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Assessing of the Competitiveness Level in the Industry using the Correlation Analysis on the Example of Agriculture of the Republic of Tatarstan, Russian Federation

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Abstract: This study presents the results of evaluation of the competitiveness of farmers and the agricultural sector in the region as a whole. Traditional approach of estimating monopolization level uses Herfindahl-Hirshman and Lerner indexes. But this methods not applicable in case of inhomogeneity of product in industry or when firms manufacture different type of products. The evaluation was performed by using the instruments of fuzzy set theory and the correlation analysis. This technique allows us to estimate the degree of monopolization of the industry and its sub-sectors, as well as to hold a comparative analysis and to identify trends of development. Technique consists several steps. Determine the maximum amount of product produced by any company in the sector in the period and the percentage of the volume of production from which the company can be named as leader. Fuzzy numbers of leadership are calculated for each firm's product. If the company produces more than one product, the fuzzy numbers for each product are aggregated into one by using the fuzzy operation "or". Depending on the percentage level in the industry will change and the number of companies that are recognized as leaders. Simulations proved that correlation between percentage level and number of leaders in industry depends on market structure: Monopoly, oligopoly or pure competition. Correlation coefficient tends from -1 for the monopolized industries to 0 for pure competition. We provided computer simulation to calculate the boundaries of correlation coefficient to identify types of market structure. The analysis was held according to the industrial and economic activity of all 509 agricultural enterprises and 13 types of products in Republic Tatarstan of Russian Federation during 2011-2013. The obtained results are comparable with the results of the calculation the Herfindahl-Hirschman index for each product. However, the proposed technique allows us to make a general assessment of industry's competitiveness. The technique has an applied significance in the development of government support measures.

Keywords: Fuzzy Sets, Herfindahl-Hirschman, Monopolization Rate, Agriculture, Correlation Analysis

Introduction

Currently there is an active policy of promoting and subsidizing farmers as the agriculture sector has long been unprofit and unattractive to investors (Kadochnikova, 2013). However, this policy has led to new problems-there have been several large investors in agriculture which led to the monopolization of the industry.

Monopolization of the agricultural industries is currently a serious problem in the Russian Federation as a whole. Agriculture is one of the most important industries in any country, as it is the basis of food sovereignty and security. The monopolization leads to lower stimuli of the quality and quantity growth of production and, consequently, it reduces the competitiveness of the industry in a regional and global scale.

Monopolization of the industry leads to the fact that there are barriers to entry in the industry for both new and small producers. The consequences are cutbacks of produced food, rising prices, uneven production of

products in the region, reducing employment, growth of threats to food security (Aidis and Adachi, 2007; Broadman, 2000; Karakaya and Parayitam, 2013; Kemp and Lutz, 2006; Kudová and Chládková, 2008; Mukoyama and Popov, 2013).

Existing traditional valuation techniques of the industry monopolizing can be reduced to estimation of the market share of each company allowing to make only indirect conclusions without providing integrated assessment of the monopolized industry. The method of estimation of the degree of industry monopolization presented in this study provides a cumulative assessment and a comparative analysis of both the dynamics and the geographic and industrial aspects.

This work is organized as following. Section 1 provides an overview of the existing methodologies for assessing the competitiveness of the industry. Section 2 describes a method based on the theory of fuzzy sets and correlation analysis. Section 3 presents the conclusions and recommendations.

Materials and Methods

The notion of level of industry monopolization is the most closely associated with the concept of competitiveness of firms in the industry. According to the classical definition, there are several levels of monopolization: Pure monopoly, oligopoly, monopolistic competition, perfect competition (Bińczak, 1992; Mitton, 2008).

The most common valuation methodology of industry monopolization is the Herfindahl-Hirschman Index (Al-Muharrami et al., 2006; Djolov, 2013). It is calculated as the sum of squares of the share of the products of all firms in the industry. If pure monopoly in an industry, the index is equal to 100% and if 100 are equal, then 1%, therefore, the values lie in the range (0, 100%) (Matsumoto et al., 2012). In the U.S. highly monopolized is considered the industry in which Herfindahl-Hirschman index is over 18%.

Agriculture is one of the traditional industries of any state. The result of the activity is a natural product that, unlike services and information, allows selecting manufacturers of identical products and comparing them (Lijesen, 2004). Services and information are the most unique and they are comparable to each other only conditionally.

Competitiveness is a producer position on the market as a whole, the assessment of its market share. On highly monopolized markets the gap volume of production is very high, which is a signal of high risk industries for food security, as the production of a form of food production is made dependent on the success of one manufacturer (Niu et al., 2012).

Methods of assessing the level of industry monopolization based on fuzzy set theory consist of the following steps. Let's introduce the linguistic variables corresponding to the main areas of agricultural activity which are a priority in the Russian Federation with the

position of food security and reflecting the competitiveness of each company in the industry:

- "Leader in cereals cultivation (including maize)" (L_1)
- "Leader in field of sugar beet" (L_2)
- "Leader in potato cultivation" (L_3)
- "Leader in rapeseed cultivation" (L_4)
- "Leader in field of milk production" (L_5)
- "Leader in cattle meat production" (L_6)
- "Leader in pig meat production" (L_7)
- "Leader in poultry meat production" (L_8)
- "Leader in eggs production" (L_9)

Leaders in a particular field can be called those enterprises, whose production constitutes not less than a certain percentage (p, %) of the maximum volume of production in the industry, that is closer to the leader, or they are. Membership function for each manufacturer will have the form:

$$\mu\left(L_\gamma\left(x_{i\gamma}\right)\right) = \begin{cases} \dfrac{1}{p*x_{\gamma\max}} * x_{i\gamma}, & if \ x_{i\gamma} < p*x_{\gamma\max}; \\ 1, & if \ x_{i\gamma} >> p*x_{\gamma\max} \end{cases}$$

Where:

$\mu(L_\gamma(x_i))$ = The value of the membership function of γ-th linguistic variable for the i-th enterprise, γ type of product, $\gamma \in [1; 9]$

$x_{i\gamma}$ = The level of output of γ type product of i-th enterprise

$x_{\gamma\max}$ = The maximum output of γ type production in the region

p = The percentage of the maximum level of output, from which the company can be considered as one of the leaders in an industry

Membership function can take values from zero to one, with equality of unity means that the firm is clearly a leader in the industry and the proximity to zero indicates the position of an outsider. We calculated what percentage of leaders (l, %) will be in the industry for different levels of per cent p for 2011 and 2012. The results of the calculations are shown in Table 1 and 2.

For models of perfect competition and some types of oligopolies, it is characteristic that firms produce about an equal volume of goods (Greenhut et al., 1995). With increasing output gap there increases the degree of monopolization of the industry too. We can display a pattern: The more dramatic gap between the percentage of the maximum output in the industry and the percentage of leaders in the industry, the more monopolized market is. i.e., in sectors close to the structure of perfect competition, a gradual increase in p percent will lead to a gradual reduction in the number of leaders in the industry.

Table 1. Percentage of leaders-producers of the Republic of Tatarstan in the agricultural sector by product category (l, %), 2011

Percentage of the largest output	Total in the republic	Cereals	Sugar beet	Potatoes	Rape	Milk	Cattle meat	Pork meat	Poultry	Eggs
0.01	100%	100%	100%	100%	100%	100%	100%	97%	75%	78%
0.1	100%	100%	100%	100%	97%	100%	99%	80%	56%	78%
1	97%	96%	94%	85%	53%	97%	95%	39%	25%	56%
2	92%	86%	85%	70%	21%	94%	90%	25%	25%	44%
5	77%	54%	68%	61%	8%	77%	71%	13%	19%	44%
10	57%	30%	57%	40%	6%	52%	50%	6%	19%	22%
15	42%	20%	53%	26%	3%	36%	36%	5%	19%	22%
20	34%	16%	40%	23%	1%	28%	27%	4%	19%	22%
25	27%	12%	30%	20%	1%	22%	18%	4%	13%	11%
30	22%	10%	28%	17%	1%	15%	12%	4%	6%	11%
40	16%	6%	21%	14%	1%	10%	7%	3%	6%	11%
50	13%	4%	19%	9%	1%	8%	5%	3%	6%	11%
60	9%	2%	15%	5%	1%	5%	4%	3%	6%	11%
70	6%	1%	9%	3%	1%	3%	3%	3%	6%	11%
80	5%	1%	6%	3%	1%	2%	1%	3%	6%	11%
90	4%	1%	2%	2%	1%	1%	1%	3%	6%	11%
100	2%	0%	2%	2%	1%	0%	0%	1%	6%	11%

Table 2. Percentage of leaders-producers of the Republic of Tatarstan in the agricultural sector by product category (l, %), 2012

Percentage of the largest output	Total in the republic	Cereals	Sugar beet	Potatoes	Rape	Milk	Cattle meat	Pork meat	Poultry	Eggs
0.01	99%	100%	100%	100%	100%	100%	99%	98%	83%	90%
0.1	98%	99%	100%	99%	99%	98%	98%	76%	67%	80%
1	91%	87%	96%	83%	49%	70%	85%	35%	39%	60%
2	78%	72%	87%	63%	31%	47%	71%	22%	17%	50%
5	52%	42%	79%	44%	11%	18%	41%	12%	17%	50%
10	30%	22%	68%	30%	7%	6%	19%	6%	17%	40%
15	20%	15%	60%	17%	5%	1%	9%	6%	17%	20%
20	17%	11%	53%	12%	3%	1%	6%	6%	17%	20%
25	13%	8%	43%	11%	3%	0%	5%	5%	11%	10%
30	10%	6%	38%	9%	2%	0%	2%	4%	6%	10%
40	8%	4%	34%	5%	2%	0%	1%	3%	6%	10%
50	6%	3%	28%	4%	1%	0%	0%	3%	6%	10%
60	5%	1%	23%	1%	1%	0%	0%	3%	6%	10%
70	4%	1%	13%	1%	1%	0%	0%	3%	6%	10%
80	2%	1%	4%	1%	1%	0%	0%	1%	6%	10%
90	2%	0%	2%	1%	1%	0%	0%	1%	6%	10%
100	2%	0%	2%	1%	1%	0%	0%	1%	6%	10%

Table 3. Correlation coefficients for the different types of market structures

Market structure	Linear correlation coefficient
Uniform distribution	-0.9999
Normal distribution	-0.9684
40% large producers	-0.8865
95% large producers	-0.8469
90% large producers	-0.8387
60% large producers	-0.8373
99% large producers	-0.8333
80% large producers	-0.8200
50% large producers	-0.8161
30% large producers	-0.7987
70% large producers	-0.7956
20% large producers	-0.7190
10% large producers	-0.6226
5% large producers	-0.3652
1% large producers	-0.1500

Low p level is a low "plank" in order to be considered a leader in the industry. But the current situation shows the number of leaders in the industry for more than one or two companies is available at very low values of p and for certain sectors it is 15-20%.

In this work, there were held simulations of different market situations. There were specified the following initial parameters: The market of similar goods where act 1000 enterprises. Production volumes of each company were specified by generation of random numbers. Uniform distribution [0, 1] describes the market situation when the probability of producing maximum output is the same for all firms in the industry. The normal distribution N~(0; 1) is the situation when the number of firms producing the basic medium volume of production for the market, the minimum and maximum volume is produced by a small part of firms.

Table 4. Correlation coefficients between the percentage of leaders in the industry and the percentage of the maximum output in the industry

	Total	Cereals	Sugar beet	Potatoes	Rape	Milk	Cattle meat	Pork meat	Poultry	Eggs
2011	-0.86	-0.76	-0.89	-0.81	-0.54	-0.84	-0.83	-0.55	-0.64	-0.70
2012	-0.76	-0.72	-0.95	-0.74	-0.57	-0.60	-0.69	-0.55	-0.60	-0.73

Table 5. Values of the Herfindahl-Hirschman Index (%)

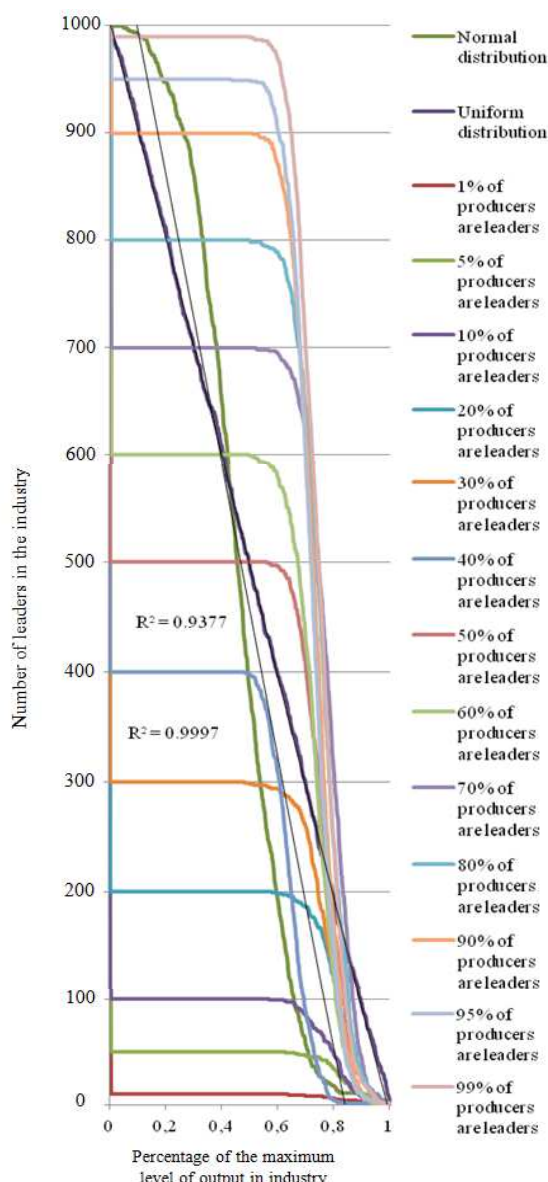|	Cereals	Sugar beet	Potatoes	Rape	Milk	Cattle meat	Pork meat	Poultry	Eggs
2011	0.8	4.7	3.3	12.3	0.6	0.6	11.3	46.9	53.6
2012	0.8	3.9	4.4	8.7	1.2	0.7	11.9	45.9	44.3

Fig. 1. Dependence of the number of leaders in the industry on p, % under different market structures

The normal distribution of output is the closest to the practical implementation of the model of perfect competition in the industry, the uniform distribution is an idealized model.

For simulations of situations close to the state of monopoly, there were carried the partition of complex of firms into two subgroups: With large and small output. Output of large firms is randomly generated with the characteristics of a normal distribution $N\sim(1000; 100)$, for small firms with characteristics $N\sim(0; 1)$ Simulations were performed for different proportions of the number of large and small firms in the industry. The simulation results are presented in Fig. 1.

The results show that at the idealized uniform distribution of output, dependence between the amount of leaders l in the industry and the percentage of the maximum level of production p is linear. With the increasing disparities in the industry in the number of large and small firms, the curves become increasingly non-linear. It can be concluded that for industries of perfect competition, the dependence between the parameters p and l is linear and the linear correlation coefficient is close to minus one, as the dependence is inverse and very close. On monopolistic markets the dependence of percent of leaders and the percent of maximum output will be of a nonlinear character and therefore, the correlation coefficient will tend to zero with increasing unevenness in output. With the results of modeling, linear correlation coefficients were calculated and shown in Table 3.

Table 3 shows that the more homogeneous volume of output of firms in the industry, the linear correlation coefficient is closer to -1. With the approach of market structure to the model of a pure monopoly, when in the industry there is one or more of the monopolists, the correlation coefficient tends to zero. When oligopoly, the correlation coefficients modulo are less than 0.7, with values modulo greater than 0.8 it can be assumed that the market structure is close to the competition (50% of manufacturers produce comparable amounts of products and can compete with each other).

Results

According to the research, we can conclude that in the Republic of Tatarstan on the main types of agricultural production, the structure of the industry is the following: There are 1-2 major manufacturers, more than 80% of agricultural produce insignificant volume of all products, the market of basic food commodities is

significantly monopolized. Food security depends on the success of activity of less than 2% of producers, which is a significant risk for the republic as a whole. It is necessary to support small and medium farmers to stimulate competition and growth in output.

We analyze the degree of monopolization of agriculture sub-sectors in the Republic of Tatarstan in 2011-2012. The analysis of correlation coefficients is shown in Table 4.

The analysis shows that most monopolized production is rape, pig meat and poultry as indicators of linear correlation modulo in these markets are minimal (less than 0.7). The most uniform distribution of production volumes is in the production of sugar beet. The sharp monopolization of the market in 2012 compared to 2011 is observed in the production of beef, where the correlation coefficient modulo decreased by 14 points and milk by 24 points, which serves a signal of the process of monopolization of the production and increase the risk to food security in the region. The state of other types of production did not change significantly. In the whole, in the region there is an increase of risk of uneven distribution of production between producers, which leads the region food security depending on the success of financial and economic activities of a few major producers.

Discussion

To analyze the effectiveness of the methodology there are compared the obtained results with calculations of the Herfindahl-Hirschman Index, listed in Table 5.

The analysis of the values of Herfindahl-Hirschman Index for agricultural industries as a whole confirms the results obtained by the presented methods. The most monopolized industries are eggs, poultry, pork and rape. The analysis also fully confirms the identified trends of the monopolization degree of industries.

An important advantage of our proposed method of calculating the level of monopolization of the industry is an opportunity to assess the level of monopolization of agriculture in general, as the number of leaders for each type of products can be summed up, opposed to the actual values used in calculating the index Herfindahl-Hirschman. This makes it possible to evaluate the agricultural sector in the region as a whole.

So the whole republic is observed to have the monopolizing rise of agriculture, which should be taken into account in the formation of public policy. Further government policies should be aimed at the diversification of this risk by encouraging small and medium forms of farmers.

Conclusion

The work presents a method of determining the degree of monopolization of sectors of economy. The

individual assessment of the competitiveness of each company in the industry leads to assess the degree of monopolization and competitiveness of the industry as a whole. The analysis is based on the calculation of correlation coefficients between the percentage received to the calculation of the maximum output in the industry and a number of leaders in the industry at this level of per cent. The simulation showed that the market structure of the industry is close to perfect competition, the correlation coefficient will tend to minus one, with the approach of the market structure to the model of a pure monopoly coefficient tends to zero.

The presented in this study method of calculating the level of monopolization industry is a new, modern instrument that allows to evaluate the monopolization not only of the production of certain goods, but also to obtain an integral estimate simultaneously in several sub-sectors, industries, regions and the country as a whole.

This technique can be an effective instrument of a cluster analysis with any quantitative and qualitative composition of the cluster as in (Safiullin *et al*., 2013).

The analysis technique is tested on an example of the agriculture sector of the Republic of Tatarstan, Russia for 2011-2012. The general situation is that in the Republic of Tatarstan there are 1-2 major producers that account for over 80% of its production. Practically all agricultural enterprises produce insignificant volume of food on a regional scale. This situation confirms the low competitiveness of agricultural enterprises and thus the heterogeneity of state support. The state support has a goal to support major producers, in order to reach the output of major products required for the region (Grigoreva and Fesina, 2014). This orientation of state policy increases food security in the region. However, in the long term, this policy has a significant disadvantage: There are prerequisites of monopolizing the industry, there reduced incentives of major producers to improve the competitiveness of their products in the global market, there created barriers to entry for small and beginning farmers (Aidis and Adachi, 2007; Broadman, 2000; Karakaya and Parayitam, 2013; Kemp and Lutz, 2006; Kudová and Chládková, 2008; Mukoyama and Popov, 2013). In this regard, the main directions of state support should be to create conditions for the exchange of information and the creation of links between producers, intermediaries and sales organizations. It is important to have the uniformity of state support for the region, in order to stimulate the production of uniform throughout the Republic.

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Author's Contributions

Svetlana Fanilevna Khasanova: Participated in the data-analysis and in its interpretation. Also she made contribution in reviewing manuscript critically for significant intellectual content.

Aigyl Ilshatovna Fazullina: Organized the conception of research, collected the data and made contribution in data interpretation. Also she made the draft of the article.

Ethics

The authors wish to state that this article conforms to the ethical standards specified by the American Journal of Agricultural and Biological Sciences.

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