Agricultural machinery market development for ensuring food security

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Abstract. Nowadays, the agricultural sector development directly affects the number of people employed in the economy, the development of rural infrastructure and living standards in rural areas, the country's food security, public health, the state of other sectors of the economy, inflation and much more. One of the main conditions for ensuring food security of the country in case of problems in the livestock industry and feed production is the optimal complex of units with maximum efficiency of use and energy conservation. The research is dedicated to the construction of the perception map of agricultural machinery manufacturers in the Nizhny Novgorod region based on the analysis of non-price competition parameters and proposals for the development of this market. Feasibility and affordability of domestically produced agricultural machinery should be a priority national project. The research identified the two main factors that ensure a competitive position in the market of manufacturers: Quality and product safety and Social responsibility. The influence of factors helps to determine the competitive status and promising areas for the development of agricultural machinery market. The conducted research is based on data of compound feed equipment.

1. Introduction

In modern economic conditions, the active development of the agricultural machinery market and the successful operation of the machine and tractor fleet are the most important means of ensuring the effective functioning of each agricultural producer. The market formation and the effective management tools use are decisive directions for increasing the efficiency of agricultural production, which confirms the relevance of research.

The effectiveness of any agricultural organization functioning usually based on the systematic approach, since all production processes are interconnected, what means that the principle of system is at the core. Some factors affect directly, others indirectly. One of the main aspects in the financial and economic analysis of the organization is the analysis of factors influence to the studied quantities, because there is a direct dependence of the effective indicator to a significant number of factors. Therefore, studies of how factors influence the value are the key to a perfect analysis and assessment of organization’s performance indicators.

Issues of ensuring food security at the regional level are considered in the works of Agaev B.V. [1], Borisov V.A. [5], Granberg A. G. [8], Savenko V. G.[12], Katusov D.N. [10], Shapovalova V.N. [19].
The theoretical and methodological aspects of this research area are presented in the scientific works of Agapova T.N. [2], Dvoryankov V. A. [9], Svetlakova A. G. [13], Serova E. V. [15], and Semenov M.Yu. [14]. The study of market development characteristics in their works involved Goncharov V.D. [7], Burtseva T.A. [6], Fokina O.V. and Fufacheva L.A. [20], Redreev G.V. [11] and other authors. The structure and mechanisms of agricultural machinery market functioning are considered by Sysuev V.A., Aleshkin A.V., Savinykh P.A. [21, 22].

The current situation analysis showed the considerable uncertainty in the functioning of agricultural commodity producers, taking into account the development of the agri-food market. Thus, there is a need for in-depth study of this problem in the agricultural organizations.

The agricultural machinery market is difficult for perception. It has the following features: seasonality of use, a complex scheme of technological operations, a wide variety of machines and mechanisms. One of the drawbacks is that these factors are not considered in the complex. The development plan and its prospects are reflected in the State program ‘Development of agriculture and regulation of agricultural products, raw materials and food markets for 2013-2020’.

Both for the machinery market development in agricultural production, and for ensuring food security, it is necessary to take into account the economic condition of the agro-industrial complex, as well as the perception of non-price competition factors for the rational provision of agricultural consumers with appliances. These need to analyze from side of the influence of various factors on production. The research conducted based on equipment for post-harvest grain processing.

2. Methods

In target to achieve the research goal, the following tasks need to lunch:
1. To identify the main features of the development of the agricultural machinery market, for example, the Nizhny Novgorod region, as well as the main factors in the functioning of agricultural business structures.
2. To develop methodological recommendations and solutions for constructing a perception map of the agricultural machinery market, including to the assessment a non-price competition parameters.
3. To analyze the results of the study.
4. Based on the analysis of the data obtained, conclude the results and suggestions.

The main part of agricultural engineering in the Nizhny Novgorod region is represented by 9 manufacturing plants: Melinvest OJSC, MKI-Rila LLC, AgroPromeks LLC (grain drying equipment), Dosa Agro LLC (feed preparation equipment), RPA Mekhinstrument LLC, Business Osnova LLC (DEUTZ-FAHR and Mahindra tractors), Utek LLC (seeders), Tesa LLC (harrows), Tekhmashstroy-NN LLC (grain flateners, deep-rippers). We also consider the products of the four largest companies - John Deere - 18%, Case New-Holland - 11%, AGCO - 7% and Claas 4%) [15].

One of the research objects was the ‘ideal point’ - an indicator that meets the requirements of consumers as much as possible and has the highest ratings. This object combines the totality of all indicators and characteristics that are characteristic of an ‘ideal producer’. Putting such a point on the map will help to determine the preferences of consumers and the gap between real market participants.

In order to assess the perception of non-price competition of manufacturers of agricultural machinery and assemblies on the market of the Nizhny Novgorod region, we develop a methodology for constructing a perception map for the 19 most competitive organizations using the factor analysis procedure:

1. Developing of the questionnaire for determining the main factors ensuring the competitive position of products. It based on the hypothesis that domestic agricultural machines compete on a par with imported equipment using the multidimensional scaling method [22]. The sample size is determined by the formula 1:

\[ n = \frac{(z^2*p*q)}{e^2} = \frac{(1.652*50*50)}{52} = 272 \text{ people} \]  

(1)
2. An expert assessment of leaders and industry experts on a 100-point scale of the main components of non-price competition of manufacturing plants made up the basic data.

3. Based on the factor analysis procedure, we determine the number of axes of the perception map (axes of the perception space) and values of the variables, what helps to name the axes. Since the inflection point is clearly visible on the graph (Figure 1), the optimal number of factors in our example is 2.

![Scree Plot of C2; ...; C17](image)

**Figure 1.** The Scree plot.

4. The perception map of the agricultural machinery market of the Nizhny Novgorod region will be built on two axes (Table 1).

| #   | Main components of non-price competition                                                                 | Axis 1: "Quality and product safety" | Axis 2: "Social responsibility" |
|-----|-----------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------------------|
| X1  | Organizational and commercial conditions of the enterprise                                                | 0.965                               | 0.987                           |
| X2  | Technology for storage and processing of agricultural products                                            | **0.983**                           | -0.019                          |
| X3  | Financial and economic sustainability of the organization                                                | 0.569                               | 0.964                           |
| X4  | Taste requirements for agricultural products                                                               | **0.987**                           | -0.011                          |
| X5  | Product safety                                                                                           | **0.983**                           | 0.010                           |
| X6  | Value for money                                                                                          | **0.979**                           | -0.144                          |
| X7  | Quality of machines                                                                                       | **0.959**                           | 0.381                           |
| X8  | Lower production costs                                                                                   | **0.982**                           | 0.156                           |
| X9  | Implementation of resource-saving innovative technologies at the enterprise                              | -0.058                              | **0.963**                       |
| X10 | Law obedience                                                                                           | 0.369                               | -0.898                          |
| X11 | Sponsorship and patronage, partnership in business                                                        | 0.459                               | 0.341                           |
| X12 | Promo-events to increase product competitiveness                                                         | **0.985**                           | 0.429                           |
| X13 | Enterprise Image                                                                                        | 0.236                               | **0.963**                       |
| X14 | Code of Ethics                                                                                           | 0.136                               | **0.947**                       |
| X15 | Development of labor potential of workers                                                                 | 0.147                               | 0.389                           |
3. Results
For factor 1, we determine that a relatively high correlation value is observed between the variables \( X_2, X_3, X_4, X_5, X_8, \) and \( X_{12} \). This combination of parameters reflects the requirements for consumers, which characterize the quality of the feed and its availability. Therefore this factor (axis 1) will be called “Quality and product safety”.

Factor 2 showed high correlation values for the \( X_1, X_3, X_9, X_{10}, X_{13}, X_{14}, \) and \( X_{16} \). These parameters demonstrate the food safety requirements as the priority areas. Therefore this factor can be called “Social Responsibility”.

4. Interpretation of the perception map results
The points’ location and the relative distance between them, as well as the position relative to the ‘ideal manufacturer’ are reflected on the Score plot (Figure 2). The magnitude of the distance characterizes the relative degree of competition and shows at a remote location competitive advantages and potential opportunities for market development.

5. Discussion
The leaders in the market of agricultural machinery manufacturers regarding of product quality and social responsibility of business are foreign manufacturers. However, among domestic enterprises, AgroPromeks LLC and Dosa Agro LLC demonstrate a high level of product quality and safety.

Map helped to understand the spatial perception of non-price competition factors by agricultural producers of the Nizhny Novgorod region. As a result, authors assessed the competitive status of market players and suggested the direction that may improve the market position.
In order to develop the market for domestic agricultural machinery production and implement factors that ensure a competitive position in the market, authors offered to develop a new compound feed equipment, specifically hammer crushers to improve the quality and organoleptic characteristics of feed.

The device and working process of hammer crushers, viz. a closed-type hammer crusher with forced feed of material, a shock-reflective grain crusher, a hammer crusher with a fan-rotor, were developed for scientific research at the Nizhny Novgorod state engineering-economic university [17, 18, 21].

The rotor and fan are combined in one unit, which reduces the size, metal consumption and cost of the crusher. The fan blades have a curved-linear profile, which leads to intensive route of a finished product to the sieve and thereby reduce overgrinding. Studies on determination of the quality of grain grinding demonstrated that particle size distribution matches to animal consumption (the content of whole grains in the finished product does not exceed 0.5%).

The advantages of these units in relation to factor ‘Quality and safety’:
- reduced time costs,
- compliance with all quality indicators of grain processing,
- increased service life of the units.

The advantages of these units in relation to factor ‘Social Responsibility’:
- improving investment attractiveness,
- increasing labor productivity,
- usability and ease of staff training

6. Conclusion

Authors developed the technique that helps to analyze the agricultural machinery market besides constructing a spatial perception map. In the process of testing the methodology, the most significant parameters of non-price competition in the agricultural machinery market were determined, that helped to suggest the production development strategy for domestic manufacture.

Thus, the development of the domestic agricultural machinery market is one of the directions for ensuring food security. Agro-industrial complex plays the main role in ensuring the country's food security. A special attention need to pay to the issues of food security and product quality in order to maintain a favorable social climate in the country.

The study identified two factors, based on which it is possible to develop modernized types of feed equipment. The proposed technical solution is available for use in personal subsidiary and peasant farms, what is extremely important in the context of the development of the domestic agricultural machinery market. It may ensure the safety of products and improve its quality.

References
[1] Agaev B 2000 Organizational and economic mechanism for ensuring food security (Moscow) p 177
[2] Agapova T 2001 Statistics Issues 2
[3] Altukhov A 2008 Economist 5 pp 33-43
[4] Arashukov V, Romanov E 2001 State and prospects of development of cooperation in the agricultural sector of the economy (Moscow: NIPKTS Voskhod-A LLC) p 220
[5] Borisova V 2006 Sumy: Agrarian Forum pp 72-73
[6] Burtseva T, Khalyavina M 2014 Bulletin of Altai State Agrarian University 12 122 pp 173-178
[7] Goncharov V 2002 Economics of Agricultural Processing Enterprises 2 pp 52-54
[8] Vasilyeva E, Mottaeva A 2019 E3S Web of Conferences 91 08051 doi.org/10.1051/e3sconf/20199108051
[9] Dvoryankov V 2001 Agrarian Russia 4 pp 23-35
[10] Katusov D, Shatov A 2015 Collection of reports ‘Scientific and technological progress in agricultural production’ pp 203-207
[11] Redreev G, Schetinina S 2012 *Bulletin of the Omsk State Agrarian University* **1** pp 71-74
[12] Savenko V 2004 *The role of the consulting service in the formation of the industry system for the development of innovations in the agricultural sector: theory, methodology, practice* (Moscow: Rosinformagrotekh) p 316
[13] Svetlakov A 2005 *Agrarian Bulletin of the Urals* **6** pp 45-50
[14] Mottaeva A, Kalinina N, Kuzmina A, Olenina O, Glashev A 2019 *E3S Web of Conferences* **91** 08072 doi.org/10.1051/e3sconf /20199108072
[15] Serova E et al. 2004 *Prospects for reforming the agrarian policy of Russia Society and Economics* **7-8** pp 254-303
[16] Snimschikova I, Semenenko K 2014 *Poli-Mathematical Network* **101** pp 1-12
[17] Savinov P, Saitov V, Turubanov N, Bulatov S, Romaniuk V, Mironov K, Nechaev V *Patent of the Russian Federation No. 2558248, IPC B 02 C 9/02 No. 2014109792/13 Bull. 21 p 6* (Nizhny Novgorod State Electron Research Institute)
[18] Savinykh P, Nechaev V, Bulatov S, Turubanov N 2013 *Patent of the Russian Federation No. 129843 No. 2013100678/13 Bull.19 p 3* (State Scientific Institution Zonal Research Institute of Agriculture of the North-East named after N.V. Rudnitsky Russian Academy of Agricultural Sciences)
[19] Shapovalova V 2016 *The role of the doctrine of food security in ensuring food security of the Russian Federation. The crisis of the economic system as a factor in the instability of modern society* pp 77-82
[20] Fokina O, Fufacheva L, Shchinova R, Agalakova O, Tetenkina O 2016 *International Review of Management and Marketing* **5** 6 pp 111-117
[21] Savinyh P, Nechaev V, Nechaeva M, Ivanovs S 2016 *Engineering for Rural Development* pp 1072-1076
[22] Sysuev V, Savinyh P, Aleshkin A, Ivanovs S 2016 *Engineering for Rural Development, Proceedings* **15** pp 1065-1071
[23] Nechaeva M, Nechaev V, Iljicheva O, Kozlova L, Kurilova A 2019 *International Journal of Advanced Biotechnology and Research* **1** 10 pp 363-371
[24] Nechaev V, Nechaeva M 2018 *The market of agricultural machinery: methodological aspects of analysis and development* pp 126-131