He also came up with the principle of putting the symbols from the top to bottom in the sequential order, which is a way how to show the flow of the process. (Graham, 2004; Krogstie, 2016)

The need of standardization was apparent and in 1947 American Society of Mechanical Engineers (ASME) came with such a standard and established a set of symbols known as the ASME Standard for Operation and Flow Process Charts. It was based on the Gilbreth work but generalized his symbols into six basic ones (American Society of Mechanical Engineers, 1947) (Figure 2).


FLOW PROCESS CHART

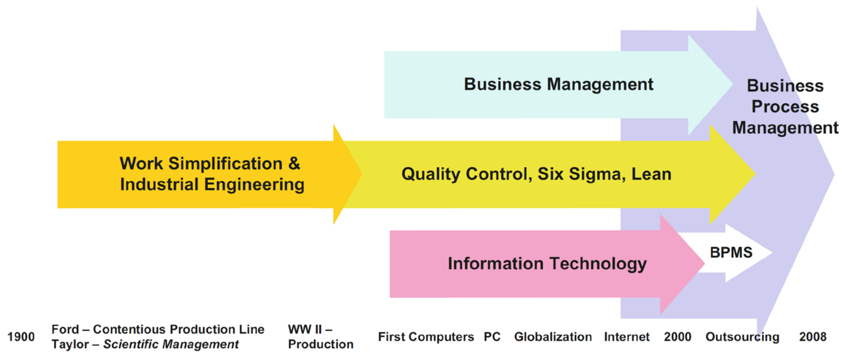
SUBJECT CHARTED RELIEF VALVE BODY — CHART NO. 1021
DRAWING NO. A-520612 — PART NO. 16150 — CHART TYPE
CHART BEGINS Barstock Storage — CHARTED BY J. Smith
CHART ENDS Assembly Department Storeroom — DATE 9-9-43
OPERATION — TRANSPORTATION — SHEET NO. 1 OF 1 SHEETS
INSPECTION — DELAY — STORAGE — COST UNIT 1 Valve Body

DIST. IN FEET	UNIT TIME IN Hours	CHART SYMBOLS	PROCESS DESCRIPTION OF Proposed METHOD
		1	Stored in bar stock storage until requisitioned
10	.0002	1	Bars loaded on truck upon receipt of requisition from machine shop (2 men)
210	.0002	1	Moved to #301 machine
10	.0002	2	Bars unloaded to bar stock rack near #301 machine
	4.00	1	Delayed waiting for operation to begin
8	.0550	3	Drill, bore, tap, seat, file, and cut off
	2.00	2	Delayed awaiting drill press operator
20	.00002	2	Moved to drill press by operator
8	.0350	4	Drill 8 holes
	2.00	3	Delayed awaiting moveman
300	.0011	3	Moved to burring department
	1.50	4	Delayed awaiting burring operation
6	.0100	5	Burr
	2.00	5	Delayed awaiting moveman
550	.0005	4	Moved to seat lapping machine in detail department
	6.00	6	Delayed awaiting operator
6	.1700	O-6 INS-1	Lap seat, test, and inspect
	2.00	7	Delayed awaiting moveman
400	.0004	5	Moved to paint booth
	6.00	8	Delayed awaiting painter
15	.0380	7	Mask, prime, paint, dry, unmask, and pack in box
425		6	Sent by conveyor to assembly department storeroom
	60.0	2	Stored until requisitioned

Fig. 9 Flow Process Chart Showing Use of Rulings as Aids in Locating and Spacing Data to Be Charted

Source: American Society of Mechanical Engineers (1947)

Figure 2: Example of process from ASME methodology.

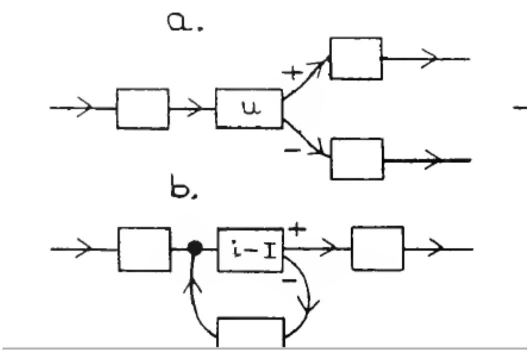


Source: Brocke, 2014

Figure 1: Evolution of business process management.

- Operation - when an object is being changed
- Transportation - when object is being moved to another place
- Inspection – when object is being checked and quality/quantity verified
- Storage – when object is being kept with no action
- Delay – when object is not being further processed until condition is fulfilled
- Combined activity – when activities perform at the same time

In the same time when flow chart idea was formed, another couple - John von Neuman and H. Goldstein developed another similar concept for programming purposes. In 1947, they published a paper in which they suggested a graphical way – flow diagram. Its main purpose is to represent computer algorithm (Goldstine and von Neumann, 1947; Morris and Gotel, 2006) (Figure 3).

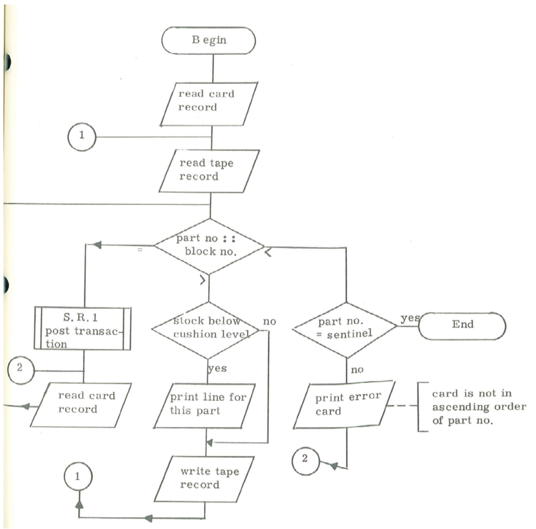


Source: Goldstine (1947)

Figure 3: J von Neuman, H. Goldstine flow diagram.

As Morris and Gotel (2011) who did an extensive research in history of flow charting note, there is a little material about early days of program design and about the development of flow-charting itself.

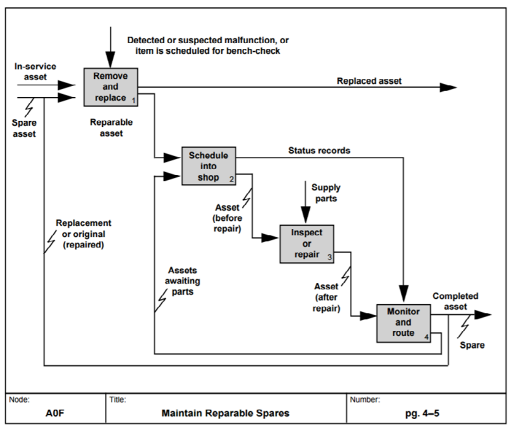
Only later in 1966 flowcharts were finally standardized by ECMA. It considered two basic usages for flowcharts. First was the program flow chart used to describe flow of a computer program. The other then Data Flow Chart used to show flow of data through the system (European computer manufacturers association, 1966) (Figure 4). Its flow chart notation is very much the notation used nowadays. Although the current standard is the ISO 5807:1985.



Source: European computer manufacturers association (1966)

Figure 4: ECMA flowchart notation example.

In parallel to how flow-charting developed there were also other initiatives which had as a goal possibility to capture process flows. One of them was the US Air Force ICAM (Integrated Computer-Aided Manufacturing) program, which was started in 1977. Within this program IDEF0 standard for functional modeling was defined. (Assembly of Engineering (U.S.). Committee On Computer-Aided Manufacturing, 1981; Godwin et al., 1989) IDEF0 shows well the interdependencies in a process. It also offers the possibility of process decomposition. Each process is split into functions with input and output flows, controls and mechanisms (Figure 5).



Source: Leonard, b.r.

Figure 5: IDEF0 process example.

In 1990s with the appearance of object-oriented programming, an effort to create a unified method, which will assist to the software development process was made. This lead to the Unified Modelling Language (UML). One of the UML charts is the activity diagram, which among other flows is used also for modelling of business processes. Activity diagrams are still very widely used for business process modelling nowadays. (Morris, 2012) We shall describe it in more details in one of the following chapters.

In 1992, there was also EPC (Event-Driven Process Chain) introduced by August-Wilhelm Scheer as a notation for semiformal charting of business processes. It was developed within ARIS (Architecture of Integrated Information Systems) framework, which was primarily used for SAP R3 enterprise resource planning system. (Scheer, 1999) Details about this notation will also follow in one of the next chapters.

In 2004, another notation – BPMN (Business Process Model and Notation) was introduced by BPMI (Business Process Management Initiative). Its main purpose was to achieve a notation which was well understandable by both business users and developers and enabled easy charting of business processes. Authors of BPMN used during its creation experience from existing notations - IDEF, UML Activity Diagram and EPC. (Object Management Group, 2011) This notation is also going to be described in detail in one of the following chapters.

UML Activity diagram

Activity diagram is one of the UML behavioral diagrams. Interestingly the initial version of UML in 1995 did not contain the activity diagram. The state machine diagram with its concept that state changes in response to an input was the main tool to model behavior. Only later, the need for modeling the flow of activities was recognized and activity diagrams were introduced in 1996. (Morris, 2012)

Activity diagrams in UML are not purely intended for business process modelling. They can also be used for modelling of computational procedures or object-oriented models to describe methods and operations. Activity diagram has similar notation as flow chart. On top of that it allows to model parallelism.

In following Figure 6 example of such a parallelism modeling is shown. Activity Determine delivery date is running in parallel with Activity Reserve packaging material. Only after both of these activities are finished process continues to the next one – Pick fresh fruits.

Main components of an activity diagram are activity nodes connected with activity edges. There are following types of activity nodes:

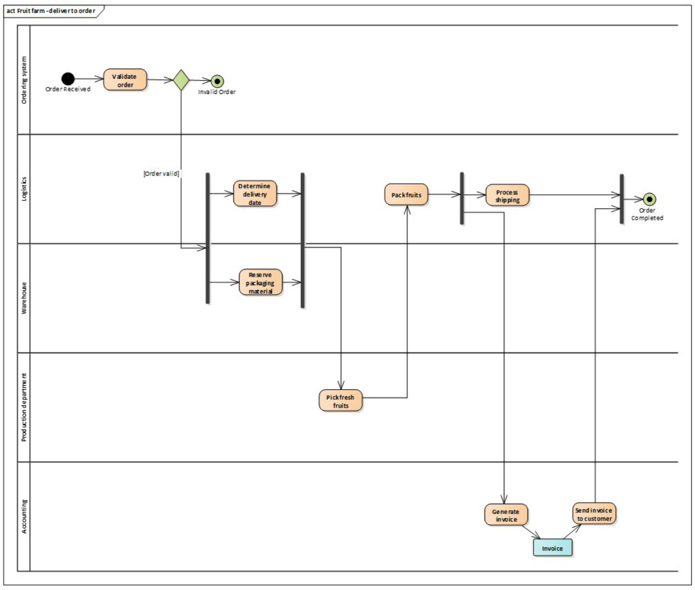
- Executable nodes – it is a behavioral step in the process. All the incoming and outgoing edges are control flows. It can also consume and produce data but only through an Object Node. In the following Figure 6, such executable node, which produces data, is activity “Generate Invoice”, which produces Object node “Invoice”.
- Object nodes – used to hold object during execution of an activity. In the following example, such node is the “Invoice”
- Control nodes – are special type of nodes used to control the flow within the process. There are different types of control nodes.
    - Initial one - starting point of the flow.
    - Final one - end point of the activity.
    - Split/Joint node – ensuring synchronization of the activity flow.
    - Decision node – decision point choosing between two or more alternative ways
    - Merge node – bringing together multiple flows. Unlike in joint node it is not synchronizing the process.

Apart of nodes there are following other objects within an activity diagram:

- Activity Edge – is a directed connection between two activity nodes. It can also hold a guard, meaning a value, which is evaluated. Only in case it is evaluated as true, process continues through this edge. Example of such a guard is the “Order valid” value in the Figure 6.
- Activity Partition – in order to split the process into parts, which have some common features, swim lanes can be used. (Object Management Group, 2015)

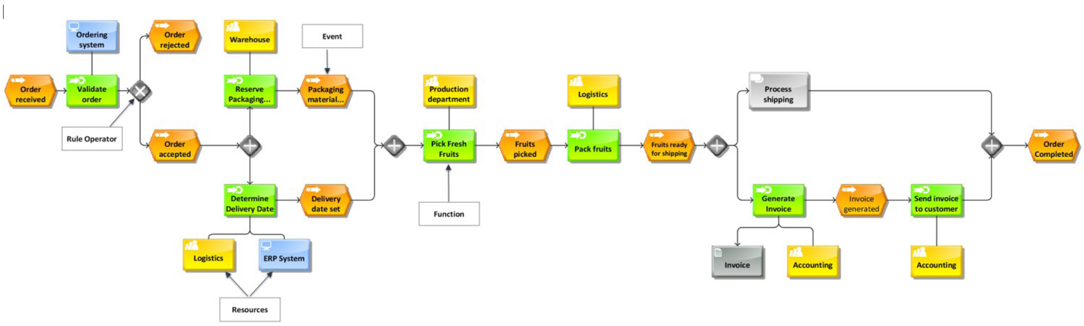
Event-driven process chains

Event-driven process chain method developed in 1992 under SAP funding has different approach to model a process. Unlike Activity diagram, which has only one main component - activities, EPC has two components: Events and Functions.



Source: own work

Figure 6: Example of an activity diagram.



Source: own work

Figure 7: Example of an activity diagram.

Function is the active part of the diagram. It represents what is happening within the process. Fact that the function happens leads to the change of the state/event. In the Figure 7 the function “Pick fresh fruits” leads to the event “Fruits picked”.

Events are then passive part of the diagram. It describes events/condition, which precede or follow some function. It can either describe event, which leads to some function, or it can describe how the situation changed by the function. In the following example, the event which precedes the “Pack Fruits” function is “Fruits picked”. By running the “Pack fruits” function “Fruits ready for shipping” event is then triggered.

Apart from events and functions there can be also other components – Rules and Resources.

Rules are similar to the decision and fork/joint nodes in the activity diagram. They have however different notation and have wider function. Depending on if they precede or follow a function they have different meaning (Table 1).

Operator	After a function	Before a function
OR	Decision – one or more path will be taken	Any combination of events will trigger the function
XOR	Exclusive OR Decision – one path will be taken	Only one event will be the trigger
AND	Flow splits into two parallel paths	All events must occur to trigger the following function

Source: own work

Table 1: EPC rules.

Resources are another component of EPC. They serve as a tool to model the relationship between the process and the business environment. There are multiple types of resources:

- Organization unit – responsible for the function to be undertaken
- Systems – represent computer and software applications needed
- Data – representing the input and output data for the function
- Knowledge – knowledge needed and relevant to the function
- Information Carriers – represent the media on which the information is being stored
- Products – showing what products are being delivered by the function
- Objective and Measures – business objective met by the function
- General Resources – other non-specific resources (Davis, 2001)

Business process model and notation

Object Management Group (2011) claims BPMN notation has two major goals. First is to achieve a notation, which is easily readable and understandable to all stakeholders. Secondly, it enables visualization of XML languages designed for business process management systems such as WSBPEL.

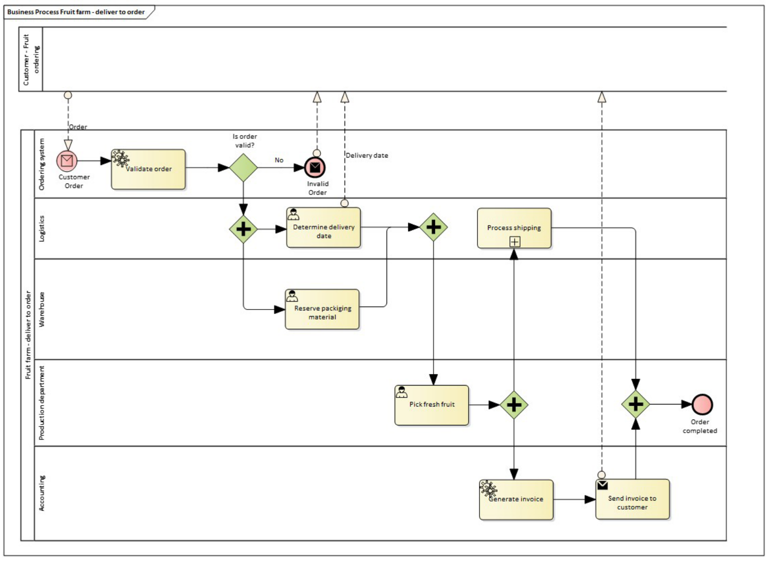
With BPMN 2.0 the scope of the notation was extended. It does not only serve to show processes, but also shows choreographies meaning the messages exchange between process participants, collaborations showing interaction of different participants and conversations showing the high-level perspective on the collaboration of different participants.

BPMN has five basic elements:

- Flow objects – these are the basic graphical elements of the business process. There is the *activity* element representing the work, which is being done, event element representing the trigger or a result of a process and the gateway which controls the flow of the process.
- Data – is used to provide information what input is required for a certain activity or what data is produced by such an activity.
- Connecting objects – serving for connecting different elements together. Basic one is the *sequence flow*, which connects activities and determines their order in the process. Another is the *message flow* determining how the different participants communicate with each other. Last one is the *association* used to link other BPMN artifacts together.
- Swim-lanes and pools – are graphical containers showing the different process participants
- Artifacts – these elements serve to provide additional information for the process, which cannot be modeled by the other elements.

(An example Figure 8).

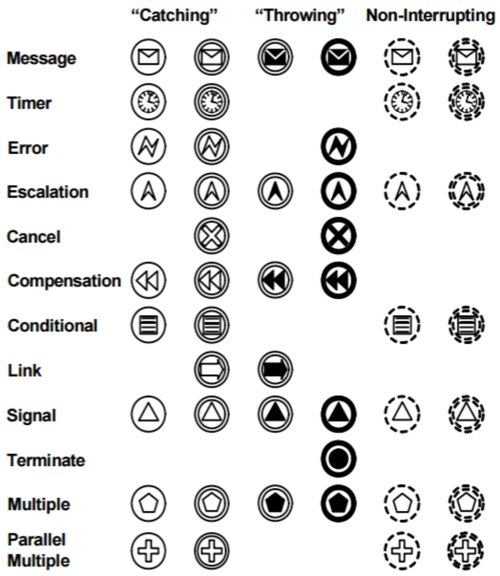
While there is only limited number of the basic BPMN elements, they have different variants, which is bringing the additional complexity



Source: own work

Figure 8: BPMN process.

of BPMN diagrams. This is especially true for the event element, which has many different variations, each of them with a specific meaning. This brings additional complexity to the modelling notation (Figure 9).



Source: Object Management Group (2011)

Figure 9: Event Element variations.

Results and discussion

In the following chapter differences among notations are described. They are clustered into five main categories:

- Notations modelling differences
- Ability to describe complex processes
- Understandability of the notations
- Usability& User acceptance
- SOA preparedness

Notations modelling differences

Following table summarizes the main differences in the modelling possibilities of each discussed notation (Table 2).

Ability to describe complex processes

Generally, BPMN and EPC considered as those having bigger variety for modelling. They have more elements, which can be used.

EPC has for example special elements for data, knowledge, information carriers or products. None of these are in BPMN or UML Activity diagrams. These can be modelled only by the general artefact element.

	EPC	**UML Activity Diagram**	**BPMN**
Diagram context	Process-oriented modeling (business oriented)	Object-oriented modelling (IT oriented)	Process-oriented modeling (business oriented)
Active element	Function – round edged box	Activity – round edged box	Task – round edged box
Event element	Hexagon element used for depicting all events; used also to describe post-function state of the process	Only start and end event available	Wide variety of elements depicting the event – circle with symbol inside
Ability to decompose process	Special process interface element used to link processes	Activity with rake style icon indicates subprocess	Activity element with plus icon indicates subprocess
Flow of data	Only flow of events and activities shown.	Only flow of activities shown.	Separation of control and message flow. Apart of sequence of steps flow of information across pools can be depicted.
Modelling of parallelism	AND connector used to fork activities to show parallel run and then join them.	Horizontal thick black line used to fork and join parallel run.	Special fork/join gateway used to model parallelism
Modeling of complex decisions	Decision point representing either OR or XOR in Boolean logic	Just simple decision point representing OR in Boolean logic	Apart OR and XOR also event based gateway and gateway for complex decisions.
Actors	Organizational unit element to indicate who is the actor	Swim-lanes and pools used to distinguish different actors	Swim-lanes and pools used to distinguish different actors
Loop in diagram	No special element for loops. Can be modeled by combination of decisions and functions.	No special element for looping. Can be modeled by combination of decision step and activity.	Special loop activity existent

Source: own work

Table 2: Comparison of modelling notations.

BPMN on the other hand has a wider variety of event elements. There are no events except of start and end event in UML Activity diagram. As Rashedul et al. (2011) notes, UML was designed for object-oriented modelling. For showing states and events of a dynamic object there is a different UML diagram, namely the state machine one. EPC has for events only one element but its description is enabling the variability.

Furthermore, White (2004) compared business processes modelling patterns between UML Activity Diagram and BPMN. He claims that both notation can adequately model most of the patterns. So even UML activity diagram does not have such a big variability, in the real use this is not an issue. As Recker (2009) notes even BPMN has theoretically bigger variability but it is rather a theoretical feature. In reality, the complexity is not being widely used.

Understandability of the notations

OMG, which is responsible for both UML and BPMN sees BPMN as the main tool for business process modelling claiming "… BPMN is to provide a notation that is readily understandable by all business users …" (Object Management Group, 2011) The UML AD is rather seen as technically oriented. One should note that there is no substantial evidence that BPMN was superior to UML Activity diagram in understandability. One of the reason is that they share same notation for the basic elements.

Jošt et al. (2016) conducted a study where they compared UML Activity Diagram, EPC and BPMN for their understandability. They found out that BPMN is not well understandable in process diagrams with lower complexity. It was outperformed by both UML Activity Diagram and EPC. On the contrary, in the complex diagrams EPC was outperformed by both BPMN and UML Activity diagrams. They concluded that UML Activity diagram is the most versatile. In addition, Peixoto et. al (2008) was investigating the comprehension of BPMN and UML Activity diagram from the readability perspective. In his experiment, both notations were equally understandable by research subjects.

Usability and user acceptance

Another research focused on how users accept different notations and what might be the usability issues.

Kruczynski (2010) made an empirical study about BPMN and EPC acceptance. His respondents were claiming in the questionnaire that EPC has a clearer layout, is more logical, comprehensive and easier to implement. Interestingly enough, when letting the same group to do the modelling they did less mistakes in BPMN than in EPC. He concludes BPMN to be more stringent in modelling which leads to less modelling mistakes.

Birkmeier et al. (2010) focused on comparing usability of BPMN and UML Activity diagram. He compared effectiveness, efficiency and satisfaction with the notations. Although BPMN is considered superior of both notations, his empirical study did not confirm that. Both BPMN and UML Activity diagram are proven as equally usable. Furthermore, some problematic aspects of BPMN were identified. One of them is the separation of data and control flows, which misleads less experienced users. In all the other discussed notations, there is only one type of activity flow. Users have to thus have sufficient knowledge about this significant BPMN difference in order to correctly understand the BPMN process. Another issue is the flexibility of usage of BPMN. They claim that it is promoting rather sequential modelling style, which is then decreasing the process flexibility. Recker (2009) notes another usability problem for BPMN and that is its complexity. He suggests that it is in the interest of learnability and user acceptance to actually reduce complexity. Wahl and Sindre (2006) then conclude that although BPMN has an easy basic graphical notation, it requires significant training for more complex features.

SOA preparedness

Next criterium is whether and how the notation is ready for the Service oriented architecture (SOA). SOA's goal is to abstract IT from its physical implementation and publish IT resources as re-usable services. It reduces the semantic gap between the business process and the implementation. BPEL (Business Process Execution Language) - standard for developing executable processes - is then a way how to build business processes based on the re-usable services. Having thus the ability to convert business process into an execution language could dramatically shorten the development lifecycle. (Jurič, 2008) When the process is well designed, it can be then executed by business process engine with minimal changes. While BPMN was built with intention to enable translation to BPEL, UML Activity diagram is missing this feature. (Geambasu, 2012)

Kruczynski (2010) notes that both EPC and BPMN are transformable to BPEL. Because BPMN was designed with the respect to BPEL, there are more transformation patterns between BPMN and BPEL than EPC and BPEL. However, as Kruczynski (2010) explains it is the tool used which makes the quality of the BPEL process not just the existence of the transformation pattern.

Conclusion

This paper described history of business process modeling notations, three most common notations – UML, BPMN and EPC and their differences. All three notations can adequately model business processes as demonstrated on the Fruit farm deliver-to-order process example.

They do however differ in some specific features. In some aspects, each of the languages always outperforms the others. Important is that except of some general objective features where the languages differ, there is also a lot of subjective perception of how the single notations perform. Therefore, both depending on the specific usage of the notation and depending also on the specific user group, different notation can be optimal for being selected. When comparing the notations, no specific characteristic was identified which would favor one of the notations from the agri-business perspective. As a result, the topic for future work is to prepare a decision framework, which will enable the user to pick the right notation for the specific situation with respect to defined criteria.

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Assessing Interdependencies Between Food and Energy Prices: The Case of Biodiesel in Germany

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Abstract

The paper aims to analyse the relationship between energy prices (biodiesel, crude oil) and food commodities - vegetable oils used also as feedstock for biodiesel production. The econometric technique of price transmission, such as unit root test, cointegration test and vector error correction model, is applied to assess the interdependencies between energy prices and vegetable oil prices in Germany. Results suggest close price linkages between prices of vegetable oils and biodiesel and confirm that the vegetable oil prices drive the price dynamics of biodiesel. However, the simultaneous relationship is only revealed between biodiesel and soybean oil prices. The increase in crude oil prices is found to lead to an upward trend in the vegetable oils used for biodiesel production, thus influencing biodiesel prices as well.

Keywords

Biodiesel, crude oil, food, Germany, price transmission.

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Introduction

The fuel and energy crises of the late 1970's and early 1980's and concerns about the depletion of the world's non-renewable resources as well as increased environmental problems provided the incentives to look for alternatives to petroleum-based fuels (Knothe et al., n.d.). There are several reasons for biofuels (i.e. security reasons, environmental concerns, foreign exchange savings, and socioeconomic issues related to the rural sector) to be considered as relevant replacement for fossil liquid fuels (Demirbas, 2008). A 'first generation' biofuel (i.e. biodiesel (bio-esters), bio-ethanol, and biogas) is characterized either by its ability to be blended with petroleum-based fuels, combusted in existing internal combustion engines, and distributed through existing infrastructure, or by the use in existing alternative vehicle technology like FFVs ("Flexible Fuel Vehicle") or natural gas vehicles (Naik, et al., 2010). Blanco et al. (2010) explain that the biofuel yield per hectare of first generation biofuels varies greatly between feedstocks and producing areas, and follows the trade-offs between crop yield per hectare and the energy yield of specific crops. Additionally, biofuels production costs can vary widely by feedstock, conversion process, scale of production and region but the cost of feedstock is a major component of overall costs, e.g. the cost of feedstock for biodiesel production is about 75–80% of the total operating cost (Demirbas, 2009).

Biodiesel has been considered a promising option as an eco-friendly alternative to diesel fuel largely utilized in the transport, agriculture, commercial, domestic and industrial sectors for the generation of power/mechanical energy (Barnwal and Sharma, 2005). Shereena and Thangaraj (2009) determine the following general advantages of biodiesel: (1) lower dependence on crude oil, (2) renewable fuel, (3) favourable energy balance, (4) reduction in greenhouse gas emission, (5) lower harmful emission, (6) biodegradable and non-toxic, (7) the use of agricultural surplus, and (8) safer handling (higher flash point than conventional diesel fuel). The feedstock for biodiesel production can be categorized as lipid feedstock and alcohol feedstock. The lipid feedstock includes vegetable oils, animal fats, and, more recently, other plant-like organisms such as micro algae and cyanobacteria; however vegetable oils are currently the major sources for making biodiesel (Issariyakul and Dalai, 2014). The primary production of biodiesel is concentrated in Europe (Germany is the leading European biodiesel producer) with rapeseed oil as the major source. Soybean oil is another lipid feedstock used for synthesis of biodiesel in Brazil and U.S and palm oil is used in biodiesel production as the major input in Malaysia (Yu et al., 2006).

There are concerns about adverse effects of first generation biofuels, including the impact they may have on biodiversity and land use and competition with food crops. The issue of biofuel-food correlation came to be examined carefully and a research on a possible impacts of biofuels on food prices has become more frequent (Capitani, 2014). Peri and Baldi (2010) analyse correlations between vegetable oil prices and conventional diesel prices in the European Union between 2005 and 2007. The results reveal a two-regime threshold cointegration model only for rapeseed oil – diesel price pair and indicate that the adjustment process of rapeseed oil prices is fast to its long-run equilibrium, but asymmetric, thus rapeseed oil appears particularly exposed to external shocks deriving from global political scenarios such as given the high quota of EU biodiesel produced by this vegetable oil. Later on, Kristoufek et al. (2012) analyse the relationship between biodiesel and related fuels and commodity prices in the US and Germany from 2003 to 2011 with the use of minimal spanning trees and hierarchical trees and confirm that biofuel is affected by food and fuel prices. However, biofuel prices show limited capacity to determine food prices. Additionally, the evidence of a strong impact of crude oil prices on biodiesel prices, and of biodiesel prices on rapeseed oil prices was found by Busse et al. (2010). Hassouneh et al. (2012) using a multivariate local linear regression model and a parametric error correction model assess price linkages among biodiesel, sunflower and crude oil prices in Spain, finding the existence of a long-run equilibrium relationship between the three prices. Lajdova et al. (2015) analyse long run relationship between biofuel prices and food commodity prices in US with the use of vector error correction model and find out the presence of bilateral causality between biodiesel and soybean prices. Hao et al. (2013) use cointegration test between biodiesel and soybean and find also a long-run relationship between the prices. Busse and Ihle (2009) study the price linkages between rapeseed oil, soy oil and biodiesel in German market during the period 2002–2007 applying a Markov switching vector error correction model (MS-VECM) and find an evidence of a weakening adjustment process provided when prices diverge from their long-run equilibrium prices after 2005, particularly for rapeseed oil prices.

Bentivoglio et al. (2014) note that current research has mainly concentrated on the US and Brazilian ethanol markets; however, the European biodiesel market has not received much concern. Therefore, the paper intends to provide a comprehensive analysis of price relationship between vegetable oils, used as a feedstock for biodiesel production, and energy prices (crude oil and biodiesel) in order to gain better insight of interacting price behavior in the EU biodiesel market. Our research contributes to the biofuel and food price debate and the results might help producers and traders of vegetable oils to plan their business operations as well as provide government with information regarding policy formulation.

The paper aims to analyse the relationship between energy prices (biodiesel, crude oil) and food commodities - vegetable oils used also as feedstock for biodiesel production.

Materials and methods

The main goal of the paper is to investigate the relationship between biodiesel price and relevant agricultural commodities - vegetable oils used for biodiesel production. Crude oil as relevant natural substitute of biodiesel is included as well. The analysis is based on monthly observations covering period from January 2006 to December 2014. Average monthly wholesale biodiesel price was taken from The Union for Promotion of Oil and Protein Plants (UFOP). We use the German prices as Germany has been one of the most important biodiesel producers in the world. Rapeseed oil prices were downloaded from UFOP as well, soybean oil, palm oil and crude oil prices were taken from Index Mundi. The logarithmic transformations of data were taken - logarithmic prices facilitate interpretation of results since coefficients correspond to percentage changes, thus can be interpreted as a price elasticity (Serra et al., 2011). The paper also provides the description of recent price dynamics of the above mentioned variables as well as introduces the evolving policy context of the biodiesel production in Germany.

According to Bentivoglio and Rasetti (2015), the biofuel-related price transmission literature has focused on studying price level links using cointegration analysis and VECM (Vector Error Correction Model). Thus, in order to examine the existence of long-run relationship between selected variables, the analytical framework was set up based on applying the cointegration and vector error correction estimation procedure. In general, regression models for non-stationary variables give biased and inconsistent results and lead to spurious regression (Kristoufek et al., 2013). A technical prerequisite for cointegration analysis is that all variables are non-stationary. This condition is tested by Augmented Dickey-Fuller (ADF) test (Bakhat and Würzburg, 2013). The null hypothesis of ADF test is that series contains a unit root and ADF test shows whether the variables are stationary or nonstationary in the first differences and in levels (Ciaian and Kancs, 2011; Hassouneh et al., 2011). The ADF can be expressed as testing H_0: $\alpha_0 = 0$ against H_1: $\alpha_0 < 0$ from the following general model used by Capitani (2014):

$$\Delta y_t = \alpha + \beta_t + \eta y_{t-1} + \sum_{i-1}^{p-1} \phi i \Delta y_{t-1} + e_t , \quad (1)$$

where y_t is the variable assessed; α refers to a constant; β is the coefficient on a time trend; p is the lag order of the autoregressive process; and e_t is the stochastic term named white noise. If time series are non-stationary in levels, but stationary in first differences, cointegration techniques may be applied. An optimal number of lags according to Akaike information criterion for providing Johansen test is determined in VAR space (Burakov, 2017). The Johansen test for cointegration evaluates the rank (r) of the matrix Π. If $r = 0$, all variables are I (1) and not cointegrated. In case $0 < r < N$, there exist r cointegrating vectors. If $r = N$ all the variables are I (0) and thus stationary, and any combination of stationary variables will be stationary. Johansen cointegration test is based on the following trace test and maximum eigenvalue test (Natanelov et al., 2013):

$$\lambda_{\text{trace}} = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i^2) , \quad (2)$$

$$\lambda_{\max}(r,\ r+1) = -T\ln(1-\lambda_{r+1}) , \quad (3)$$

where r is the number of cointegrated vectors and is the estimated value for the i^{th} order eigenvalue from the Π matrix and T is the total time period (Jena, 2016).

If the existence of the cointegration relation is found, a following form of vector error correction model (VECM) is estimated:

$$\Delta P_t = \mu + \alpha\beta' P_{t-1} + \Gamma_1 \Delta P_{t-1} + \Gamma_2 \Delta P_{t-2} + \cdots + \Gamma_k \Delta P_{t-k} + \varepsilon_t \quad (4)$$

where β is known as the cointegration vector and shows the long run relationship between the prices and $\beta' P_{t-1}$ is the disequilibrium error indicating the deviation of the price relationship from the long run equilibrium. α represents adjustment speed and refers to the percentage of disequilibrium error that would be corrected in each period. P_t is a r x 1 vector with its elements the price series under investigation at time t, μ refers to r x 1 intercept vector, ε_t is the error vector and k represents the number of lags of the series (Chen and Saghaian, 2015). VECM estimates both short-run price dynamics and the adjustment of individual prices to deviations from the cointegration relationship (Hassouneh et al., 2012).

Results and discussion

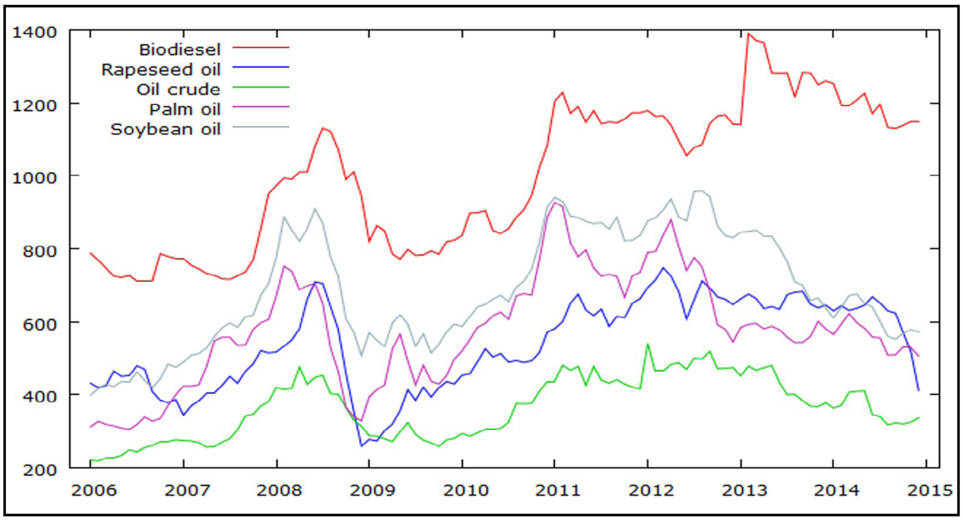
Busse et al. (2010) explain that the use of vegetable oil as fuel was unregulated until 2003 in Germany. Later on, the growth of the biodiesel industry was mainly encouraged by investment assistance and tax exemptions granted since 2004. However, the situation changed in August 2006 when an energy tax of 103 EUR/t of biodiesel sold as B100 (pure biodiesel), and a full taxation (541 EUR/t) for biodiesel used in blends were implemented. As noted by Pires and Schechtman (2010), under the new legislation, biofuels face the same specific taxes as fossil fuels, with the exemptions replaced by discounts to be requested from the government after sale. The discounts given to biofuels used in blends were abolished in 2007, while discounts for pure biodiesel were progressively reduced (38.04 ct/l in 2006, from 2013 2.14 ct/l). According to the Biofuels Quota Act (in force since January 2007), that sets a minimum level of biofuels that must be used in road transport in Germany, the total biofuels quota for 2009 was 5,25 % rising to 6.25% based on energy content since 2010. Since January 2015, the quota has no longer been calculated on the basis of calorific value. As a result, the biofuels quota has been replaced by a climate protection quota, which will specify the minimum net contribution that must be made by biofuels to the reduction of GHG emissions and it will be increased to 7% by 2020 (International Energy Agency, 2015).

Recently, the oil price shock was observed during the period June 2014 – March 2015 when prices dropped down significantly with the main decrease after September 2014. The second biggest annual loss since trading started in the 1980s was recorded from June 2014 to December 2014 – OPEC contributed to the dramatic fall in prices because of refusing to cut oil production despite of huge global oversupply. The decline in crude oil prices has led to a downward trend in diesel fuel prices and affected the vegetable oils used for biodiesel production, thus influencing biodiesel economics as well. Regarding vegetable oils, the prices continued the downward trend in 2014/15 that was shown during 2013/14. The sharp drop down in vegetable oil prices was caused by ample global oilseed supply in 2014. During much of the observed period, soybean oil prices were above palm oil prices and rapeseed oil prices (Figure 1).

Correlation analysis reveals positive and strong correlation between crude oil and vegetable oil prices. Also biodiesel and oil prices are positively and significantly correlated. It means that the null hypothesis that the two variables are linearly independent or uncorrelated is rejected for all performed cases (Table 1). The price of biodiesel has a high correlation with crude oil, indicating that the demand linkage between the variables is at least as important as the cost structure linkage between the feedstock – vegetable oils and biodiesel. Also, there is a high correlation among the commodity prices: rapeseed oil and soybean oil 76%, rapeseed oil and palm oil almost 70%, soybean oil and palm oil almost 90%.

Augmented Dickey Fuller (ADF) test is conducted in order to test the null hypothesis of a unit root in the price series against alternative of a stationary time series. The test confirms the presence of a unit root in all examined price series. The number of lags is determined by Hannan-Quinn information criterion, Akaike information criterion and Schwarz Bayesian information criterion. The results suggest an optimal lag order of 1 (Table 2).

Johansen co-integration test is performed for detecting the co-integration rank r. The seasonal dummies are included in order to capture seasonality in the data (time plot of the series indicates some seasonal fluctuations). Based on the results, a long



Source: own processing based on UFOP and Index Mundi

Figure 1: Development of biodiesel, crude oil prices (EUR/ 1 000 l) and vegetable oil prices (EUR/t) during 2006-2015.

Correlation coefficients	Biodiesel	Crude oil	Rapeseed oil	Soybean oil	Palm oil
Biodiesel	1.00	0.7954	0.8263	0.6956	0.5708
Crude oil		1.00	0.8133	0.9446	0.8009
Rapeseed oil			1.00	0.7600	0.6691
Soybean oil				1.00	0.8977
Palm oil					1.00

Source: own processing

Table 1: Correlation coefficients among the variables.

Price	Test without constant		Test with constant		Test with constant and trend	
	Level	FD	Level	FD	Level	FD
Biodiesel	0.415698	-6.41107***	-1.51986	-6.43773***	-2.39879	-6.42126***
Crude oil	0.0858165	-7.12354***	-1.92475	-7.10979***	-1,33064	-7.24073***
Rapeseed oil	-0.612710	-4.43556***	-2.26777	-4.40357***	-2.19810	-4.45211***
Soybean oil	-0.177199	-5.83148***	-2.04070	-5.80956***	-1.58641	-5.95635***
Palm oil	-0.359486	-6.54082***	-2.44671	-6.52029***	-2.27196	-6.61664***

Notes: FD: First difference; *** significant at 1% level
Source: own processing

Table 2: ADF test results for prices of biodiesel, crude oil and agricultural commodities.

Variables	L- max test		Trace test	
	r = 0	r = 1	r = 0	r = 1
Biodiesel – Rapeseed oil	20.164	2.6996***	22.863	2.6996***
Biodiesel – Soybean oil	21.252	8.2790**	29.531	8.2790**
Biodiesel – Palm oil	17.096	0.0090163***	17.105	0.0090163***
Crude oil– Rapeseed oil	12.774	0.00015955***	12.774	0.00015955***
Crude oil– Soybean oil	38.093	3.4245**	41.517	3.4245**
Crude oil – Palm oil	34.095	6.6663***	40.761	6.6663***

Notes: r = 0 – no co-integration relationship; r = 1 – at most one co-integration relationship; ***significance at 1% level, ** significance at 5% level
Source: own processing

Table 3: Results of Johansen co-integration test for prices of biodiesel and agricultural commodities; and prices of crude oil and agricultural commodities.

run relationship is confirmed among the majority of selected variables (Table 3).

The co-integration relationship is statistically significant, the constant and the adjustment coefficients α referring to vegetable oils are also statistically significant at 1% level in all examined equations[1]. Parameters α have the same sign for each tested pair variables representing that non-profit relationship do not exist in all three price equations. Biodiesel prices adjust more rapidly to the long-run equilibrium than the examined vegetable oils. In case of biodiesel prices, 14.80% of the disequilibrium error is corrected in the equation with l_rapeseed_oil, 12.20% is corrected in the equation with l_soybean_oil and 10.20% is corrected in the equation with l_palm_oil. On the other hand, only 2.64%, 8.79% and 5.51% are corrected for rapeseed oil, soybean oil and palm oil. Furthermore, vegetable oil prices seem to be weakly exogeneous as the null hypothesis cannot be rejected in equations with l_rapeseed_oil and l_palm_oil and the results indicate that biodiesel prices respond to a price change of vegetable oils. The results clearly show that the tested variables cannot be treated as weakly exogenous in the equation with soybean oil and the long-term relationship between the variables is simultaneous. Looking at co-integration vector *β*, the following price linkage is detected: a 1.00% increase in rapeseed oil price would lead to 0.86% increase in biodiesel price and 1.00% increase in soybean price would cause a rise of 0.73% in biodiesel price. Additionally, the value of 0.72 expresses price transmission elasticity indicating that increase in palm oil price by 1.00% would result in rise of biodiesel by 0.72%. To sum up, relationship between the pairs of considered series is not simultaneous and indicates only one-way relation with the impact of vegetable oil prices on the biodiesel prices in case of rapeseed and palm_oil. However, there is an evidence of simultaneous relationship between biodiesel and soybean oil prices. Similarly, Bentivoglio (2016) points out that the positive relationship between biodiesel and rapeseed oil prices is not surprising given the relevance of feedstock costs on the total costs for producing biodiesel (80%). Hence, the biodiesel sector reacts to price changes in the agricultural commodity market.

Busse et al. (2010) state that the international vegetable oil markets were found to play a more important role than the biodiesel market during

[1] According to Zahran (2013) non-profit relationship exists between the variables, if the speed of mean reversion for both equations would have opposite signs, where positive profits will cause biodiesel price to fall and vegetable oil price to rise sufficiently eliminating profit.

the food crisis that was indicated by the strong influence of past vegetable oil price changes and the missing reaction to past biodiesel price changes. Diagnostic checks show that null hypothesis of homoscedasticity is accepted, the null hypothesis of no autocorrelation is not rejected as well and the regression models account for approximately 28% of the variance in all three equations (Table 4).

The VECM results indicate that crude oil prices have significant impact on vegetable oil prices and biodiesel prices and appear to be weakly exogeneous demonstrating that vegetable oil and biodiesel prices are affected by crude oil prices (Table 5). More specifically, 1.00% increase in crude oil prices would lead to 0.91% increase in rapeseed oil price, 1.47% in soybean oil prices and 0.57% in palm oil prices. In case of biodiesel prices, an increase in the crude oil prices by 1.00%, the biodiesel prices would rise by 0.96%. Banse et al. (2011) consider that high feedstock prices make biofuels less profitable, as does a low oil price and the higher the crude oil price the more competitive biofuel crops become versus petroleum production. Similarly, Busse et al. (2010) show stable long-run relationship between crude oil and biodiesel as well as between biodiesel, rapeseed oil and soybean oil, however, the price adjustment behaviours change in different phases of the market development. Crude oil prices adjust slower to deviations from the long run equilibrium in comparison to the other examined series. Error correction coefficients have opposite signs in the equation with l_rapeseed_oil and l_palm_oil indicating there is only one equilibrium relation between the variables. The examined models are considered as stable and reliable due to the fact that null hypotheses of homoscedasticity and no autocorrelation are accepted.

Conclusion

The paper analyses price interdependencies between energy and vegetable oil prices. The research is conducted on the basis of price transmission technique - cointegration test and vector error correction model. Co-integration test provides evidence of long-run relationship between prices of biodiesel, crude oil and selected vegetable oils used for biodiesel production

	l_rapeseed_oil	**l_soybean_oil**	**l_palm_oil**
Constant	0.223640***	0.262872***	0.240115***
Cointegration vector β	-0.86371	-0.73205	-0.72296
Adjustment coefficient α	l_rapeseed_oil -0.026438 l_biodiesel -0.14802 ***	l_soybean_oil -0.087938** l_biodiesel -0.122024 ***	l_palm_oil -0.055149 l_biodiesel -0.10196 ***
R-squared	0.287125	0.268599	0.286434
ARCH	p-value 0.848118	p-value 0.813032	p-value 0.69611
Autocorrelation	p-value 0.109	p-value 0.104	p-value 0.225

Notes: ***significance at 1% level, ** significance at 5% level
Source: own processing

Table 4: VECM estimation - biodiesel prices and vegetable oil prices.

	l_rapeseed_oil	**l_soybean_oil**	**l_palm_oil**	**l_biodiesel**
Constant	0.133214 ***	0.293672 ***	0.240115***	0,150813***
Cointeg. vector β	-0.90854	-1.4678	-0.57188	-0.95799
Adjustment coefficient α	l_rapeseed_oil -0.14622 *** l_crude_oil 0.052298	l_soybean_oil 0.13739*** l_crude_oil 0.099254	l_palm_oil -0.095694** l_crude_oil 0.066228	l_biodiesel -0.11690*** l_crude_oil -0.0083727
R-squared	0.340494	0.352621	0.412069	0.236620
ARCH	p-value 0.318208	p-value 0.324158	p-value 0.70116	p-value 0.910583
Autocorrelation	p-value 0.946	p-value 0.975	p-value 0.624	p-value 0.334

Notes: ***significance at 1% level, ** significance at 5% level
Source: own processing

Table 5: VECM estimation – crude oil prices and vegetable oils.

in Germany. The results suggest, as expected, that increase in crude oil prices would lead to an upward trend in the vegetable oils used for biodiesel production, thus influencing biodiesel prices as well. These results are in line with Ghaith and Awad (2011) who proved the co-integration between crude oil and biofuel crop prices which might be at least a signal of the linkage between the biofuel industry and crude oil prices. The relationship between the biodiesel – rapeseed oil and biodiesel – palm oil is not simultaneous and indicates only one-way relation with the impact of vegetable oil prices on the biodiesel prices. On the other hand there is an evidence of simultaneous relationship between biodiesel and soybean oil prices. The findings of Busse et al. (2010) also demonstrate the strong evidence for co-integration between German biodiesel and crude oil prices.

Our research provides better insight of interacting price behaviour of energy prices and vegetable oils used as a feedstock for biodiesel production in the EU biodiesel market and contributes also to the biofuel and food price debate. Based on our research we conclude that crude oil prices could be considered as an acceptable predictor of food commodity price changes; however, there is evidence that biofuel prices do not determine food prices (except the impact of biodiesel on soybean oil price). In principle, enhanced biodiesel demand leads to increase in production of biofuel crops and competition for land, thus the concept of cultivation crops for non-food uses results in less land availability for food and higher agricultural prices whereas food prices are less impacted by biofuels production (Vasile et al., 2016). An alternative is to look for other feedstocks (e.g. lignocellulosic crops) and use marginal land for growing biofuel crops without displacing existing crops. The second generation biofuels are considered to be more cost–effective and more effective in reducing greenhouse gas emissions. Additionally, Bobadilla et al. (2017) show the high quality of the biodiesel produced from waste cooking oil hence waste cooking oil is a potential replacement for vegetable oils in the production of biodiesel. This study can be extended by investigation of the patterns of land use for biofuel feedstock in order to find out further interdependences between the agri-food sector and biodiesel industry using the land for the crop production for non-food purposes.

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Metadata Formats for Data Sharing in Science Support Systems

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Abstract

The article deals with analysis of model data formats suitable for metadata description of digital objects (artifacts) occurring in scientific social network applications. The emphasis of analyzes is on the issue of a metadata description of artefact links to other artifacts and artifact links to individuals. The examined metadata formats include LOM (Learning Objects Metadata), MODS (Metadata Object Description Schema) and DC (Dublin Core). The article also deals with dictionaries of controlled descriptors used to refine and unify the metadata description for agricultural research.

The article presents part of the results of author's dissertation thesis.

Keywords

Metadata, application profile, social network service for scientists, data sharing, LOM, MODS, DC, AGROVOC.

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Introduction

The development of information and communication technologies has greatly contributed to speeding up publication processes. Before the massive expansion of modern technology, the author of the article had to send his handwriting to the publisher, which he handed over to the writer who prepared the text for the press. After printing, materials had to be delivered to readers. This process could last several days. Now, you can do this with few simple mouse clicks from the convenience of your office, and immediately post the article on the Internet. Such readily published information can be read through the computer network by anyone almost anywhere in the world, immediately after its release. Internet users create their own content. However, this acceleration and simplification of processes also has its negatives. The Internet is overwhelmed by various types of information. The information network creates a jungle which can be hard to navigate. Mislabeled records can be easily lost in vast space of the network. The traceability of specific information depends on how well digital objects are cataloged and shared (Jarolimek and Martinec, 2016).

Readers must be alert when selecting relevant information. As the amount of information grows, the quality of the entire network is decreasing. The Internet is full of articles that spread half-truthfully which are not built on consistent and relevant data. For the future development of information networks, it is important to support the quality of information. We do not need quantity but quality! This issue of excess information has permeated many other areas of human activity. This paper focuses on publishing and sharing scientific information.

The phenomenon of recent times, which has significantly changed communication in human society, is social networks. This new communication platform also affected science and research. Each scientific work begins with a thorough study of the current state of the subject. To support this activity, a number of specialized mostly web-based applications have emerged recently. Examples of these applications are Social Network for Scientists, ResearchGate or the VOA3R (Virtual Open Access Agriculture & Aquaculture Repository Project) social network.

Most scientists are forced to work with multiple applications. In each application, the user is prompted to create a profile and upload metadata for each scientific publication. Each application creates its own identifier for the user and his publications. It is difficult for the enriched data created in this system to be exported or transferred from one application to another.

Methods of writing metadata

The word "metadata" was first used by P. R. O. Badgley in the book "Extension of programming language concepts".

Metadata is most commonly and simply defined as "data about data" or "information about information", but there are many more complex definitions. The definition according to Brand (2003): "Metadata are structured data that describe, explain, localize, and facilitate the easier acquisition, use and management of an information resource." The definition states: "Metadata are structured data - descriptive information about digital objects whose primary purpose is to facilitate search in resources. They include elemental information about primary data, structured according to specific rules and standards, thereby streamlining the management of a large number of objects in data structures." One of many formal definitions states that metadata is data associated with objects that remove the need for pre-existing knowledge of the characteristics of these objects for potential users (Bartošek, 1999).

Metadata itself can be further described by other metadata. Metadata is written according to established rules and therefore machine-readable.

Metadata can be separated into following groups according to Bretherton, (1994):

- *Descriptive metadata* serves to uniquely identify a document. They include, for example, title, author name, keywords etc.
- *Structural metadata* show which parts the document consists of, such as page numbering, chapters, etc.
- *Administrative metadata* includes technical information about the document (format), access rights, etc.

Metadata serves primarily to allow search and help with search-related issues. Among the selected metadata functions are (Bartošek, 1999):

- *Documentation functions* (description of important characteristics of information source),
- *Identification functions* (unambiguous time- and space-independent identification),
- *Search functions* (discovering sources existence and its localization),
- *Selection functions* (selection of sources based on their characteristics).

Social networking application for scientists

These are applications that support science, they work with metadata of digital artifacts, and expand metadata (enrichment) with other metadata. These applications can be divided into the following groups:

- Social networks for scientists
- Systems managing of references
- Search engines for scientific works

Digital artifact

It is a digital form of human creation. Digital artifacts can be represented primarily in the form of texts, visualizations or sounds, or combinations of these. The term digital object can also be used.

Controlled descriptors dictionaries

Controlled dictionaries of descriptors are also referred to as Thesauri. Thesaurus is a reference guide, a kind of dictionary that offers the user a list of synonyms, sometimes also antonyms, and often also defines dependencies between terms.

The descriptors can have defined relations of superiority and inferiority, synonyms and other related terms. In the professional literature, it is described as a controlled and changeable dictionary of descriptor and selection language arranged to explicitly capture relations between lexical units (Easylibrary, 2010).

Identifier DOI

DOI (Digital Object Identifier) is a centralized commercial system of identifiers for digital works. The DOI is described by ISO 26324 (ISO 26324, 2012) standard. DOI ensures unambiguous identification of the digital document on the Internet and provides a permanent reference to the document. The DOI identifier is the most common and widespread system for identifying scientific publications at present time.

ORCID identifier

ORCID (Open Research and Contributor ID) is a non-proprietary alphanumeric code that uniquely identifies academic or scientific authors and contributors. It provides people with a lasting identity identification in a similar way the digital object identifiers (DOIs) provide identification for content. ORCID is trying to encompass and merge both ResearchID and Scopus AuthorID. ORCID is managed by a non-profit organization (Nature, 2009).

Another author's identification systems include, for example: The Digital Author Identifier (DAI).

Materials and methods

Standard Dublin Core

For the Dublin Core standard, the abbreviation DC is used in the literature. DC is a set of fifteen metadata elements and its main purpose is to facilitate the search for electronic resources. DC was developed by professionals from various fields (computer science, librarianship). The set of DC elements is standardized in accordance with ISO 15836:2009 (International Organization for Standardization), the latest update for 2014 and ANCI / NISO Z39.85 (American National Standards Institute / National Information Standards Organization) from 2007 (ANCI/NISO, 2007). DC is currently maintained by the Dublin Core Metadata Initiative (DCMI) (DCMI, 2016). All of the fifteen metadata elements are optional.

The primary purpose of DC was to describe digital documents published on the Internet directly by the author. For its universal design it has been used by institutions dealing with the formal processing of resources (museums, libraries, universities, etc.). DC can be used to describe both digital and non-digital objects (Dublin Core: Czech, 2006).

Qualified and unqualified Dublin Core

DC is divided into two types, the so-called Simple Dublin Core or the Unqualified Dublin Core and the Qualified Dublin Core. The simple Dublin Core element values are not limited in any way unlike to the Qualified Dublin Core, where the limitations for element values are specified using qualified terms and qualifiers. Input formats are based on generally accepted standards (Hodge et al., 2005).

Dublin Core record formats and its elements

Dublin Core metadata entry can be created using two extended formats.

The first option is to write a record in a separate XML format (Extensible Markup Language). For each described digital object, there is one metadata file. This option is used, for example, to describe archive data. In practice, a metadata entry is stored in the database of the appropriate archive, and an XML file is generated for sharing purposes (Taheri and Hariri, 2012).

The second option is to write metadata directly into the described file. The file is usually a web site in HTML (Soundarara et al., 2010). Metadata are then written to the "head" section using the HTML tag "<meta>".

The set of fifteen metadata elements of Dublin Core can be divided into three groups: *source content, intellectual property and source identification* (Celebová, 2013).

DCMI type dictionaries

The Qualified Dublin Core record utilizes terms of Dublin Core Metadata Initiative (DCMI). DCMI qualifiers include Collection, Dataset, Event, Image, InteractiveResource, MovingImage, PhysicalObject, Service, Software, Sound, StillImage, and Text (DCMI, 2010).

MARC formats

MARC (MAchine-Readable Cataloging) is a standard consisting of MARC formats (see Table 1) for machine-readable cataloging (a code sample shown in Figure 1). Formats were created in the 1960s at the US Congress Library. The MARC record structure is an implementation of ISO 2709, also known as ANSI / NISO Z39.2. Data content records are defined by other standards, such as AACR2, LCSH, or MeSH. MARC comprehensively solves the problem of machine-readable cataloging, but thanks to obsolete technologies is not currently widely used. The response to technology obsolescence the more current MARC 21 format for more effective cataloging information exchange (Table 1) (Taylor and Joudrey, 2009).

MARC format	Description
Authorization	Provides information on individual names, subjects, and titles.
Bibliographic	Describes the thought and physical properties of bibliographic resources (books, phonograms, sound recordings, etc.).
Classification	MARC records containing data classification.
Community information	MARC records describing the source of the provided services.
Ownership	Provides information about the printout (catalog number, shelf placement, number of pieces, etc.)

Source: Taylor and Joudrey (2009)

Table 1: MARC – formats.

```
=LDR  05594cam  2200565 i 4500
=001  ocn798437851
=003  OCoLC
=005  20131018101403.0
=006  c\\\\\\\\d\\\\\\\\
=007  cr\\\\\\
=008  120705s2013\\\\mauaf\\\\b\\\\001\0\eng\\
=020  \\$z9780262018555 (hardcover : alk. paper)
=020  \\$z0262018551 (hardcover : alk. paper)
=040  \\$erda
=050  14$aBF503$b.A28 2013
=082  04$a153$223
=245  00$aAction science :$bfoundations of an emerging discipline /$cedited by Wolfgang Prinz, Miriam Beisert, and Arv
=264  \1$aCambridge, Mass. :$bMIT Press,$c[2013]
=264  \4$a©2013
=300  \\$a1 online resource (xi, 450 pages, 5 unnumbered pages of plates) :$billustrations (some color)
=336  \\$atext$btxt$2rdacontent
=337  \\$aunmediated$bn$2rdamedia
=338  \\$aonline resource$bcr$2rdacarrier
=504  \\$aIncludes bibliographical references and index.
=505  0\$aAcknowledgments -- Contributors -- Action science emerging : introduction and leitmotifs / Arvid Herwig, Mir
=520  \\$aThe emerging field of action science is characterized by a diversity of theoretical and methodological appro
=588  \\$aDescription based on print version record.
=650  \0$aMotivation (Psychology)
=650  \0$aCognitive psychology.
=700  1\$aPrinz, Wolfgang,$d1942-
=700  1\$aBeisert, Miriam,$d1980-
=700  1\$aHerwig, Arvid,$d1979-
=776  08$iPrint version: $tAction science.$dCambridge, Mass. : MIT Press, [2013]$w(DLC)  2012024586$w(OCoLC)798437851
=856  40$uhttp://cognet.mit.edu/book-detail/9780262312974$zMITCogNet
```

Source: Abrahamse (2013)

Figure 1: Example of record using the MARC format.

MODS

Metadata Object Description Scheme (MODS) was developed by experts under the auspices of the US Congress Library and Marc Standard Office as a subset of MARC. The first version of the MODS metadata schema was released in 2002. The schema allows digital libraries to describe any document using a XML file. The MODS schema consists of 20 elements that are taken from other metadata schemas, making the scheme convertible into MARC 21 and Dublin Core (MODS, 2009; Svastova, 2009).

Data model LOM

Learning Object Metadata (LOM) is a standardized model designed to describe learning objects. The model is defined by the open standard IEEE 1484.12.1 - 2002 created by IEEE (Institute of Electrical and Electronics Engineers Standards Association, New York). The relevant attributes of "learning objects" to be described include: the type of object, author, owner, distribution conditions, format and pedagogical attributes such as learning styles or interactions (Veron et al., 2016).

Learning Object Metadata is a data model, usually encoded in XML, used to describe a learning object and similar digital resources used to support learning. The purpose of object learning metadata is to promote the reusability of learning objects, to facilitate their discovery and to facilitate their interoperability, usually in the context of online Learning Management Systems (LMS) (Stoces et al., 2015).

Other metadata formats

Other metadata formats include Darwin Core, EBU Core, PBCore, CDWA-Lite/CCO, EAD, DACS, ISAD (G), VRA Core, SPECTRUM In the area of cataloging scientific works and digital libraries, the most widely used is the DC metadata format.

Identification of artifacts by social networks for scientists

Metadata records from institutional repositories are loaded (harvested) and collected in central repositories. Repository provides search services over metadata entries from institutional repositories. The current trend is to create a social networking site for scientific workers above the repository, which extends the primary search function of the repository to other communication functions. Within social networking applications for scientists, enriching data is generated by users, but it is not shared yet. Social networks and their data are an appropriate complement to LMS - integrating social networks into LMS to enhance the quality of sharing knowledge and communication between users and authors. It also enables users to easily access new knowledge in the field. In doing so, social networks create many metadata that enrich the original records (enriching data). Enriching data has been classified into two groups based on analyses, namely linking metadata and other metadata. The structure and function of other metadata is created by each social network separately. Examples of such data may be comments, ratings, etc. Linking metadata includes the following relations (among others):

- Digital artifact <-> Person (author, co-authors)
- Digital artifact <-> Digital artifact (citation, reference)

Application profile

When creating a knowledge database that contains object metadata, you need to define its structure. By defining metadata elements, value rules and managed dictionaries, the so-called Application Profile (AP) is created. A large group of Application Profiles uses DC and its elements to describe objects and extends them based on application requirements. For example, the VOA3R Application Profile or EVSKP-MS (Metadata File for Electronic Higher Education Qualifications in the Czech Republic) can be used (Bratkova and Mach, 2008).

"AP is a metadata scheme that consists of metadata elements selected from one or more standard metadata schemas and is designed to allow the application to meet its functional requirements" (Heery and Patel, 2008) .

The European Committee for Standardization (CEN) defines the AP as a set of metadata elements selected from one or more metadata schemes and combined in a compound scheme. Application profiles provide means to express the principles of modularity and extensibility. The purpose of the application profile is to customize or combine existing schemes into a package that is tailored to the specific application's functional requirements while maintaining interoperability with the original schematics.

According to IMS GLC, the reasons for creating new application profiles are as follows:

- Meeting technical and other project requirements that are domain, country or region specific.
- Solving ambiguity and generality in a specification or standard.
- Support semantic interoperability, e.g. using commonly-used dictionaries.
- To facilitate compliance testing and successful collaboration.

Results and discussion

The following section analyses selected social networking applications for scientists. Systems are analyzed (see Table 2) based on the following aspects:

- Identifier used to identify the author,
- Identifier used to identify the digital artifact,
- Ability to import metadata about digital artifact
- Ability to export metadata about digital artifact

Social networks for scientists do not allow users to export the data created within them. To identify the author they often use their own proprietary identifiers. Most of the systems analyzed allow for export of records, but no additional data such as ORCID identification of the author is enriched.

ORCID and DOI are used as the identifiers by most of the analyzed applications. The multiplicity of author’s identity is still a problem, mostly in systems that publish digital artifacts (Mitrovic and Protic, 2014; Brown et al., 2016).

Appropriate metadata models for describing object metadata in social networking environments for scientists according to previous sections include LOM, DC and MODS. In the next section, the issue of describing links to the author and other digital artifacts of selected models will be discussed. The XML data format was used to write metadata in the following examples.

Link between work and its author

Dublin Core

Authors are identified in the *dc:creator* element, which does not contain any extensions (Figure 2).

Name	author ID	object ID	Import	Export
Mendeley	Scopus author ID, ORCID	DOI and others	yes, various	yes, various
ResearchID/EndNote	ORCID, researchID	DOI and others	yes, various	yes, various
Google Scholar	own	own	no	yes, various
ResearchGate	own	DOI, own	yes, various	no
Academia edu	own	own	no	no
ORCID	ORCID, Scopus author ID, researchID	According to database import	yes, various	yes, BibTex

Source: own processing

Table 2: Analysis of applications for scientific support.

```
<dc:creator>Michal Stočes</dc:creator>
```

Source: own processing

Figure 2: dc:creator.

Data model LOM

The problem of linking to a person is solved very complexly in the LOM model using the breakage element:lifeCycle and its descendants. There is no possibility of more detailed identification of the author in the standard (Figure 3).

```
<lom:lifeCycle>
    <lom:contribute >
        <lom:role>
            <lom:source>LOMv1.0</lom:source>
            <lom:value>Author</lom:value>
        </lom:role>
        <lom:entite>
            Michal Stočes
        </lom:entite>
    </lom:contribute >
</lom:lifeCycle>
```

Source: own processing

Figure 3: lom:lifeCycle.

MODS schema

The MODS schema contains a description that allows a reference to specific author, through, the mods:name element. (Figure 4)

```
<mods:name type="personal">
   <mods:namePart type="family">Michal</mods:namePart>
   <mods:namePart type="given">Stočes</mods:namePart>
   <mods:role>
      <mods:roleTerm type="code" authority="marcrelator">
         aut
      </mods:roleTerm>
      <mods:roleTerm type="text" authority="marcrelator">
         Author
      </mods:roleTerm>
   </mods:role>
</mods:name>
```

Source: own processing

Figure 4: mods:name.

Link between works (reference, citation)

In all three models, the difference between a reference and a citation is made using the references/isReferedBy quantifier.

Dublin Core

As a record of metadata identifying the reference, Qualified Dublin Core is used. In DC standard there is no clear procedure for writing a link to a specific place in the document (Figure 5).

```
<dcterms:references xsi:type="dcterms:URI">
    http://doi:10.17221/313/2015
</dcterms:references >
```

Source: own processing

Figure 5: dcterms:references.

Data model LOM

The IEEE LOM standard has the same drawbacks as DC - there is no unambiguous procedure for writing a reference to a specific location in the document (Figure 6).

```
<lom:relation>
    <lom:kind>
        <lom:source>LOMv1.0</lom:source>
        <lom:value>references</lom:value>
    </lom:kind>
    <lom:resource>
        <lom:identifier>
            <lom:catalog>URI</lom:catalog>
            <lom:entry>
                http://dx.doi.org/10.7160/aol.2016.080108
            </lom:entry>
        </lom:identifier>
    </lom:resource>
</lom:relation>
```

Source: own processing

Figure 6: lom:relation.

MODS schema

In its definition the MODS schema contains a link to a specific place in the document. Further, the mods:identifier element has a type property that does not specify what values it can take, making MODS very universal in terms of unambiguous identification of the work (Figure 7).

```
<mods:relatedItem type="references">
    <mods:identifier type="doi">
        10.7160/aol.2016.080108
    </mods:identifier>
    <mods:part>
        < mods:extent unit="pages">
            <mods:start>85</mods:start>
            <mods:end>86</mods:end>
        </mods:extent>
    </mods:part>
</mods:relatedItem>
```

Source: own processing

Figure 7: mods:identifier.

Mapping between metadata models

The following tables (3 and 4) show examples of mapping between metadata models.

Dublin Core (DC) element	Learning object metadata (LOM)element
dc:identifier	/lom/general/identifier/entry
dc:title	/lom/general/title
dc:language	/lom/general/language
dc:description	/lom/general/description
dc:subject	/lom/general/keyword *nebo* /lom/classification *s* /lom/classification/purpose *equals* "discipline" *or* "idea".
dc:coverage	/lom/general/coverage
dc:type	/lom/educational/learningResourceType
dc:date	/lom/lifeCycle/contribute/date *when* /lom/lifeCycle/contribute/role *equals* "publisher".
dc:creator	/lom/lifeCycle/contribute/entity *when* /lom/lifeCycle/contribute/role *equals* "author".
dc:otherContributor	/lom/lifeCycle/contribute/entity *with contribution type in* /lom/lifeCycle/contribute/role
dc:publisher	/lom/lifeCycle/contribute/entity when /lom/lifeCycle/contribute/role equals "publisher".
dc:format	/lom/technical/format
dc:rights	/lom/rights/description
dc:relation	/lom/relation/resource/description
dc:source	/lom/relation/resource *when* /lom/relation/kind equals "isBasedOn".

Source: own processing

Table 3: Mapping between DC a LOM.

MODS elementy	DC elementy
<titleInfo><title>	Title
<name><namePart>	Creator, Contributor
<subject> <topic> <classification> <name> <occupation>	Subject
<abstract> <note> <tableOfContents>	Description
<originInfo><publisher>	Publisher
<originInfo><dateIssued> <originInfo><dateCreated> <originInfo><dateCaptured> <originInfo><dateOther>	Date
<typeOfResource><genre>	Type
<physicalDescription><internetMediaType> <extent><form>	Format
<identifier><location> <url>	Identifier
<language><languageTerm>	Language
<relatedItem>	Relation
<subject> <geographic> <temporal> <hierarchicalGeographic> <cartographics>	Coverage
<accessCondition>	Rights

Source: own processing

Table 4: mapping between DC a MODS.

Thesaurus AGROVOC

AGROVOC is an extensive thesaurus developed by researchers of the Food and Agriculture Organization (FAO), which is a United Nations (UN) specialized agency within the AIMS (Agricultural Information Management Standards). AGROVOC contains terms from food, nutrition, agriculture, fisheries, forestry and the environment. Thesaurus contains over 32,000 terms in 23 languages (April 2017) including the Czech language. This entire thesaurus is expressed as a Simple Knowledge Organization System (SKOS) and published as Linked Data, a data model for representing structured dictionaries. Conceptual scheme of the thesaurus AGROVOC uses three levels of display:

- terms have abstraction meanings and are also often described using the Uniform Resource Identifier (URI), e.g. for beef is used: *http://aims.fao.org/aos/agrovoc/c_861*
- terms specified by language, for instance.: ابقار حوم (*Arabic*), 牛肉 (*Chinese*), hovězí maso (*Czech*), Viande bovine (*French*).
- terms have specific options (ranges) such as spelling variants or singular and plural numbers, e.g.: hen, chicken, poultry, cow, bull, cattle, etc.

This system provides for terminological relations between concepts and specific meaning. AGROVOC is thus well-suited to describe, for example, scientific research articles, expert articles, information or news from the agrarian sector, audiovisual data, etc. (Simek et al., 2013a; Masner et al. 2016).

The Czech version was prepared by the Institute of Agricultural and Food Information in 1995 and 1996 as part of the project „Czech version of the AGROVOC thesaurus“. It was a prerequisite for the creation of a national agricultural information system commissioned by the Ministry of Agriculture of the Czech Republic. Since 1997, the Czech Agriculture and Food Bibliography has been used in the processing of records in bibliography articles. (Simek et al., 2013b; Beneventano, et al., 2016).

Conclusion

Selected DC, LOM and MODS metadata models were analyzed and the following conclusions and recommendations were found: DC is the appropriate format for writing basic metadata. This is due to its versatility and modifiability. The basic set of 14 elements is precisely defined but can be further extended by qualifiers to meet the demands and needs of different social networks for scientists. The LOM standard, complemented by the MODS element identifier, is suitable for describing links to people. Standart LOM defines a lifeCycle element that contains a comprehensive metadata entry to describe people. Entering an identifier element from MODS model extends its definition. The MODS model is suitable for describing the links to the digital artifact. The identifier element from MODS can be extended by adding attributes for various types of digital artifact description.. Schemas can be mapped to each other to allow transformation between them. The unequal identity of the author is still a problem, mostly in systems that publish digital artifacts. Identifiers that are expanding and being increasingly exploited are ORCID - Author Identification and DOI - Digital Object Identification. ORCID tries to join the two proprietary identifiers researchID and Scopus Author ID. For the proposed methodology it is recommended to provide all available identifiers to improve the resulting record. A suitable addition to metadata entries is the use of keywords from controlled dictionaries of descriptors, for the area of agriculture there is a large thesaurus AGROVOC developed by the FAO.

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Economic Value of Information Systems in Agriculture: Cohesion and Coupling of Information Elements

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Abstract

Evaluating the economics of information systems is a difficult task. In addition to classical approaches to the economic evaluation of information systems, attention is paid to individual processes and workflows. The quality of information systems functionality is based on a quality workflow processes. A poorly designed workflow of the information system leads to a number of errors and problems in exchanging information within the system. The lower the error rate and the higher the efficiency of individual activities, the higher the economic value of the information system and, as the case may be, of other analytical, expert or decision systems in the organisation. In this paper, known principles of cohesion and coupling are used. The selected real process is evaluated within the framework of the agricultural information system operated by the Ministry of Agriculture of the Czech Republic. In the article is created a design the structure of information elements of the modelled workflow, measured cohesion and coupling and compared with two alternatives.

Keywords

Workflow process, information systems, cohesion, evaluating process, agriculture.

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Introduction

The area of economic evaluation of information systems is a relatively complex issue which is well described in the study (Verstegen et al., 1995). In general, there are two approaches to assessing the economic value of information systems: a normative and positive approach. Normative approaches are based on decision making through theoretical (e.g. decision three analysis (Lahtinen et al., 2017), Bayesian information economics (Kleijnen, 1980)) or analytical approaches (e.g. simulation or linear programming). Positive approaches are based primarily on experimental designs (time series, econometric modelling).

At present, however, there are other methods that may determine the economic value of the information system in the theoretical approaches. Functionality and individual functions of the information system are based on workflow processes. A poorly designed workflow for working with the information system leads to a number of errors and problems in exchanging information within the system. The lower error rate and the higher efficiency of individual activities, the higher the economic value of the information system and, as the case may be, of other analytical, expert or decision systems in the organisation.

According to (Vanderfeesten et al., 2008) there is a similarity between software programs and workflow processes, for which similar quality metrics can be used for the quality workflows area. According to (Troy and Zweben, 1981; Conte et al., 1986; Shepperd, 1993), the quality of the design of programs and the workflow in general is evaluated according to five metrics: coupling, cohesion, complexity, modularity and size. Of these, coupling and cohesion are considered to be the most important as the studies (Troy and Zweben, 1981; Conte et al., 1986; Shepperd, 1993) shows. Coupling is measured by the number of interconnections and cohesion is a measure of the relationships of the elements. Metrics are measured with absolute numbers. Important for evaluation is comparison with another measured workflow.

A loose coupling of activities leads to several information elements that need to be exchanged between activities in the workflow process which reduces the likelihood of process mistakes. Highly cohesive activities are better understood and are better performed by people than large clusters of unrelated work linked together. Since the creation of large activities will reduce the coupling measure and the creation of small activities will increase cohesion, then high cohesion and loose coupling represent the right value that leads to the improvement of the workflow process.

Motivation

There are very specific information systems currently used in the agricultural sector of the Czech Republic (CR). The largest representative is the Farmer's Portal operated by the Ministry of Agriculture of CR (MACR). The Farmer's Portal is intended for agricultural entrepreneurs and agricultural professionals for whom it provides a legal agenda. The basic applications of the Farmer's Portal are the Soil Register, the Animal Register and the Preparatives and Fertilizer Register. The quality of the Farmer's Portal has long been neglected in agriculture although some problems with the use of the Farmer's Portal have long been announced by farmers themselves (Tyrychtr and Vostrovský, 2017; Tyrychtr et al., 2015). Based on the outputs of detailed and systematic analyses, the Farmer's Portal can be adapted to achieve higher service performance, better user-friendliness and efficiency in completing legal electronic forms. Since the principles of cohesion and coupling have not yet been used for the Farmer's Portal, the goal of this article is to demonstrate the use of such measurement on the selected Farmer's Portal workflow. The evaluation of the indicators is presented in the workflow process which deals with the announcement of the sale of the animal. The presented process is a realistic version of the actual procedure. Farmers must undertake according to the legal rules defined by the MACR. First, the author of this article describes this process within the Farmer's Portal. Subsequently, the author illustrates the design of the information element structure and measures cohesion and coupling compared to two alternatives.

Materials and methods

Self-assessment of cohesion and coupling of a real workflow process is preceded by scenario identification and workflow modelling using workflow net notation (Van Der Aalst and Van Hee, 2004). In the framework of cohesion and coupling, the following definitions are used by the author to derive the basic measures: process cohesion, process coupling and process coupling / coefficient ratio (Vanderfeesten et al., 2008):

Definition 1 Operations structure

An operations structure is a tuple (D,W,O) with:

D: the set of information elements that are being processed.

W: the set of resource classes or roles that are available to the process. A relation $\preccurlyeq$ is defined on these resource classes. $v \preccurlyeq w$ means that a person with role w is allowed to do all the work v is allowed to do (and potentially more).

$O \subseteq D \times W \times \wp(D)$: the set of operations on the information elements, such that there are no “dangling” information elements and no value of an information element depends on itself, i.e. the graph (V, E) with $V=D$ and $E = \{(p,c) \in D \times D | \exists (p,w,cs) \in O (c \in cs)\}$ is connected and acyclic.

So, if operation $(p,w,cs) \in O$ for a given operations structure (D,W,O), this means that it is possible for a resource with role w to produce a value for information element p on the basis of values for the set of information elements cs.

Definition 2 Activity

An *activity* T on operations structure (D,W,O) is a tuple $(t,e) \in \wp(O) \times W$ with

t: a set of operations
$(t = \{(p1,w1,cs1),(p2,w2,cs2),\ldots\})$, and

e: the resource that is allowed to execute the activity, fulfilling the following requirement:

$\forall (p,w,cs) \in t (w \preccurlyeq e)$.

Definition 3 Process

A process S on an operations structure (D,W,O) is a set of activities:

$S \subseteq \wp(O) \times W$

Definition 4 Activity relation cohesion

For an activity $T = (t,e)$ on an operations structure (D,W,O), the activity relation cohesion $\lambda(T)$ is defined as follows:

$$\lambda(T) = \begin{cases} \frac{|\{((p1,cs1),(p2,cs2)) \in T^{\check{}} \times T^{\check{}} | ((\{p1\} \cup cs1) \cap (\{p2\} \cup cs2)) \neq \emptyset \wedge p1 \neq p2\}|}{|T^{\check{}}| \cdot (|T^{\check{}}|-1)}, & for |T^{\hat{}}| > 1 \\ 0, & for |T^{\hat{}}| \leq 0 \end{cases}$$

Definition 5 Activity information cohesion

For an activity $T = (t,e)$ on an operations structure (D,W,O), the information cohesion $\mu(T)$ is defined as follows:

$$\mu(T)=\begin{cases}\frac{|\{d\in D|\exists(p1,cs1),(p2,cs2)\in T^{\check{}}(d\in((\{p1\}\cup cs1)\cap(\{p2\}\cup cs2))\wedge(p1\neq p2))\}|}{|T^{\hat{}}|}, & for|T^{\hat{}}|>0\\ 0, & for|T^{\hat{}}|=0\end{cases}$$

Definition 6 Activity cohesion

For an activity $T = (t,e)$ on an operations structure (D,W,O), the activity cohesion $c(T)$ is defined as follows:

$$c(T)=\lambda(T)\cdot\mu(T)$$

Definition 7 Process cohesion

For a process which consists of a set of activities (S) on the operations structure (D,W,O), the average cohesion, or process cohesion ch, is defined as follows:

$$ch=\frac{\sum t\in S^{\check{}}c(t)}{|S^{\check{}}|}$$

Definition 8 Process coupling

For a process that consists of a set of activities (S) on the operations structure (D,W,O), the process coupling cp is defined as follows:

$$cp=\begin{cases}\frac{|\{(T1,T2)\in S\times S|T^{\check{}}1\neq T^{\check{}}2\wedge(T^{\hat{}}1\cap T^{\hat{}}2)\neq\emptyset\}|}{|S^{\check{}}|\cdot(|S^{\check{}}|-1)}, & for|S|>1\\ 0, & for|S|\leq 1\end{cases}$$

Definition 9 Process coupling/cohesion ratio

For a process which consists of a set of activities (S) on an operations structure (D,W,O), the process coupling/cohesion ratio ρ is defined as follows:

$$\rho=\frac{cp}{ch}$$

Measure tool

The CoCoFlow tool (COhesion-COupling metrics for workFLOW models) is used for measuring cohesion and coupling in the workflow process. The CoCoFlow user interface consists of three different sheets, i.e. a metric sheet, a visualisation sheet and an XML file which is created and enclosed in Appendix B by the author of the article.

Results and discussion

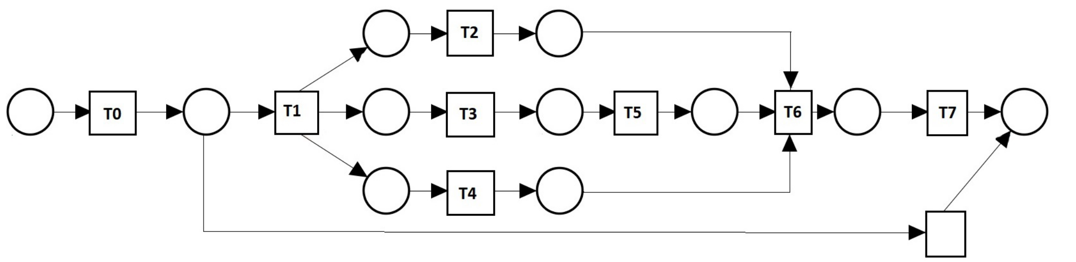
In this section, the author has designed a workflow process, identified information elements and designed their structure including operations. Consequently, cohesion and coupling is measured and the achieved results are evaluated.

Process of reporting the sale of animal

Figure 1 shows the workflow of the sale of the animal through the Farmer's Portal. Seven individual activities are labelled as rectangles that contribute to processing the report of sales as follows. Firstly, the activity T0 determines whether the applicant is entitled to access the register of animals. If this is the case, the animal register will be started and the T1 stables' register will be displayed. In concurrent activities T2, T3 and T4, the type of stables' register is determined. The T5 activity builds on T3 activity and determines the animal or animals that are for sale. In the T6 activity, the submission form for reporting the animal's status change is completed. Finally, in the T7 activity, the form is generated and sent as a report to the Central Register of the MACR.

Structure of information elements and their operations

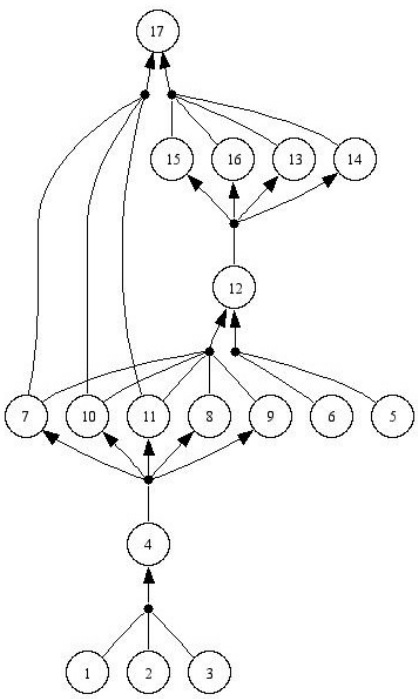
The CoCoFlow tool reads a XML file (see Appendix B) that contains the information element structure and several designs defined for that structure. Figure 2 shows the structure of information elements for the workflow of reporting the sale of an animal. The structure consists of a total of seven operations. Each operation uses different information elements (listed in the table in Appendix A). Operation 1 uses information elements: name of the establishment, cadastral territory, animal species, and stable's register. Operation 2 uses information elements: stable selection, animals by exclusion, and ear-tag number. Operation 3 uses information elements: stable's



Source: own work

Figure 1: The visualisation of information element structure for process.

register, ear-tag number, date of birth, breed, note to the animal, and note on arrival of animal. Operation 4 uses information elements: ear-tag number, date of birth, breed, note to the animal, note on arrival of animal, and list of animals. Operation 5 uses information elements: list of animals, date of departure of animal, tracking code, transfer to zoo, and from/to. Operation 6 uses information elements: ear-tag number, note to the animal, note on arrival of animal and the information that leads to sending the request. The last operation 7 uses information elements: date of departure of animal, tracking code, transfer to zoo, from/to and the information that leads to sending the request. The entire process is divided into several activities that include operations. The first activity concerns the selection of the establishment and the stable's register and includes operation 1. The second activity concerns the display of animals in the register and contains operations 2, 3 and 4. The third activity is related to the completion of a form for reporting the state of the animal, in our case the sale of the animal and contains operation 5. The last activity sends all information in the form of reports to the Central Register, the activity contains operations 6 and 7.



Source: own work

Figure 2: The visualisation of information element structure for process.

Quality metrics

In the next phase, measures are calculated for each activity of the information element structure - information cohesion, relational cohesion and activity cohesion. Information cohesion focuses on all information elements that are used as inputs or as outputs for any operation. This measure determines how many information items are used more than once in relation to all the information elements used. Relational cohesion quantifies how the various operations within a single activity are continuous. This measure for each activity operation determines how many other operations overlap by sharing the input or output. The total activity cohesion is given as a result of information and relational cohesion. This measure explains how much joint operations are interconnected and how information is shared.

	Information cohesion ($\mu(T)$)	Relational cohesion ($\lambda(T)$)	Activity cohesion ($c(T)$)
Activity 1	0	0	0
Activity 2	0.333	0.111	0.037
Activity 3	0	0	0
Activity 4	0	0	0

Source: own work

Table 1: Metrics for available activities.

In the next phase, the designed workflow of the model for the sale of an animal was subjected to heuristic testing. Two alternative models were created for this proposal. The first prefers to combine operations into one major activity and the second one prefers to divide operations into two activities.

	Average activity cohesion (ch)	Process coupling (cp)	Coupling/ cohesion ratio (ρ)
Original design	0.009	0.667	72
Alternative 1	0.018	0.765	42,5
Alternative 2	0.024	0.769	32
Activity 4	0	0	0

Source: own work

Table 2: Cohesion and coupling for information structure.

Table 2 shows cohesion values and coupling metrics for the original design and two alternatives. Due to the desirable low value for the coupling / cohesion ratio, alternative 2 is the best choice. Considering this alternative, it can be noted that it does not contain unnecessarily small or redundant activities. This means that the workflow should not be too complicated. It can be assumed that this alternative design is one that is easier to understand and leads to fewer mistakes in the process. This means that alternative 2 represents a higher economic value of the information system than alternative 1 or the original design.

Conclusion

Cohesion and coupling metrics help designers create workflow models that are superior while carried out and are understood better by people. The aim of this article was to use these measures in the field of information systems in agriculture. For this purpose, the article used the workflow process to report the sale of an animal. This process is part of the Farmer's Portal. The chosen process only demonstrates the possibility of improving the structure of information elements. In case of measuring cohesion and coupling for multiple workflow processes of the Farmer's Portal, it is possible to improve the workflow of the entire system. It can be assumed that this improvement would have a qualitative and, consequently, economic impact on the value of the information system. More efficient and understandable workflow processes lead to time savings, small error rates and a higher level of satisfaction with the use of the information system.

The limits and constraints of this article are in the use of an already existing metric that has not yet been innovated. The metric itself is rather labor-intensive for evaluating the entire complex information system. At present, there is not study to focus on evaluation the cohesion of workflows in agriculture. The exception is innovation of the modelling workflows. According to the study (Janssen et al., 2017), new types of workflows have been developed for use in visual analysis, including reactive workflows (eg EdiFlow, Manolescu et al., 2009), which specify that every time data and interactive workflows discover a set of operations (e.g., VisTrails, Callahan et al., 2006) that interactively create and run sequences including visualizations. In this article, presented results are only the first step of a more complex research of evaluation information systems in agriculture.

In the next phase of the research of information systems in agriculture it is necessary to:

- Focus on the workflow processes of the entire Farmer's Portal. The farmer's portal is the most widespread representative of information systems for small and medium-sized farms in the CR.
- Compare these workflow processes with processes of business information systems that are used in CR mainly by representatives of larger farmers.
- Distinguish workflow processes for information, analytical and administrative activities.
- Create a framework for evaluating different types of workflow processes in agriculture.

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Appendix A. Information request for reporting the sale of animal

Number	Description
1	Name of the establishment
2	Cadastral territory
3	Animal species
4	Stable’s register
5	Stable selection
6	Animals by exclusion
7	Ear-tag number
8	Date of Birth
9	Breed
10	Note to the animal
11	Note on arrival of animal
12	List of animals
13	Date of departure of animal
14	Tracking code
15	Transfer to zoo
16	From/To
17	The information that leads to sending the request.

Source: own work

Table A.1: Description of information elements of the information element structure.

Appendix B. XML sheet of the information structure (own work)

```
<?xml version="1.0" encoding="UTF-8"?>
<InformationStructure xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
	<InformationElements>
		<InformationElement Identifier="1"/>
		<InformationElement Identifier="2"/>
		<InformationElement Identifier="3"/>
		<InformationElement Identifier="4"/>
		<InformationElement Identifier="5"/>
		<InformationElement Identifier="6"/>
		<InformationElement Identifier="7"/>
		<InformationElement Identifier="8"/>
		<InformationElement Identifier="9"/>
		<InformationElement Identifier="10"/>
		<InformationElement Identifier="11"/>
		<InformationElement Identifier="12"/>
		<InformationElement Identifier="13"/>
		<InformationElement Identifier="14"/>
		<InformationElement Identifier="15"/>
		<InformationElement Identifier="16"/>
		<InformationElement Identifier="17"/>
	</InformationElements>
	<Resources>
		<Resource Identifier="Resource1"/>
	</Resources>
	<Process id="Process 1">
		<ProcessInformationStructure>
			<Operation label="Operation1">
				<InformationElementSet>
					<InformationElementRef>1</InformationElementRef>
					<InformationElementRef>2</InformationElementRef>
					<InformationElementRef>3</InformationElementRef>
				</InformationElementSet>
```

```xml
				<InformationElementSet>
					<InformationElementRef>4</InformationElementRef>
				</InformationElementSet>
				<ResourceRef>Resource1</ResourceRef>
			</Operation>
			<Operation label="Operation2">
				<InformationElementSet>
					<InformationElementRef>5</InformationElementRef>
					<InformationElementRef>6</InformationElementRef>
				</InformationElementSet>
				<InformationElementSet>
					<InformationElementRef>12</InformationElementRef>
				</InformationElementSet>
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			</Operation>
			<Operation label="Operation3">
				<InformationElementSet>
					<InformationElementRef>4</InformationElementRef>
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					<InformationElementRef>8</InformationElementRef>
 <InformationElementRef>9</InformationElementRef>
 <InformationElementRef>10</InformationElementRef>
 <InformationElementRef>11</InformationElementRef>
				</InformationElementSet>
				<ResourceRef>Resource1</ResourceRef>
			</Operation>
			<Operation label="Operation4">
				<InformationElementSet>
					<InformationElementRef>7</InformationElementRef>
					<InformationElementRef>8</InformationElementRef>
					<InformationElementRef>9</InformationElementRef>
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					<InformationElementRef>11</InformationElementRef>
				</InformationElementSet>
				<InformationElementSet>
					<InformationElementRef>12</InformationElementRef>
				</InformationElementSet>
				<ResourceRef>Resource1</ResourceRef>
			</Operation>
			<Operation label="Operation5">
				<InformationElementSet>
					<InformationElementRef>12</InformationElementRef>
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				<InformationElementSet>
					<InformationElementRef>13</InformationElementRef>
					<InformationElementRef>14</InformationElementRef>
					<InformationElementRef>15</InformationElementRef>
					<InformationElementRef>16</InformationElementRef>
				</InformationElementSet>
				<ResourceRef>Resource1</ResourceRef>
			</Operation>
			<Operation label="Operation6">
				<InformationElementSet>
					<InformationElementRef>7</InformationElementRef>
					<InformationElementRef>10</InformationElementRef>
					<InformationElementRef>11</InformationElementRef>
				</InformationElementSet>
				<InformationElementSet>
					<InformationElementRef>17</InformationElementRef>
				</InformationElementSet>
				<ResourceRef>Resource1</ResourceRef>
			</Operation>
<Operation label="Operation7">
				<InformationElementSet>
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					<InformationElementRef>14</InformationElementRef>
					<InformationElementRef>15</InformationElementRef>
```

```xml
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                    </InformationElementSet>
                    <InformationElementSet>
                        <InformationElementRef>17</InformationElementRef>
                    </InformationElementSet>
                    <ResourceRef>Resource1</ResourceRef>
                </Operation>
            </ProcessInformationStructure>
            <InformationStructureDesign description="One activity" id="Design 1">
                <Activity>
                    <WorkflowModelElement>Activity 1</WorkflowModelElement>
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Economic Aspects of Food Security in Ukrainian Meat and Milk Clusters

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Abstract

The goal of the article was to accomplish mathematical estimations of the misbalances and calculate available reserves in providing food security by meat and milk. This issue has considerable economic and social values that imply maintaining agrarians' welfare and people's health. The disproportions in meat and milk clusters have been analyzed by means of Lorenz curves and inequality indicators – Hoover and Theil indices, Gini coefficient, and also 20:20 Ratio. It has been grounded that increasing animal productivity and wholesale prices for meat and milk, as well as reducing their retail prices and raising solvency of population would be the essential reserves in supporting food security in the agricultural clusters. The proposed model of defining interregional clusters has made possible to identify the priority options of providing food security and balancing meat and milk supply and demand. All the offered developments and recommendations have been verified at Ukrainian meat and milk clusters.

Keywords

Food security; meat and milk clusters; indicators of misbalances; production and consumption; productivity and profitability; prices and solvency; cluster model.

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Introduction

Food security is one of the key economic issues for agrarians and scientists all over the world. The problem of balancing agricultural clusters is also a very important objective, relying on the primary vital human right on healthy nutrition. Furthermore, providing rational agriculture is a social and ecological responsibility as for preserving and passing undamaged natural recourses and clear environment to the future generations. It was determined that an accelerated growth of population brought new challenges to conventional agriculture (Grafton et al., 2015). The appeared advantages are connected with the increasing demand for food products, while the additional obligations force to satisfy the contemporary norms of products quality.

At present agrarian markets in Europe are saturated with sufficient quantities of qualitative food products, according to the modern nutrition standards. Therefore, the main task of European agriculture is to continue its balanced economic development in conditions of strong competition and limitations to production volumes.

While integrating into European economic space and following the best world examples, Ukraine should modernize its agrarian sector and, simultaneously, eliminate the striking disproportion between branches of crop and animal production. Practical actuality of these issues is focused on two points. On the one hand, Ukrainian animal husbandry does not realize own resource potential, especially in cattle and pigs breeding. It results in a crucial breaking of nutrition maintenance of Ukrainian population by meat and dairy products. On the other hand, a poor solvency in Ukraine affects demands for meat and milk, which are even less than the suggested supplies of the national producers. Thus it is necessary to study correlation between consumption and production of beef, pork and milk at Ukrainian agricultural markets.

Analysis of recent relevant publications highlights scientific actuality of explorations on providing food security in the global scale. Namely, Godfray and Garnett (2014) presented a new concept of uniting food security and sustainable intensification under the principle “more food with less environmental impact”, which emphasizes ecological components of saving biodiversity, multifunctional landscapes, and animal welfare together with facilitating rational human nutrition. Contemporary criteria and indicators of measuring food security were obtained by Headey and Ecker (2013), as well as Kavallari et al. (2014). Grafton et al. (2015) targeted their strategic researches on ensuring food security by countries and agricultural branches. The last ones correspond to the Cluster Concept, developed by Porter (2000), on achieving essential competitive benefits in increasing productivity, expanding market scopes and accelerating innovative modernization by territories and products. Hansen (2013) clarified the effectiveness of this approach in the largest agricultural and food European clusters. At the same time Phillips et al. (2012) proved it for the similar prosperous clusters of North America.

The grounded solutions of the formulated problem need applications of mathematical methods that would be a robust basis for the obtained conclusions and recommendations. For a long time researches on applying mathematical apparatus to the problems of agricultural economics attract scientists’ attention in diversified directions all over the world. Namely, these issues found their fundamental reflection in the developed and generalized results of Thornley and France (2007), Bessler et al. (2010), as well as Mitchell (2011).

As a matter of fact, mathematical models and assessments should be “the more – the better” adjusted to the features and factors of the expected applied economic environment. Therefore, this study is focused on analyzing Ukrainian clusters of meat and dairy products. It continues the previous ones of Vasylieva (2015; 2016) on simulating optimal animal numbers and productivities for saturating Ukrainian domestic regional markets with meat and milk, decreasing their costs, providing profitable livestock breeding at the level of agricultural enterprises and modelling clusters of intensified development in the national households. At the same time, the problem of facilitating food security by animal products is still an open question in terms of demand and supply or production and consumption in the whole country. It is not only significant economic, but also urgent social issue, since balanced production of meat and milk means welfare and employment of rural population, while sufficient consumption of meat and milk supports health of people at present and for the future. Thus, the goal of this investigation was to assess the current misbalances and to define some reserves on maintaining rational nutrition by meat and milk with regard to providing Ukrainian food security. This goal implies solving the following tasks:

- to choose complex of indicators for evaluating disproportions in Ukrainian meat and milk food security;
- to ground quantitative options in increasing meat and milk production;
- to figure out reserves of growth in meat and milk consumption;
- to create a mathematical model of regional clusters, which facilitate balanced food security in Ukrainian animal husbandry.

Materials and methods

Defining current disproportions in nutrition maintenance by meat and milk should be started from determining main tendencies in dynamics of key economic indicators of Ukrainian animal husbandry as a part of the general agricultural analysis, performed by Vasylieva et al. (2015). Ministry of Health Care grounded annual rational norms of nutrition per capita in Ukraine, including bread, sugar, oil, potato, vegetables, fruit, meat, milk, and eggs. Ukrainian Ministry of Agricultural Policy and Food applies them to assessing capacities of domestic markets and monitoring level of food security by products and regions (Lupenko and Mesel-Veselyak, 2012). Annual rational diet includes 75 kg of meat and 330 kg of milk per capita that are anchor points in indicating saturation of domestic markets and grounding export abilities.

After becoming aware of degradation in Ukrainian animal husbandry its components should be studied more thoroughly. According to Todaro (2014) and Lee (2014), modern mathematical apparatus offers a broad spectrum of procedures for setting and assessing data entropies, especially widespread in incomes management or estimations of economic development. For quick responding to rapid changes in economic environment and better adjusting to regional features of agricultural activity it is expedient to conduct and revise assessments of inequalities in meat and milk production and consumption at the latest annual official statistical data by 24 Ukrainian regions (State Statistics Service of Ukraine, 2017). Set of agricultural and economic indicators to Ukrainian regions are aggregated in Annex. In particular,

- #1 is a share of population by Ukrainian regions, %;
- #2 denotes a number of cattle, thousands heads;
- #3 is a number of pigs, thousands heads;
- #4 denotes a daily average live weight gain of cattle, g;
- #5 is a daily average live weight gain of pigs, g;
- #6 denotes an annual average milk yield per cow, kg;
- #7 is a share of arable regional lands under fodder crops, %;
- #8 denotes an annual meat production per capita, kg;
- #9 is an annual meat consumption per capita, kg;
- #10 denotes an annual milk production per capita, kg;
- #11 is an annual milk consumption per capita, kg.

Aligning production and consumption by regions would provide local food security, reduce expenses in transport and storage logistics, encourage regional farmers in running effective meat and milk agribusiness under the concept of rural development (Velychko, 2013).

In this research the chosen indicators of inequality, applied to Agricultural Economics, were Lorenz curve, Hoover and Theil indices, Gini coefficient, and also 20:20 Ratio. The reasons for such a choice of the listed set of tools were the next ones. Firstly, the Lorenz curve method allows visual scanning and supports regular qualitative monitoring of tendencies in misbalanced meat and milk production and consumption. Secondly, in order to obtain quantitative descriptions of the existing disproportions, it is expedient to apply Hoover index (*H*). It estimates the highest level of inequality, while Theil index (*T*) assesses its general average distribution. Finally, Gini coefficient (*G*) gives a total measure of the inequality, while 20:20 Ratio (*R*) permits comparing its maximum and minimum limits.

After the identification of the core of misbalances in Ukrainian food security by meat and milk one should suggest some ways of solving the problem in question. Contemporary fundamental approaches to strategic improvements in Agribusiness and Farm Management were accumulated by Olson (2010), Beierlein et al. (2013), Popescu and Jean-Vasile (2015), Kay et al. (2015). Extensions of their results to the problem in question made possible to specify relevant reserves of strengthening meat and milk components of Ukrainian food security, connected with production productivity, wholesale and retail prices, and solvency of consumers. Data for such calculations are available for free at official site of State Statistics Service of Ukraine.

Firstly, let us have a production segment with a share of s_l and animal productivity p_l. Then in case of increasing productivity in all segments up to

$$p_{\max} = \max_l p_l , \tag{1}$$

the total additional share of production Δs can be calculated with the formula

$$\Delta s = \sum_l s_l (p_{\max} / p_l - 1) . \tag{2}$$

Secondly, let us denote Z – a current production profitability, P^w – a wholesale price of the considered product. Then the necessary increase in the wholesale price (ΔP^w), which facilitates production profitability at the desired level of Z^{opt}, can be found with the formula

$$\Delta P^w = P^w (Z^{opt} - Z)/(Z + 100) . \tag{3}$$

Thirdly, let us designate W^{min} – a minimum month's wage in the country, P^r – a retail price of the considered product. Than to compare solvency of population by meat and milk (S) in different countries it is expedient to apply the formula

$$S = W^{\min} / P^r . \tag{4}$$

Finally, let f be a coefficient that transforms a wholesale price into a retail one. Then a grounded value of f enables us to estimate a decrease ΔP^r in the retail price of the considered product with the equality

$$\Delta P^r = P^r - f(\Delta P^w + P^w) . \tag{5}$$

Joint innovative improvements of meat and milk production and consumption would accelerate their implementations, reduce costs, and increase effectiveness. So, to unite regions with the similar tendencies in meat and milk production and consumption it is expedient to divide them between several interregional clusters. The offered mathematical model to such development was stated as follows. Namely, let us denote the given components of a statistical sample to the region *i* with

X_{1i} – an annual meat production per capita;

X_{2i} – an annual meat consumption per capita;

X_{3i} – an annual milk production per capita;

X_{4i} – an annual milk consumption per capita.

Let Y_{1j}, Y_{2j}, Y_{3j}, Y_{4j} be the corresponding unknown in advance average values of the listed indicators to the cluster *j*. Then the proposed optimization model of defining interregional meat and milk clusters searches for such their centers Y_{1j}, Y_{2j}, Y_{3j}, Y_{4j} that maintain minimum of the objective function

$$\sum_i \min_j \sum_{k=1,\dots,4} (X_{ki} - Y_{kj})^2 \to \min. \qquad (6)$$

All the listed theoretical developments and conclusions on providing food security in the meat and milk clusters were verified and illustrated by the calculations at the annual statistical data to Ukrainian agriculture, obtained from the official electronic resource (State Statistics Service of Ukraine, 2017).

Results and discussion

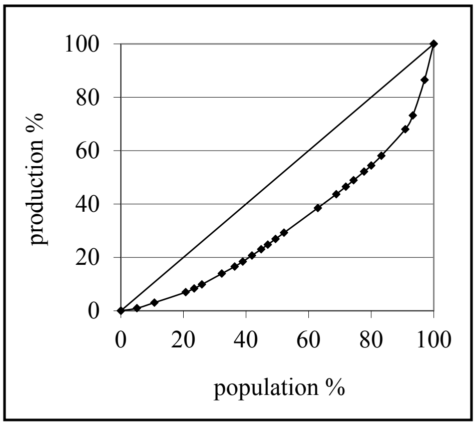
1. Analysis of misbalances

Official statistical data (State Statistics Service of Ukraine, 2017) disclose an immense reduction of the structural share of Ukrainian animal production from 48.5% down to 29.7% that is 2.4 times less than the structural share of Ukrainian crop production. This striking interbranch imbalance was caused by the decrease in meat production by 53.3% from 4357.8 thousands tons down to 2322.6 thousands tons in 1990–2016. Essential reductions of government support, disproportions between expenses, wholesale and retail prices, lack of experience in market competition affected Ukrainian farmers since 1991. Significant inflation decreased population's solvency and, consequently, capacities of meat consumption, as even importers could not propose affordable prices. However, it should be noted that the worst value of 1517.4 thousands tons was in 2001, and since then meat production has been demonstrating slow, but consistent recovery. A state of milk production is characterized by negative stable shrinking by 43.3% from 24503.8 thousands tons down to 10615.4 thousands tons at the same period. Indicators of annual meat (84 kg) and milk (472.3 kg) production per capita in 1990 even exceeded human rational nutrition norms, respectively 75 kg and 330 kg. The corresponding milk consumption (373.2 kg) was sufficient. Yet the volume of meat consumption, only 68.2 kg, was by 9% lower than the recommended nutrition norm. At present the indicators of meat annual production and consumption per capita are equal to 54.2 kg and 50.9 kg, which, on the one hand, remain worse by 35.5% and 25.4% than those ones in 1990, but, on the other hand, are essentially higher than a critical production of 31.2 kg and an extremely insufficient consumption of 31.1 kg in 2001. Similarly, the current indicators of milk annual production and consumption per capita are equal to 247.8 kg and 209.9 kg, which are almost 2 times worse than those ones in 1990. Furthermore, they are only slightly higher than 242.5 kg of milk, produced per capita in 2011, and 199.1 kg of milk, consumed per capita in 2000.

The accomplished calculations of inequality in production and consumption of meat and milk in Ukraine resulted in the following. Figure 1 contains Lorenz curve on an unequal interregional distribution of meat production in Ukraine. Accompanying indicators of the disproportion are

$$G_{p\ meat} = 0.3677,\ T_{p\ meat} = 0.2584,$$
$$R_{p\ meat} = 6.88,\ H_{p\ meat} = 0.2566.$$

They mean that the total misbalance of meat supply from domestic producers is 36.77%. Though the inequality entropy has an average level of 25.84%, but the gap between top 20% and bottom 20% of meat producers reaches 6.88 times. To align their concentration meat production needs replacement by 25.66%.

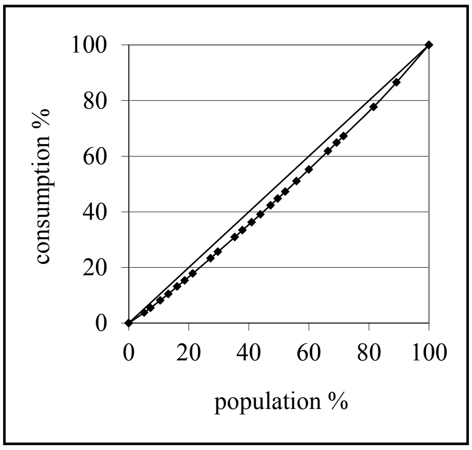


Note: population = 24 Ukrainian regions
Source: own calculation based on State Statistics Service of Ukraine (2017)

Figure 1: Lorenz curve on inequality of meat production in Ukraine.

Figure 2 shows Lorenz curve on an inequality of meat consumption in Ukraine. Lorenz curves at Figure 1 and Figure 2 confirm relatively uniform meat consumption in comparison with its production in Ukrainian agriculture. The calculated indicators of inequality in meat consumption are

$G_{c\ meat} = 0.0703$, $T_{c\ meat} = 0.0084$,
$R_{c\ meat} = 1.44$, $H_{c\ meat} = 0.0488$.



Note: population = 24 Ukrainian regions
Source: own calculation based on State Statistics Service of Ukraine (2017)

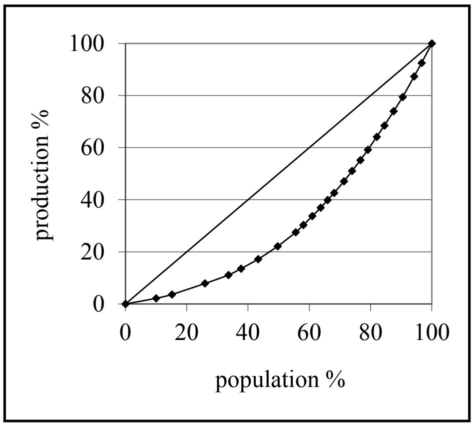
Figure 2: Lorenz curve on inequality of meat consumption in Ukraine.

Their economic interpretation explains that the total disproportion of meat nutrition in Ukraine is 7.03%, at the same time its inequality entropy (0.84%) is also low. The difference between top 20% and bottom 20% in meat consumption reaches 44%. It would be eliminated after redistribution of meat consumption by 4.88%.

Lorenz curve at Figure 3 visualizes an unequal interregional distribution of milk production in Ukraine. It has a more misbalanced state with respect to domestic meat production, illustrated by Figure 1. Accompanying indicators of the disproportion in milk production are

$G_{p\ milk} = 0.3593$, $T_{p\ milk} = 0.2250$,
$R_{p\ milk} = 7.79$, $H_{p\ milk} = 0.2806$.

They reveal that the total misbalance of milk supply from Ukrainian producers is 35.93%. Though the inequality entropy has an average level of 22.50%, but the gap between top 20% and bottom 20% of milk producers reaches striking 7.79 times. To align their concentration milk production needs replacement by 28.06%.

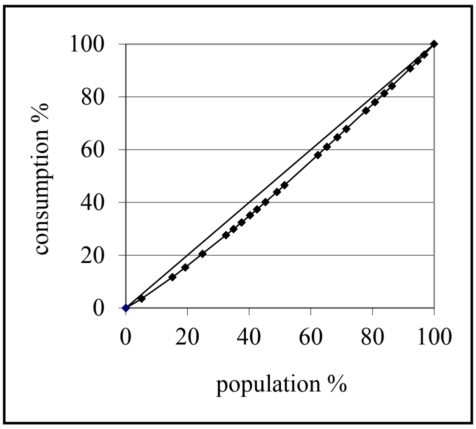


Note: population = 24 Ukrainian regions
Source: own calculation based on State Statistics Service of Ukraine (2017)

Figure 3: Lorenz curve on inequality of milk production in Ukraine.

Lorenz curve at Figure 4 describes an inequality of milk consumption in Ukraine. Like in the pair of meat production–consumption, Lorenz curves at Figure 3 and Figure 4 confirm relatively uniform milk consumption in comparison with its production in Ukrainian agriculture. Measures of inequalities in milk and meat consumption are almost similar. The calculated indicators of an inequality in milk consumption are

$G_{c\ milk} = 0.0690$, $T_{c\ milk} = 0.0076$,
$R_{c\ milk} = 1.43$, $H_{c\ milk} = 0.0518$.



Note: population = 24 Ukrainian regions
Source: own calculation based on State Statistics Service of Ukraine (2017)

Figure 4: Lorenz curve on inequality of milk consumption in Ukraine.

Their economic interpretation discloses that the total disproportion of milk nutrition in Ukraine is 6.90%, at the same time its inequality entropy

(0.76%) is also low. The difference between top 20% and bottom 20% in milk consumption reaches 43%. It would be eliminated after redistribution of milk consumption by 5.18%.

2. Options of increasing production and consumption

Positive and long-term experiences of the countries, leading in the effective animal husbandry, enable us to be optimistic about prospects of nutrition maintenance by meat and milk in Ukraine. Official statistical data (FAO, 2017) convince that Ukrainian meat producers should pattern the farmers from leading countries, where annual meat production per capita achieves 82 kg (in Hungary), 86 kg (in France), 99 kg (in Germany), 100 kg (in Poland), 106 kg (in Austria), 116 kg (in Spain), 123 kg (in Canada), 130 kg (in Brazil), 133 kg (in the USA), 159 kg (in the Netherlands), 337 kg (in Denmark). By the way, the above mentioned countries not only provide their domestic food security, but also facilitate it in the global scale. In particular, the USA took the 1st, the Netherlands – 3rd, Germany – 5th, Canada – 6th, Poland – 7th, and France – 9th place among the World Top Fresh Beef Exporting Countries. Brazil was at the 3rd, the USA – 4th, Canada – 9th, and Poland – 10th position in the World Top Frozen Beef Exporters List. The USA took 1st, Germany – 2nd, Spain – 3rd, Denmark – 4th, Canada – 5th, the Netherlands – 6th, Brazil – 8th, France – 9th, Poland – 10th, Austria – 14th, and Hungary – 15th place among the World Top Pork Exporting Countries. The Netherlands were at the 1st, the USA – 2nd, Poland – 3rd, Germany – 5th, France – 7th, Hungary – 10th, and Austria – 12th position in the World Top Fresh Chicken Exporters List. Brazil took the 1st, the USA – 2nd, the Netherlands – 3rd, Poland – 5th, and France – 6th place among the World Top Frozen Chicken Exporting Countries (World's Top Exports, 2015).

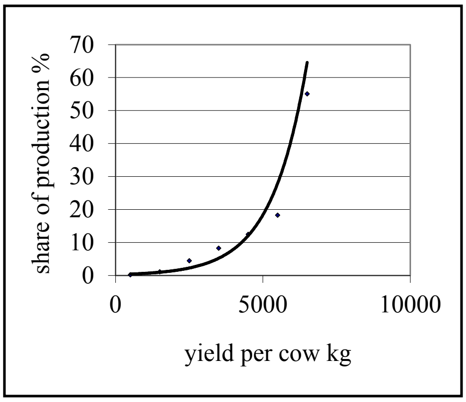
Similarly, Ukrainian milk production should be rearranged like those ones in the leading countries, where annual milk production per capita is 333 kg (in Poland), 376 kg (in Germany), 382 kg (in France), 404 kg (in Austria), 742 kg (in the Netherlands), and 908 kg (in Denmark) (FAO, 2017). As before, the above named countries have sufficient milk nutrition maintenance and make their immense contribution into the global food security system. Indeed, Germany was at the 1st, France – 2nd, the Netherlands – 4th, Austria – 5th, Poland – 8th, and Denmark 12th place in the World Top Milk Exporters List (World's Top Exports, 2015).

The dominant raw for dairy products in Ukraine is cow milk. The main kinds of meat in Ukrainian agriculture are poultry meat, pork and beef with the structural shares 49.2%, 32.7%, 16.5% in 2016 (State Statistics Service of Ukraine, 2017). It should be underlined that production of poultry meat has been increasing its share since 1990, starting from 16.3%. At the same time, pork and beef production have been losing their shares since 1990, starting from 36.2% and 45.5%. Nutrition norms suppose almost equal proportions of beef, pork and poultry meat. These arguments forced us to focus this research on strengthening livestock breeding. Furthermore, volumes of beef and pork production in Ukraine diminished critically 2.1 and 5.2 times in 1990-2016 (State Statistics Service of Ukraine, 2017).

Positive world agricultural experience grounds that the key approach to achieving prosperous and competitive animal husbandry lies in raising animals' productivities. State Statistics Service of Ukraine provides available data on annual average milk yield per cow from 1000 to 6000 kg with a step of 1000 kg. Statistical analysis of dependency of total milk production on annual average milk yield per cow in Ukrainian agriculture demonstrates their convincing parallel increase (see Figure 5). It is highlighted by the non-linear regression

$$y = 0.2759e^{0.0008x}$$

with the coefficient of determination $R^2 = 0.9307$. Farmers with an annual average milk yield per cow over 6000 kg provide 55.1% of total milk production. Calculations with the formulae (1) and (2) gave $p_{max} = 6000$ and $\Delta s = 0.293$. In other words, in case of the general growth of cows' productivities up to the accessible level of 6000 kg, it would raise total Ukrainian milk production by 29.3% or up to 320.3 kg of annual milk production per capita. Besides, the latter value approximately coincides with those ones in Poland, Sweden and the USA. So, this gives us confidence that the calculated reserves could partly solve a problem of nutrition maintenance in Ukrainian milk husbandry.



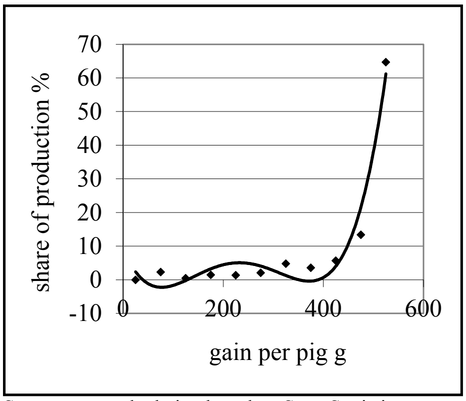
Source: own calculation based on State Statistics Service of Ukraine (2017)

Figure 5: Dependency of milk production on yield per cow in Ukraine.

State Statistics Service of Ukraine provides available data on daily average live weight gain of pigs from 50 to 500 g with a step of 50 g. As before, statistical analysis discloses that total pork production and daily average live weight gain of pigs in Ukrainian agriculture are characterized by parallel growing (see Figure 6). It is highlighted by the non-linear regression

$$y = 10^{-8}x^4 - 10^{-5}x^3 + 0.0036x^2 - 0.359x + 9.2914$$

with the coefficient of determination R^2 = 0.9557. Farmers with daily gain per head of pigs over 500 g provide 64.7% of total pork production. Calculations with the formulae (1) and (2) gave p_{max} = 500 and Δs = 0.279. In other words, in case of the general increase of pigs' productivities up to the available level of 500 g, it would bring additional 27.9% of total Ukrainian pork production or raise annual pork production per capita from the current 17.7 kg to 22.6 kg.



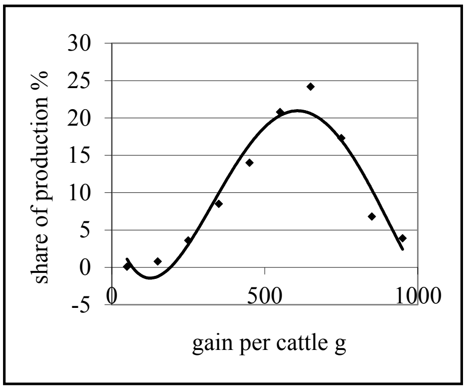
Source: own calculation based on State Statistics Service of Ukraine (2017)

Figure 6: Dependency of pork production on gain per pig in Ukraine.

State Statistics Service of Ukraine provides available data on daily average live weight gain of cattle from 100 to 900 g with a step of 100 g. Statistical analysis of dependency of total beef production on daily average live weight gain of cattle visualizes that the core of production corresponds to an average cattle's productivity (see Figure 7). It is highlighted by the non-linear regression

$$y = 4 \cdot 10^{-10}x^4 - 10^{-6}x^3 + 0.0007x^2 - 0.1367x + 6.2773$$

with the coefficient of determination R^2 = 0.937. The ways of improving such a situation lie in changing breeds of cattle into modern high-productive ones and implementing innovative intensive technologies of beef production. Calculations with the formulae (1) and (2) gave p_{max} = 900 and Δs = 0.78. In other words, in case of the general growth of cattle's productivity to the accessible level of 900 g, it would raise total Ukrainian beef production by 78% or up to 16 kg instead of the current 9 kg of annual beef production per capita. Thus, total annual meat production per capita would reach 66.1 kg that approximately coincides with those ones in Italy and the United Kingdom. So the calculated reserves assure us of real opportunities of enhancing nutrition maintenance in Ukrainian meat husbandry.



Source: own calculation based on State Statistics Service of Ukraine (2017)

Figure 7: Dependency of beef production on gain per cattle in Ukraine.

Sustainable development immensely depends on permanent monitoring and adjusting of prices, costs and profitability. These concern not only agricultural economics in general (Norton et al., 2014), but also affect meat and milk clusters (Bakucs and Ferto, 2015; Zakova Kroupova, 2016). Indeed, practice reveals that improvements of productivities in domestic livestock breeding have been braking by low unstable incomes and frequently even unprofitable results. First, for the past 10 years breeding of pigs was 4 times unprofitable down to –27.6% and 6 times profitable up to 12.6%. Second, milk production has been operating with incomes. But their abrupt changes in profitability, ranging between 1.4% and 18.5 %, cannot be associated with expanded reproduction. Third, cattle breeding appeared to be in the worst state, running with losses from –16.9% down to –43.3%. The key reasons of the introduced situations are low wholesale prices for meat and milk in Ukrainian agriculture. They (P^w) were US$ 813.56 per livestock ton in live weight and US$ 161.01 per ton of milk, while the retail prices (P^r) per kg of beef (slaughter coefficient 0.7), pork (slaughter coefficient 0.8) and milk were US$ 3.89, US$ 3.33, US$ 0.56 in 2016 (State Statistics Service of Ukraine, 2017). Corrections of the described disproportions outline the second reserve in facilitating food security in Ukrainian animal husbandry, while prices in domestic crop production are almost equal to the world level (Vasylieva and Pugach, 2017). The performed calculations with formula (3) showed that increasing wholesale price for cattle in live weight by 50.42% up to US$ 1223.77 per ton will provide profitability of beef production at the level of 25% (Z^{opt}). Similarly, raising wholesale prices for pigs in live weight by 33.21% up to US$ 1083.79 per ton and for milk by 33.10% up to US$ 214.30 per ton will guarantee expanded pork and milk production with 50% of profitability (Z^{opt}).

Recent analysis of retail prices and solvency of population (Bakucs and Ferto, 2015; Benda Prokeinova and Hanova, 2016) permitted us to ground some reserves on improving consumption of meat and milk as components of nutrition maintenance in Ukrainian food security. Certainly, the retail prices for beef, pork and milk in Ukraine are less by 37%, 28% and 24% than those ones in Eastern Europe (concerning Hungary, Lithuania and Poland), 3.1, 2.6 times and by 70% less than in Western Europe (regarding Austria, France and the Netherlands), 2.2, 2.2 and 2.3 times less than in North America (with respect to Canada and the USA) (FAO, 2017). But simultaneously, Ukrainian population has poor solvency that is identified by the value of the official minimum wage W^{min} (see Table 1).

Calculations with formula (4) justified this conclusion. Indeed, the minimum month's wage in Ukraine allows people to buy 30 kg of beef, 35 kg of pork and 212 kg of milk. At the same time, 98 kg, 127 kg and 736 kg of these products are available per average minimum month's wage in the listed countries of Eastern Europe, 132 kg, 182 kg and 1650 kg – in Western Europe, 161 kg, 196 kg and 1137 kg – in North America. So, the first reserve of improving consumption of meat and milk, as a component of nutrition maintenance in Ukrainian food security, assumes the increase in the minimum wage. However, implementation of this issue implies further persistent and unavoidable state reforms, focused on strong control and transparency of budget revenues and expenditures.

Country	W^{min}, US$ per month
Ukraine	118.00
Eastern Europe	
Hungary	560.00
Lithuania	423.00
Poland	475.00
Western Europe	
Austria	1320.00
France	1657.17
The Netherlands	1722.75
North America	
Canada	1524.50
The USA	1256.67

Source: based on Minimum wage rates by country (2017)

Table 1: Minimum wages by country.

The second reserve in enhancing solvency of Ukrainian population is based on the above calculated changes in prices. Firstly, it is expedient to set 50% structural share of agricultural producers in the retail prices of meat and milk. Secondly, it is necessary to cut disproportionately high structural share down to 50% of the retail prices for processing and trade services, partly compensating their losses by some tax privileges, i.e. $f = 2$. Finally, according to the formula (5) even under the above calculated increase in meat and milk wholesale prices (ΔP^w), the retail prices per kg of beef, pork and milk could diminish by 10.09%, 18.72% and 22.85% down to US$ 3.50, US$ 2.71 and US$ 0.43. As a result, it would generate growing in demands, in turn, stimulating increases in supplies for meat and milk and, eventually, facilitating the desired improvements of food security in Ukrainian animal husbandry.

Priorities of applying the described options on providing food security in meat and milk clusters need strict substantiations under the current conditions of poor financing. Cluster approach confirmed its effectiveness in Ukrainian crop production and animal husbandry

(Vasylieva, 2016; Vasylieva and Pugach, 2017). Calculations, accomplished with the model (6) by means of the instrument NXL Clusterizer, made possible to divide 24 Ukrainian regions into 3 interregional clusters. Their profiles, including average characteristics Y_{1j}, Y_{2j}, Y_{3j}, Y_{4j} and the corresponding average weighted deviations around average Ukrainian annual meat and milk production and consumption ΔY_{1j}, ΔY_{2j}, ΔY_{3j}, ΔY_{4j} were collected in Table 2.

The performed analysis of Table 2 showed that, firstly, cluster 1 aggregated 8 regions, where consumption of meat and milk essentially dominated over their domestic production. Therefore, the priority options on providing food security and reducing such disproportions should be connected with the clarified increases in productivity and wholesale prices.

Secondly, cluster 2 united 8 regions with the most balanced Ukrainian meat and milk production and consumption. A comparison of meat and milk segments confirmed recommendations to focus on improving meat production and consumption that demonstrated worse results than those ones for milk.

Indicators	Clusters		
	1	2	3
Y_{1j}, kg	35.5	45.5	98.8
Y_{2j}, kg	52.0	46.0	49.4
Y_{3j}, kg	138.8	317.4	471.6
Y_{4j}, kg	192.3	224.1	228.0
ΔY_{1j}, %	–40.8	–24.0	64.8
ΔY_{2j}, %	5.9	–6.4	0.6
ΔY_{3j}, %	–55.1	2.6	52.5
ΔY_{4j}, %	–10.5	4.3	6.1

Source: own calculation based on State Statistics Service of Ukraine (2017)

Table 2: Profiles of Ukrainian interregional meat and milk clusters.

Finally, cluster 3 comprised 8 regions, where production of meat and milk dominated over their domestic consumption. It implies that the priority options on providing food security and reducing such disproportions should be linked with the possible increase in customers' solvency and grounded shrink of retail prices.

Conclusion

Economic results of the accomplished research are focused on saturating and aligning domestic meat and milk markets. The issue of providing food security by means of balancing production and consumption in the agricultural clusters has double economic and social importance in the global scale and for every country. Nutrition maintenance in the clusters of animal products is a fundamental task in the frame of supporting food security in Ukraine. The most ruined states of production and consumption have been set for beef, pork and cow milk, which capacities diminished 5.2, 2.1 and 2.3 times in 1990–2016.

In comparison with general and conceptional studies on Food Security of Headey and Ecker (2013), Godfray and Garnett (2014), Kavallari et al. (2014), Grafton et al. (2015), this research established quantitative evaluations and options, confirmed by figures, as for facilitating specific branch of meat and milk production. While Bakucs and Ferto, (2015), Zakova Kroupova (2016), Benda Prokeinova and Hanova (2016) explored meat and milk markets in Hungary, Slovakia, and the Czech Republic, the identified in the article disproportions and found reserves of the further improvements concerned the Ukrainian agriculture.

Lorenz curves together with the inequality indicators have visualized the essential interregional misbalances in meat and milk production that need aligning replacement on average by 26.9%. The same calculations have highlighted more uniform states in consumption of meat and milk, where satisfactions of top 20% and bottom 20% of consumers vary on average by 43.5%.

The recovery of Ukrainian meat and milk production should be focused on the capacities in 1990, when they were enough not only for providing the domestic food security, but also for participating in support of food security in the global scale. It has been grounded that the appropriate reserves to achieve this goal would be connected with

- increasing animal productivity, which could bring additional 78%, 27.9% and 29.3% of beef, pork and milk;
- raising their wholesale prices that might provide stable profitable expanded reproduction.

The perspective reserves of improving meat and milk consumption have been associated with

- the decrease in retail prices for beef, pork and milk by 50.4%, 33.2% and 33.1%;
- the growth of the minimum wage for strengthening solvency of Ukrainian population.

The proposed model of defining interregional clusters has made possible to focus on priority options of providing food security and balancing meat and milk production and consumption in conditions of restricted financing. Cluster model enables Ukrainian farmers to share experience and knowledge in solving similar economic problems, as well as gain advantages in supporting regional food security in meat and milk segments.

In general, the accomplished investigation has confirmed the effectiveness of applying the contemporary mathematical apparatus to assessing misbalances and finding reserves of nutrition maintenance in Ukrainian food security. It inspires us to extend the obtained results at the other products clusters, applying wider spectrum of mathematical methods in the further scientific research.

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Appendix

Region	Indicators										
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Cherkasy	3	186	400	576	435	5724	8	252	53	425	227
Chernihiv	2	205	194	565	428	4735	11	33	46	526	239
Chernivtsi	2	90	148	528	464	4764	16	45	41	323	244
Dnipropetrovsk	8	130	470	546	447	4387	3	70	59	106	195
Donetsk	10	72	445	515	236	4426	5	21	53	53	171
Ivano-Frankivsk	3	159	313	517	716	4354	21	62	42	343	259
Kharkiv	6	196	300	517	466	5483	6	35	53	193	228
Kherson	2	107	166	565	483	4163	6	46	51	282	196
Khmelnytskiy	3	230	340	598	561	4175	10	50	49	448	233
Kirovohrad	2	104	254	510	398	4984	3	54	53	318	208
Kyiv	11	134	467	572	537	6048	8	47	63	96	223
Luhansk	5	58	66	416	285	4197	4	10	38	72	145
Lviv	6	203	349	530	540	4180	15	47	47	225	236
Mykolayiv	3	135	115	462	315	4110	3	28	44	296	207
Odesa	6	179	350	396	390	3502	4	20	48	161	195
Poltava	3	256	409	568	523	6016	7	53	50	550	224
Rivne	3	146	282	472	469	4206	18	47	46	376	213
Sumy	3	147	140	503	411	4940	7	39	49	373	204
Ternopil	2	154	440	568	503	4561	8	52	48	431	235
Vinnytsya	4	301	371	564	404	5137	9	193	51	522	214
Volyn	2	157	307	501	479	4082	18	116	50	408	221
Zakarpattya	3	128	275	370	383	3634	24	42	46	284	223
Zaporizhya	4	105	304	478	423	4266	3	35	52	148	186
Zhytomyr	3	167	176	464	522	4877	17	43	49	462	231
Ukraine	100	3750	7079	536	482	4644	7	54	51	248	210

Note:

- #1 is a share of population by Ukrainian regions, %;
- #2 denotes a number of cattle, thousands heads;
- #3 is a number of pigs, thousands heads;
- #4 denotes a daily average live weight gain of cattle, g;
- #5 is a daily average live weight gain of pigs, g;
- #6 denotes an annual average milk yield per cow, kg;
- #7 is a share of arable regional lands under fodder crops, %;
- #8 denotes an annual meat production per capita, kg;
- #9 is an annual meat consumption per capita, kg;
- #10 denotes an annual milk production per capita, kg;
- #11 is an annual milk consumption per capita, kg.

Source: aggregated from State Statistics Service of Ukraine (2017)

Table: Agricultural and economic indicators by Ukrainian regions in 2016.

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