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Impact of Digitalisation on Corporate Finance in the Agro-Industrial Complex

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The presented model allows us to forecast with a sufficient degree of confidence (deviation not exceeding 10%) a probable value of the digitalisation index of dairy cattle breeding for 10 prospective economic entities of the Novosibirsk Region (Table 7). Consequently, the organisations which plan 'chipping' of their dairy herd may consider the digitalisation index of dairy cattle breeding a reasonable reflection of an attractive business format for them.

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Abstract

The purpose of our paper is to examine the interrelation between digitalisation indicators of dairy industry government regulation and economic efficiency, using large corporations of Novosibirsk Region as an example. We propose to identify an integrated system approach to evaluating the influence of state programs related to digitalisation of the dairy industry on industry performance.

A system-wide transition to digital technology in the infrastructure of dairy industry regulation is nearly totally absent from academic research. The existing literature considers the influence of state programs and policies on the industry and proposes various performance indicators. However, it is uncertain how industry digitalisation may affect these performance indicators.

To address this gap in the literature, we propose a hypothesis of dependency between digitalisation indicators and performance indicators of dairy corporations. The basis of the methodology is the calculation of a digitalisation index used to assess the efficiency of government support of the industry corporations. In order to substantiate the hypothesis, we apply a correlation and regression analysis and established interrelations between the offered criteria (digitalisation index and share) and operating performance of dairy industry economic entities.

Our results indicate general consistent patterns and interrelations between digitalisation of state regulatory programs and the performance of dairy industry corporations. Our statistical analysis reveals digital technology as a tool of government has a significant impact on business performance. The offered digitalisation criteria and patterns of performance efficiency are indicative of the possibility to manage the digitalisation process based upon preset parameters of business performance.

Our research will be of interest to specialists developing state programs and policies applying digital technology, directors of dairy companies, and scientists who conduct research in related fields, who may use our approach for evaluating and forecasting performance in the dairy industry, accounting for the impact of government regulation.

Keywords: financial stability, dairy industry, government regulation, digitalisation, correlation and regression analysis, forecasting

Introduction

Recent decades have been characterised by a global trend towards increased interest in food security and the government's role in providing such security. On the basis of a review of literature in the area, we identified the following important aspects of the authors' research: the influence of factors on food security via the interrelation between armed violence and food supply chain [1]; via evaluation of influence of extractive industries [2]; via assessment of quality of government regulation and government efficiency [3]; via influence of government regulation on development of dairy industry [4], and the influence of food security itself on key indicators of national security such as public health care [5].

One of the key spheres of food security is supplying food to public including dairy products [6]. Dairy products, as a nutritious source of protein, fat, micronutrient elements, prebiotics and probiotics, make a substantial contribution to food security and human health [7]. So, the primary objective of any government is the provision of sustainable development and proper functioning of companies engaged in this industry. In spite of the fact that the dairy industry exists in every state, its state and development level differ significantly from country to country. Developed economy countries such as European countries, USA, India, China, New Zealand, Australia are the leaders in this sphere. The main milk producer among them is the USA which accounts for 25% of the total output [8]. In this market segment Russia is 6th, and its share in the total milk output is approximately 8%. The state and further development of dairy subcomplex are subject to a significant government influence. Analysis of the scientometric database of the Russian Index of Science Citation (RISC) showed lack of attention to issues of dairy industry government regulation (less than 3%) and digitalisation in particular (0.15%). Analysis of the scientometric database WoS yields similar results. It also gives little, although more than RISC, attention to issues of dairy industry regulation (a little over 5%) and digitalisation in particular (0.2%) while dairy subcomplex regulation under conditions of digitalisation is described in just four papers. Exponential growth of interest to publications dedicated to dairy subcomplex regulation against the background of digitalisation was revealed.

Heavy demands are placed on the system of government regulation, and one of them is its efficiency. In the scientific literature, a lot of research is related to evaluation of state programs and policies [8–11]. However, the interrelation between government influence and efficiency of industry development under the circumstances of digitalisation has been insufficiently studied [12].

In our opinion, there is no doubt that study of influence of the state digitalisation policy on the state and development of dairy corporations is of academic interest. In our research we tried to generalise the accumulated experience and offer a common approach to evaluation of digitalisation influence on performance of dairy corporations.

We presume that results of our research and the ones similar to it will be interesting to specialists developing state programs and policies applying digital technology, directors of dairy companies, and scientists who conduct research in this and related fields.

Literature Review

Assessment of the State of the Dairy Industry

Dairy industry development trends in Russia are dubious. So, in the past few decades milk production in Russia has showed a downward trend, while its efficiency has grown (Table 1).

Table 1. Main performance indicators of agricultural organisations for 2000–2018 (according to Rosstat)

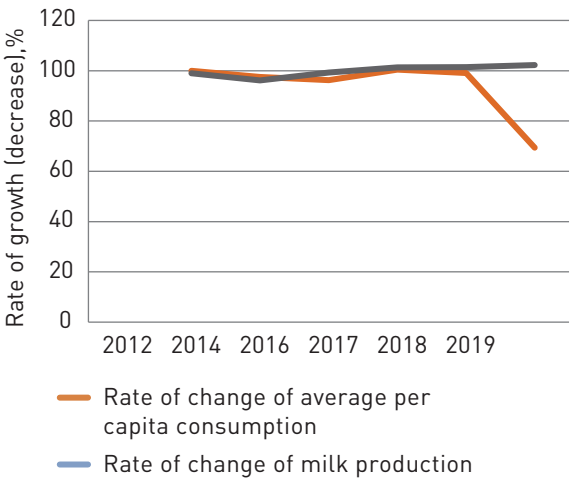
Indicator	Year					
	2000	2014	2015	2016	2017	2018
Number of cattle, million heads	16.5	8.5	8.4	8.4	8.3	8.1
Number of cows	6.5	3.4	3.4	3.4	3.3	3.3
Raw milk production, millions of tons	–	30	29.9	39.8	30.2	30.6
Milk production (except raw milk), thousands of tons	–	–	–	5430	5301	5382
Butter and butter pastes, thousands of tons	–	–	–	251	270	267
Cheese, thousands of tons	–	–	–	450	454	467
Condensed milk products, millions of conventional tins	–	–	–	842	837	806
Milk products for infant food, thousands of tons	–	–	–	229	285	313

Indicator	Year					
	2000	2014	2015	2016	2017	2018
Consumption of concentrated feed per 1 liter milk	0.31	39	0.4	0.4	0.4	0.41
Milk output per 1 cow, kg	2502	4021	4134	4218	4368	4492
Milk sales, millions of tons	16.1	19.4	19.8	20.3	21	21.5
Milk vendibility (share of sales of production)	81.6	93.7	94.2	94.5	94.7	94.8
Number of agricultural organizations, total, thousand, including:	27.7	5.9	5.2	5	5.2	5.2
Number of profit-making organisations, thousands	13.7	4.3	4	3.9	4	3.8
Share of profit-making organizations, %	49.3	73.6	77	77.7	75.6	73.8
Product profitability in cattle breeding, %	1.4	18.3	15.4	9.8	12	12.8
Profitability of milk and milk products, excluding budget subsidies, %	–	23.7	19.5	18.5	25	14.5
Profitability of milk and milk products including budget subsidies, %	–	33.3	26.6	28.2	32.3	23.9

A decrease in raw milk production of more than 40% is caused by cow livestock reduction in agriculture. Reduction in the size of dairy herds resulted in a decrease of cattle stock and, consequently, the decline of production in the meat industry. Research conducted by Russian scientists discovered a trend of outstripping rate of cattle head count decline in comparison to milk yield per head of livestock which they correctly transpose to all Russian regions [13]. Within the reviewed period milk output per cow increased by 1.8 while the cattle stock decreased more than twice. What is conspicuous, is the dramatic reduction in the number of agricultural organisations, from 28,000 in 2000 to 5,000 in 2018, but still the share of revenue-earning enterprises grows. The industry state may be evaluated as unstable. Some indicators (for example, milk and dairy products output, product profitability) show an ambiguous trend: growth periods are followed by declines and vice versa. According to Table 1, due to budget subsidies the product profitability is higher on average by 7–8%. Self-production of milk increases but at the same time the structure of agricultural production changes by way of decrease of the milk share.

The dairy industry in Russia, as well as in other countries, is susceptible to government regulation. But along with this, the problems the government solves are different. So, in China and Brazil intensive growth of milk production is encouraged by price control and capital indemnification, in EU, USA and Canada restraint policy is implemented to solve the problem of milk excessive production, and independent quality inspection is applied at all stages of the production process. In Russia, milk producers' subsidising policy is carried out at the federal and regional levels in the form of concessional lending offered by PJSC SberBank and PJSC Russian Agricultural Bank, compensatory and stimulating subsidising (subsidies for development of genetic and pedigree infrastructure, recovery of a part of capital expenditure), and concessional leasing. The current policy of government support of dairy industry implemented in recent years resulted in increase of raw milk output while consumption of dairy products decreased, which is shown in Figure 1 [14].

Figure 1. Dynamics of production of per capita milk consumption in Russia for 2012–2019, %



Government support is based on a corresponding legal framework comprising state programs as well as laws and regulations which regulate the dairy industry. The problem in the system of industry government support

consists in nonconformance of the criteria for programs' efficiency evaluation to the indicators embodied in them. One such indicator is the level of milk and dairy products self-production, which is 84% at present, while the established key indicator amounts to at least 90%. The following key indicators of implementation of the program for development of agriculture and regulation of markets of agricultural products, raw materials and commodities for 2013–2020 were established: growth of livestock products output (in comparable prices) by 20.8%, growth of the index of physical volume of capital investments in agriculture by 36%, rise in profitability of agricultural organisations by at least 10–15% (taking into consideration subsidies). However, the above indicators are not performance indicators and, consequently, they cannot be used as criteria for evaluating the efficiency of state programs.

A. Panyshev and O. Katlishin specified in their paper the problem of assessing the influence of a certain state program on dairy industry development [8]. The approaches to evaluation of government influence on the dairy industry are studied in papers by Russian [12; 15; 16] and foreign authors [17–19]. The search for and substantiation of the optimal way of government regulation of producers and consumers of dairy products are described in the paper by E. Twine [20]. J. Tricarico et al. [11] speak of the possibility of public-private partnership in regulation of the dairy industry. Y. Chen and X. Yu assessed the influence of subsidies on competitiveness of the Chinese dairy industry [18]. The literature review is indicative of the problem of efficiency of state programs aimed at supporting and developing the dairy industry.

On the basis of our review of academic papers [6; 8; 13] in this paper we make an attempt to systemise the problems of low efficiency of state programs regulating corporations in the dairy subcomplex. Unlike the existing research, we idnetify innovative problems which have to be addressed.

The problems of low efficiency of government programs intended to support and develop the dairy industry may be systematised as follows (Figure 2).

Figure 2. Key problems of low efficiency of state programs in the dairy subcomplex

Economic	• insufficient government support; • problems of concessional lending; • a large amount of counterfeit dairy products; • input intensity of the industry; • problems of effective coopertaion of dairy producers and distribution network
Political	• monopolisation by foreign companies of the dairy industry
Technology-related	• low efficiency of use of modern feeds; • outdated technology in milking operation; • high degree of manufacturing equipment wear; • capacity bottleneck.
Investment-related	• low attractiveness of the industry to private investors
Innovative	• an extremely low use of modern technology for collection and processing of data on the state of dairy herd; • insufficient digitalisation of dairy production

Government Regulation of the Industry under the Conditions of Digitalisation

Academic literature has not yet accumulated a sufficient amount of research on dairy industry government regulation against the background of digitalisation. The majority of research is *ad hoc* and non-systemic. Absence of a consistent approach impedes evaluation of influence of government regulation digitalisation on operations of dairy entities and, as a consequence, the assessment of the efficiency of state programs and policies in this economic sector.

So, scientists study various aspects of digitalisation issues: investment-related [21], manufacturing [22], and financial [23]. Digitalisation of corporations is considered as an essential prerequisite for government regulation of the dairy industry [24].

A successful digitalisation of the dairy and other AIC industries depends to a great extent on the level of digital infrastructure built in a country. We presume that nowadays one of the components which characterise efficiency of state programs implemented in the industry should be the level of its digitalisation. The strategy of agricultur-

al-industrial and fisheries industry complex development for the period up to 2030 defines one of six goals – AIC digital transformation. This associates with the national goal to speed up implementation of digital technology in the economy and the social sector. It is assumed that it may be achieved due to implementation of the AIC state program and the national project Digital Economy of the Russian Federation.

Figure 3. Problems hindering digitalisation of the agro-industrial complex

Lack of financial resources to implement ICT	• a bipolar economy evolved in the agricultural sector: • one side is represented by highly profitable enterprises with a wide access to high performance technology (most often agroholdings); • the other side is represented by enterprises on the edge of payback which use outdated technology
Shortage of skilled personnel	• In Russia there are half as many IT specialists engaged in agriculture than in the countries with a traditionally highly developed AIC; • The Russian agricultural sector needs approximately 90,000 IT specialists
Absence of digital infrastructure	• underdevelopment of digital infrastructure in rural areas; • digital inequality between town and countryside
Imperfection of legal regulation of ICT development	• the issues of development of the system of government information support in agriculture are governed by art. 17 of Federal Law of December 29, 2006 No. 264-FZ On Agricultural Development which needs improvements and adaptation to the current situation
Consequences of imperfection of legal regulation of ICT development	• a weak policy of agricultural protectionalism; • poor cooperation of milk and dairy product manufacturers; • difficulties in their cooperation with processing companies and distribution networks

Source: compiled by the authors on the basis of [25–28].

Solving the problems (Figure 3) which impede AIC digitalisation, including the dairy industry, is a part of the national goal of an integrated development of rural areas which comprises the necessity to develop (taking into consideration the spatial development of the country) the pattern of AIC industries' and organisations' arrangement and specialisation arrangement on the basis of a multilevel integrated information space applying current digital technology[1].

In order to provide government support to AIC, an Analytical Center is established in the Ministry of Agriculture of the Russian Federation. It builds up a digital technology and a solutions portfolio for AIC, and provides a more efficient informing of farmers on new opportunities, technology, and existing practices. Russian academic literature offers the main areas of improvement of parameters of dairy industry regulation via its digitalisation. A.V. Glotko et. al [29] outlined the methodological framework for dairy industry modeling, applying digital technology, and showed the possibility to define the necessary amount of government financing to achieve the targeted indicators of the dairy industry at any regulation level by means of inverse forecasting. S.E. Terentyev et. al [30] described the implementation of cross-platform technology into manufacturing processes, the building of new business models of enterprises' market interaction on the basis of add-on applications for solving various practical problems as a prerequisite for development of the innovative mechanisms of the dairy industry. E.V. Zakshevskaya et. al offer a series of government regulation measures to overcome the problems structured in Figure 4. However, the possible ways of solving the above problems fail to comprise an important modern area of dairy subcomplex digitalisation which may mitigate and even eliminate the majority of identified problems.

[1] Digital Transformation of Russian agriculture: official publication – M.: Federal State Funded Research Institution Rosinformagrotech, 2019. ISBN978-5-7367-1495-7

Figure 4. Problems of development of the dairy subcomplex and measures of state regulation to overcome them

Development problems	• a weak policy of agricultural protectionism; • poor cooperation of milk and dairy product manufacturers; • difficulties in their cooperation with processing companies and distribution networks; • a long investment cycle; • a low operating efficiency of manufacturing; • no well-established approach to control of livestock breeding, quality of used materials (bull semen, supplement feeds etc.) and manufactured milk
Regulation measures	• restoration of stock breeding in cattle breeding; • investments in construction of drying equipment to even out the seasonal factor; • strengthening of protectionist measures and targeted government support of milk producers; • increase of state control of price volatility in the markets of feed, fuels, electricity and other resource markets; • development of the transport, social and engineering infrastructure in rural areas to attract skilled personnel

Source: [27].

The majority of papers on the regulation of the dairy subcomplex are dedicated to indicators of dairy stock farming as the basic parameters which define its development level. In particular, papers by A. Voitko [31; 32] describe some aspects of dairy stock farming development in Russia using the Stupinsky District of the Moscow Region as an example. He considers the issues of modernisation and enhancement of the industry efficiency by means of providing government regulation of production and sales of agricultural products. Digital technology will provide an opportunity to forecast the necessary extent of government support, its target orientation and eliminate intermediaries which assist in selling it.

Papers by N.I. Strekozov et. al are dedicated to the study of the problems in the dairy sector of AIC. They emphasise that [33] the existing situation in the Russian dairy market raises certain difficulties for using competitive advantages of Russian corporations. It is mainly related to underperformance of government regulation in solving the top-priority problems in this multicommodity system [34]. The existing model of economic relations between all players of the Russian dairy market does not provide an optimal accord of interests of the dairy subcomplex partners. A price imbalance between the agricultural and servicing sectors of the dairy subcomplex caused a conundrum: on the one hand, agricultural corporations find it very difficult to sell their products (milk vendibility for all categories of entities does not exceed 65%), and on the other hand, there is a milk deficiency in the retail market where demand is unsatisfied [28]. The end links of the product promotion chain – an agricultural producer and retail buyer – are either forced to agree to the dictated terms and suffer losses, or reduce their share in the internal food market, which is the main cause for continuing reduction in livestock number and milk and dairy products consumption per capita. In terms of Russian cattle breeding the main impediment in development is low profitability of the industry [35]. Digitalisation of government regulation of price formation processes and product promotion from the producer to the end consumer is necessary in order to solve these problems of the dairy subcomplex. Consequently, we may identify the main aspects which need digitalisation of the dairy subcomplex in the first instance:

Sale of dairy products over the internet, applying electronic commerce systems [36].

Use of cloud technology for cooperation and integration of economic entities in the virtual environment [37].

Evaluation of Corporations Readiness for Digitalisation

Dairy stock farming develops according to the scenario of the industries with rising expenses [38]. Reduction in expenses is possible mainly due to efficient development of innovative technology in the areas of manufacture, management, marketing, and logistics. Improvement of the ways of government support implies an increase of agricultural output with a simultaneous decrease in customer prices, which will make food affordable to the general public.

After analysis of the Russian experience of government regulation of dairy subcomplex digitalisation, we made an attempt to structure the problems of the enterprises of this industry and to offer ways of their solving. The obtained results are systematised in Table 2.

Table 2. Problems of state regulation of digitalisation of the dairy subcomplex and ways to overcome them

Problems	Ways to overcome the problems
Insufficient attention to the issues of government regulation of the dairy industry in scientometric bases	Analysis of results applying digital technology of scientometric bases and statistics
Lack of financial resources to implement ICT Shortage of skilled personnel Absence of digital infrastructure Imperfection of legal regulation of ICT development	Necessity to develop (taking into consideration spatial development of the country) the pattern of AIC industries' and organisations' arrangement and specialisation arrangement on the basis of a multilevel integrated information space applying current digital technology
Insufficient genetic potential of livestock's productive capabilities	Noncontact remote measurements using digital technology
Assessment of personnel qualification, exterior and noncontact measurements	Possibility to apply the comparative analysis, scientific classification, systematisation, theoretical generalisation and statistical methods
Evaluation of the state of a regional dairy market	Possibility to use digital technology as the most important resource of government regulation
Assessment of automation and robot automation of economic entities	Development of digital technology which improves accuracy of data analysis, automation not just for operational staff but for specialists as well
Assessment of the potential of dairy farming and the dairy industry	Development of digital technology aimed at vendibility improvement of the produced milk
Development of economic entities	Development of the mathematical apparatus of digital technology which defines prospective lines of development
Making a regional program for development of all areas of activities	Development of the mathematical apparatus of influence of regulation on dairy subcomplex performance
Formation of state policy and regulation measures	Development of the mathematical apparatus of forecasting the necessary extent of government support
Evaluation of government regulation efficiency	Digitalisation of government regulation of the processes of price formation and product promotion from the manufacturer to the customer
Cost reduction	Development of the mathematical apparatus of cost optimisation
Innovative modernisation	Bank of the best available technology and mechanisms based on simulation modeling

As we see in Table 2, several key aspects of the problems of digitalisation of government regulation in the dairy subcomplex may be defined: information, financial, personnel-related, and selection aspects. Solving of the problems requires application of mathematical tooling and digital technology.

So, according to the academic literature, problems in the digitalisation of the economy are studied in papers by Russian and foreign authors but in spite of the number of these papers some issues have not been covered in full. In particular, the economic science has not developed a consistent approach to study of influence of government regulation on performance of dairy subcomplex enterprises under the conditions of digitalisation.

The performed research is based on the data concerning one of the largest constituent entities of the Russian Federation – the Novosibirsk Region. This constituent entity has been chosen for several reasons. First, the Novosibirsk Region ranks among top 10 regions of the Russian Federation according to the three key indicators: cow population, output and milk sale and consumption per capita. The Novosibirsk Region is the location of a large-scale livestock

industry, and overall, local enterprises manufacture 80% of milk and 83% of meat. Second, in 2018 the Novosibirsk Region was the 18th in the country by dairy cow production and its share in all-Russian milk output amounted to 2.4%. As long as our research is dedicated to dairy industry digitalisation we think it is necessary to confirm that the region chosen for analysis is ready for such transformation. Study of innovative development of the Novosibirsk Region on the basis of the Russian regional innovative index is indicative of moderate incremental dynamics: so, within the period of 2014 – 2019 the Novosibirsk Region went up in the rating from the 41st to the 8th position and became a part of the first group of constituent entities of the Russian Federation which index deviates from the leader's index (Moscow) less than 20%. Besides, it is necessary to emphasise that the region occupies the 3rd position in the quality of innovative policy. Affiliation to the first group, according to the Russian regional innovative index, is all the more important because this constituent entity lacks social and economic conditions for innovative activity (index of 38). On the basis of the results of the National Investment Climate Index, the Novosibirsk Region is steadily in the top 20 and is the 19th for the past two years. As for dynamics and current development of digital life the Novosibirsk Region is in the first of the four groups which is characterised by strengthening leadership with high current indicators and high dynamics, i.e. it develops quicker than the leader (Ekaterinburg) and its digital life index is above the average.

Thus, the chosen constituent entity of the Russian Federation has several characteristics most important for research: a pronounced specialisation of cow population (milk production), a high level of productivity, and a high level of prerequisities for the implementation of digital technology in government regulation of the industry (as well as in the activity of the corporations which form this industry).

Research Methodology

A preliminary analysis revealed the following main fields of high-priority research.

1) Development of criteria for assessment of the digitalisation level of economic entities (organisations, districts, regions) of the dairy subcomplex.
2) Defining possible interrelations between the offered criteria and operating profit of economic entities.
3) Development of the methods of preliminary evaluation of efficiency of the procedure of economic entities' digitalisation depending on the offered evaluation criteria.

In order to study the offered fields of research, we suggested the following hypotheses.

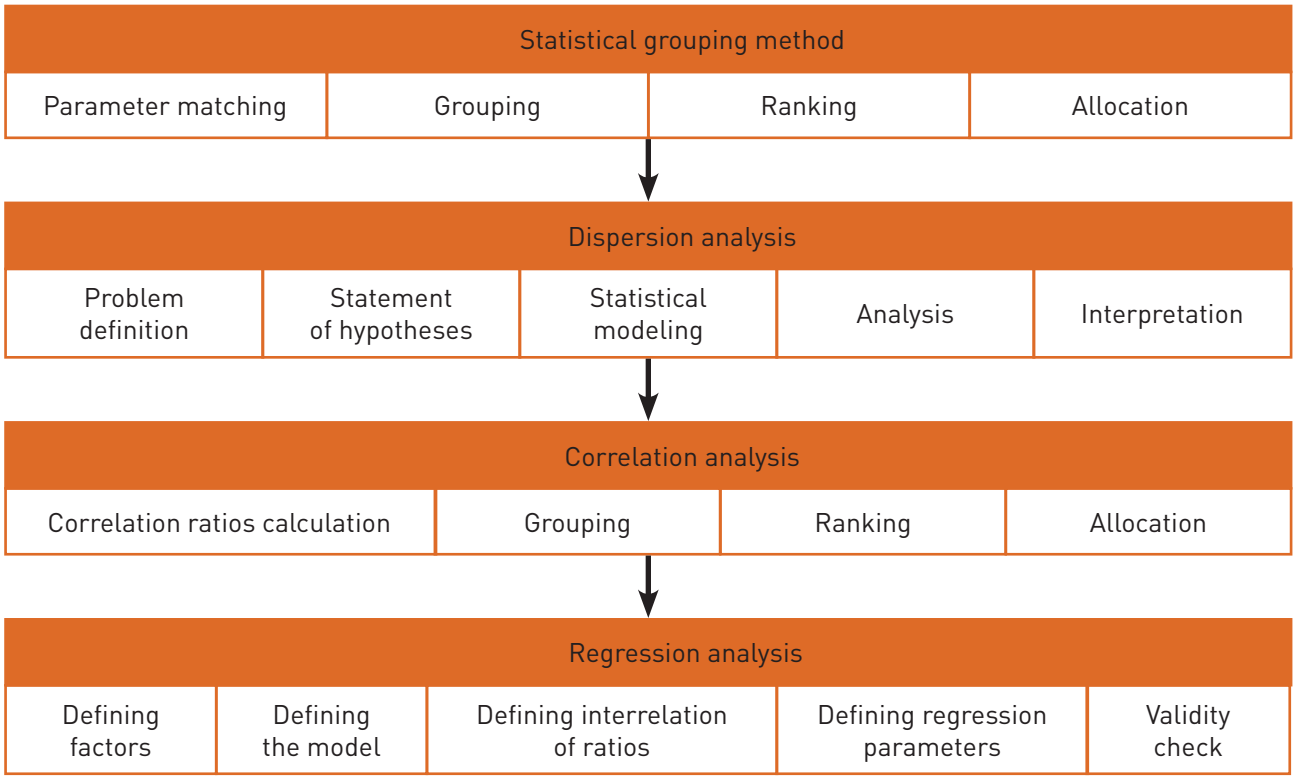
1) As long as the academic community offered various criteria for assessment of the digitalisation level of countries and organisations (Figure 5) development of such criteria is possible for the milk industry as well.

Figure 5. The criteria of digitalisation

BCG (Boston Consulting Group) [39; 40]	• I_1 – subindex Infrastructure development • I_2 – subindex Online expenses • I_3 – subindex User engagement
Country Digitalisation Index (E-Government Development Index) [41]	• I_1 – subindex Web presence of government authorities • I_2 – subindex Telecommunication infrastructure • I_3 – subindex Human capital
Digital Spillover (Free goods of the digital economy) [42]	• I_1 – subindex Speeding up of knowledge transfer • I_2 – subindex Innovation in business • I_3 – subindex Productivity improvement
N.A. Stefanova Evaluation of efficiency of the digital economy [43]	• I_1 – subindex Readiness to networked economy • I_2 – subindex Readiness to electronic commerce • I_3 – subindex Readiness to e-government • I_4 – subindex Readiness to society informatisation
Small and medium business digitalization index (Business Digitization Index, BDI) [44]	• I_1 – subindex Information transfer channels • I_2 – subindex Information storage channels • I_3– subindex Use of Internet for sales • I_4 – subindex Information security • I_5 – subindex Digital training
Business Digitalisation Index (Institute of Statistic Studies and Economics of Knowledge) NRU HSE [45]	• I_1 – subindex Broad Band Internet • I_2 – subindex Cloud services • I_3 – subindex RFID technology • I_4 – subindex ERP systems • I_5 – subindex Electronic sales using special forms on a site/ extranet, EDI systems

Source: developed by the authors on the basis of [39–45].

Figure 6. Statistical analysis algorithm with classification of methods



Source: developed by the authors.

Table 3. Characteristics of precision (precision) animal husbandry in the Maslyaninsky district of the Novosibirsk region, heads

Company	Monitoring of livestock products quality	Electronic database of production process	Identification and monitoring of certain herd individuals	Monitoring of herd health
Sibirskaya Niva LLC	8391	18 699	17 025	17 025
Sibirskiy Pakhar, LLC	423	–	–	–
Head of KFH Gerasimov A.I., Individual entrepreneur	160	–	–	–
Gasimov Ch.R.O., Individual entrepreneur	20	–	–	––

If there exist criteria for evaluation of the digitalisation level of dairy subcomplex economic entities, there may be a functional relationship with performance indicators of economic entities and a possibility to define efficiency of the digitalisation process using them.

We used the data from the sites of Novosibirskstat[2], Ministry of Agriculture of the Novosibirsk Region[3] and related publications as sources of initial information. Statistical analysis was applied as methods of evaluation of the situation in AIC. Its algorithm is presented in Figure 6.

[2] Territorial body of the Federal State Statistics Service for the Novosibirsk Region, Ministry of Agriculture of the Novosibirsk Region. URL: https://novosibstat.gks.ru/

[3] Ministry of Agriculture of the Novosibirsk Region. URL: https://mcx.nso.ru/

On the basis of the results of previous research (Figure 5) we offer to introduce criteria of evaluation of the informatisation level of dairy subcomplex economic entities in order to define their readiness to transformation into the digital economy. We accepted as analogues the last two criteria indicated in Figure 5. Due to a specific character of the industry it is problematic to apply the above indices to all economic entities of the dairy subcomplex because other digitalisation criteria are used (Table 3).

It should be noted that the characteristics listed in Table 3 may be applied in economic entities in their entirety as well as partially and also may differ or concur in number.

Taking into consideration industry characteristics, we attempted to perform an integral evaluation of the level of expansion of digital technology in dairy cattle breeding using the following two parameters: digitalisation share and index. The first indicator characterises the share of an economic entity among all entities participating in digitalisation of dairy herd, while the second one characterises the four indicators of the rate of adaptation to digital transformation by the level of use.

In view of the necessity of defining the influence of the industry corporations' digitalisation established in state programs on corporations' performance, we used the correlation and regression analysis approach.

Research Results

Development of Criteria for Evaluation of the Corporations' Digitalisation Level

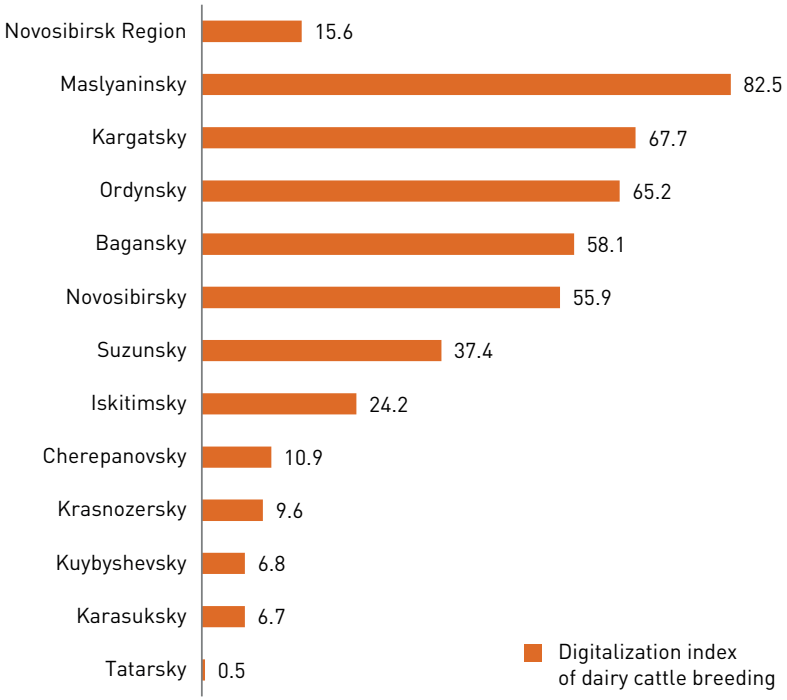
On the basis of the objective stating that it is necessary to develop criteria for evaluation of the digitalisation level of economic entities, conditions and limitations imposed when achieving this can assume hypothetically that there is an interrelation between digitalisation indicators and performance indicators of dairy industry corporations. We applied the correlation and regression analysis to verify this hypothesis (Figure 6).

For integral evaluation of the expansion level of digital technology in dairy cattle breeding we offer to use two parameters: digitalisation share and index of dairy cattle breeding.

Development of the Corporations Digitalisation Index

The first indicator characterises the share of an economic entity among all entities participaring in digitalisation of dairy herd, while the second one characterises the four indicators of the rate of adaptation to digital transformation by the level of use. See the examples of calculation of the offered digitalisation indicators for the districts and economic entities of the Novosibirsk Region in Figures 7-10.

Figure 7. Index of digitalisation of dairy cattle breeding in the Novosibirsk Region by districts

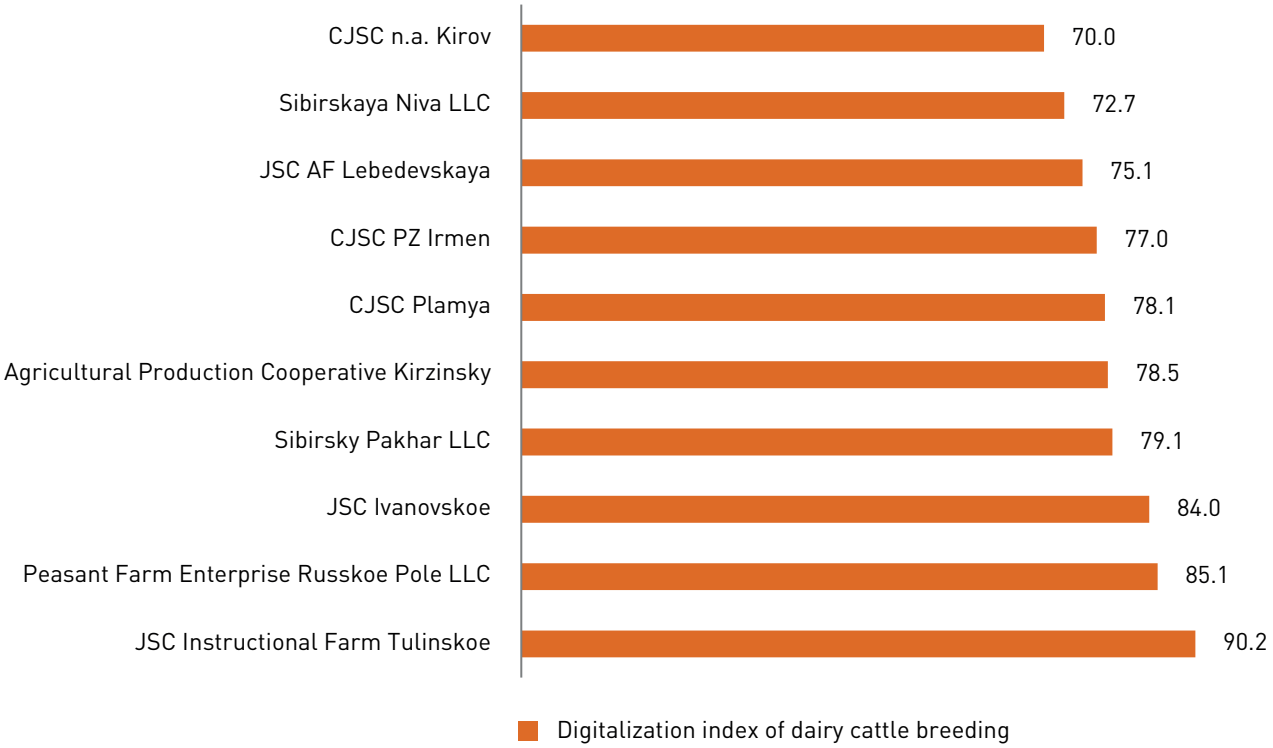


Source: developed by the authors.

The data from Figure 7 is indicative of a low rate of adaptation to digital transformation of the dairy industry in Novosibirsk Region. Thus, digitalisation covers less than 50% - just 12 districts of the region out of 29. The index in Figure 8 shows that in general in the Novosibirsk Region 15.6% of dairy herd administration has been digitalised, with Maslyaninsky district as the leader with 82.5%, and Tatarsky district is an outsider with a digitalisation index of less than 1%. A wide distribution of the obtained index values (82%) is indicative of a significant differentiation of the digitalisation level even in the districts where it is conducted.

The digitalisation index of dairy cattle breeding is calculated in a similar way for corporations (Figure 8).

Figure 8. Index of digitalisation of dairy cattle breeding in the Novosibirsk Region by companies



Source: developed by the authors.

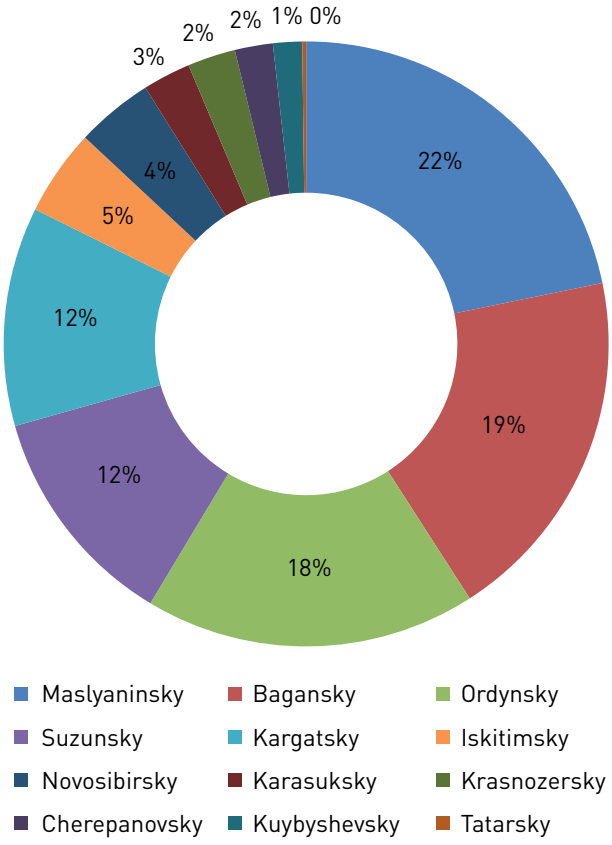
The digitalisation index of dairy cattle breeding with a breakdown into corporations demonstrated in Figure 8 confirms the assertion expressed above on insufficient digitalisation of the industry. The figure shows the top 10, where over 70% of dairy herd of the entity is digitalised. Over half of these 10 largest corporations – milk producers - failed to achive the digitalisation index level of 80% and just one corporation - Instructional Farm Tulinskoe LLC has a digital index exceeding 90%.

Development of Digitalisation Share of Economic Entities of Dairy Cattle Breeding

The second indicator of the integral evaluation which characterises the share of an economic entity among all entities participating in digitalisation of dairy herd is shown in Figures 9–10.

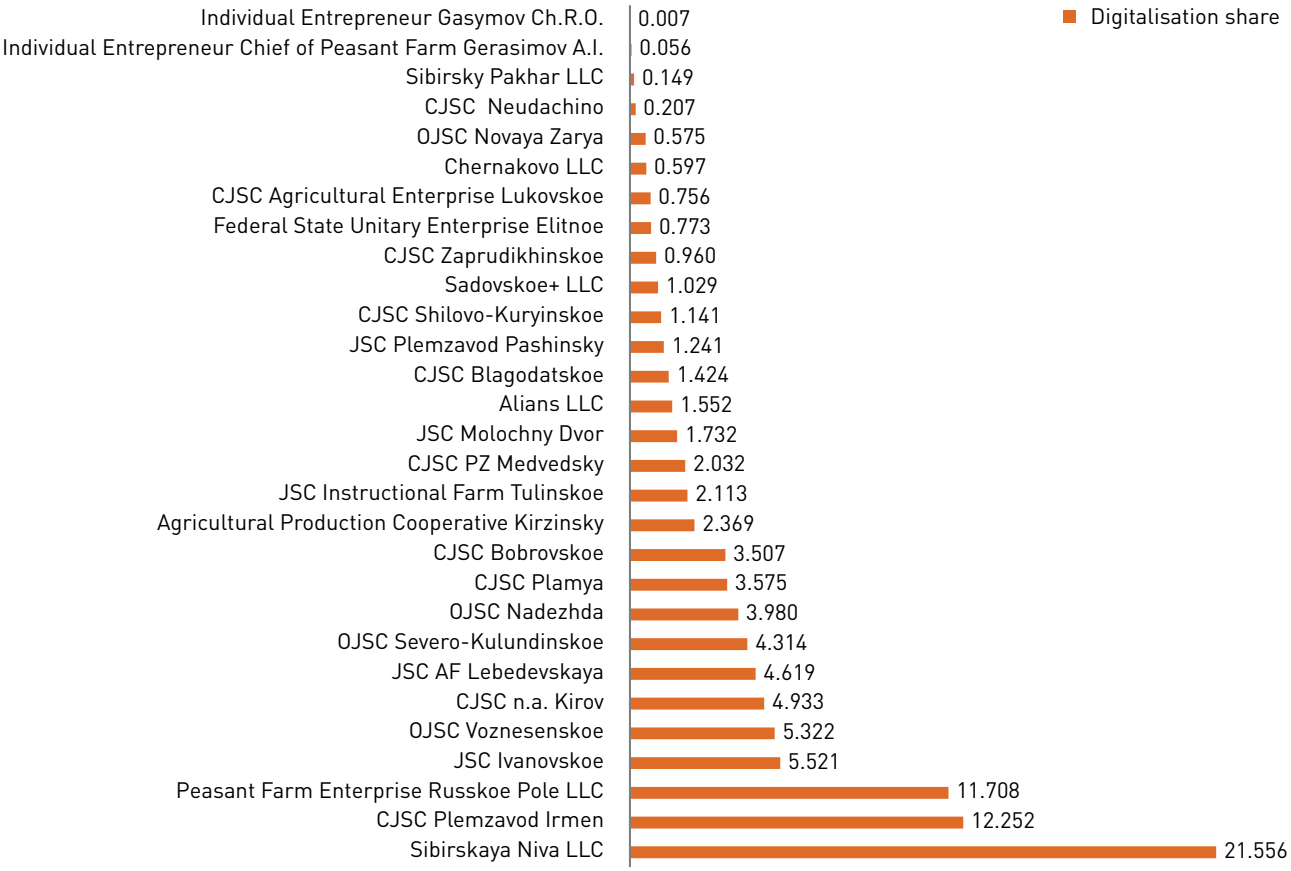
The indicated data confirms the conclusions made earlier. So, by the digitalisation share, the top three is comprised of the same districts of the Novosibirsk Region as by the digitalisation index: Maslyaninsky, Kargatsky, Ordynsky. The digitalisation share in these districts exceeds 65%. As we see from Figure 9, only in five out of 12 districts is more than half of dairy cattle breeding digitalised. In the remaining seven districts the digitalisation share is less than 40% and in four districts out of these seven the share is below 10%, which is indicative of the districts' unpreparedness to digital transformation.

Figure 9. Share in digitalisation of dairy cattle breeding in the districts of the Novosibirsk Region



Source: developed by the authors.

Figure 10. Share in digitalisation of dairy cattle breeding by corporations in the Novosibirsk Region



Source: developed by the authors.

29 economic entities implement digitalisation of dairy cattle breeding, including two individual entrepreneurs, out of 10 districts of the Novosibirsk Region. Moreover, the top three accounts for almost a half of the share in digitalisation of dairy cattle breeding.

Financial Standing of AIC Companies

An opportunity to establish relations between financial parameters and digitalisation indicators offered by the authors is of special interest. Comparative characteristics of financial indicators of ten economic entities in the Novosibirsk Region with digitalisation parameters are presented in Table 4.

The indicators listed in Table 4 in comparison to industry average values are declarative of an ambiguous character of financial standing of dairy corporations of the Novosibirsk Region. So, by financial soundness indicators, Novosibirsk corporations are less sound (the equity to total assets ratio is less than the industry average indicator, while the leverage ratio is greater) which indicates a higher financial risk level. However, with profitability indicators the situation is reverse: return on assets and return on equity exceed the industry average value. The presented data shows a top five of corporations – leaders in the key financial indicators (their values exceed the industry average value). They comprise CJSC Plemzavod Irmen, CJSC n.a. Kirov, Agricultural Production Cooperative Kirzinsky, CJSC Plamya and Sibirsky Pakhar LLC. Such enterprises as Sibirskaya Niva LLC (GK EcoNiva - Agro-Industrial Complex Holding), Peasant Farm Enterprise Russkoe Pole LLC, CJSC Agricultural Firm Lebedevskaya are in a difficult financial position due to a high financial dependence and insufficient working capital, but regardless, these companies are profitable. In spite of different financial situations all corporations are to some extent involved in digitalisation.

Let us conduct a correlation analysis of comparative characteristics of financial indicators in Table 5.

Table 4. Comparative characteristics of financial indicators of 10 economic entities of the Novosibirsk Region with digitalisation parameters

	Parameter	CJSC Plemzavod Irmen	Sibirskaya Niva LLC (GK EcoNiva - AIC Holding)	Peasant Farm Enterprise Russkoe Pole LLC	JSC Agricultural Firm Lebedevskaya	JSC Ivanovskoe	CJSC n.a. Kirov	APC Kirzinsky	CJSC Plamya	JSC Instructional Farm Tulinskoe	Sibirsky Pakhar LLC	Industry average values of indicators[4]
Y1	Revenue, rub	2 495 091	2 023 843	1 463 589	736 546	318 942	262 026	214 501	214 151	131 625	50 641	–
Y2	Cost of sales, rub	2 071 171	1 732 180	1 353 470	714 861	301 978	261 485	206 056	207 748	118 680	45 464	–
Y3	Profit on sales, rub	406 496	289 214	–1969	21 685	16 964	541	2759	1764	12 945	5177	–
Y4	Net profit, rub	486 133	62 982	26 975	1426	43 194	24 015	18 529	16 139	18 502	11 185	–
Y5	Equity capital, rub	3 286 493	445 131	43 654.5	166 726	498 340	317 857	218 268	318 205	17 044	82 064	–
Y6	Autonomy coefficient	0.95	0.04	0.01	0.10	0.72	0.88	0.78	0.83	0.34	0.97	0.56
Y7	Financial leverage ratio	0.06	21.68	172.01	9.07	0.40	0.14	0.29	0.20	1.96	0.03	0.31
Y8	Noncurrent assets, rub	1754369	6214146,5	5 531 414.5	1 105 065	392 536	160 567	143 958	129 053	785	33 812	–
Y9	Share of non-current assets,%	50,55	61,55	73.24	65.79	56.44	44.24	51.24	33.73	1.55	39.97	–
Y10	Current assets, rub	1716231	3882333	2 021 256	574 566	302 914	202 355	137 011	253 563	49 702.5	50 786	–
Y11	Share of current assets,%	49,45	38,45	26.76	34.21	43.56	55.76	48.76	66.27	98.45	60.03	–
Y12	Total asset value, rub	3470600	10096479,5	7 552 670.5	1 679 631	695 449	362 922	280 969	382 616	50 487.5	84 598	–
Y13	Ratio of own circulating assets	0,89	-1,49	–2.72	–1.63	0.35	0.78	0.54	0.75	0.33	0.95	0.37
Y14	Net profit sales margin,%	19,48	3,11	1.84	0.19	13.54	9.17	8.64	7.54	14.06	22.09	10.2
Y15	Return on equity,%	14,79	14,15	61.79	0.86	8.67	7.56	8.49	5.07	108.55	13.63	22
Y16	Return on assets,%	14,01	0,62	0.36	0.08	6.21	6.62	6.59	4.22	36.65	13.22	8.9
Y17	Digitalisation share,%	12,252	21,556	11.708	4.619	5.521	4.933	2.369	3.575	2.113	0.149	–
Y18	Digitalisation amount, heads	34752	61140	33 208	13 100	15 660	13 992	6720	10 140	5992	423	–
Y19	Digitalisation index of dairy cattle breeding, %	77,0	72,7	85.1	75.1	84.0	70.0	78.5	78.1	90.2	79.1	–

[4] According to the site: https://www.testfirm.ru/otrasli/01/

Table 5. Correlation analysis of comparative characteristics of financial indicators of 10 economic entities of the Novosibirsk Region with digitalisation parameters

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19
Y1	1.00	1.00	0.88	0.73	0.69	–0.32	0.33	0.74	0.49	0.85	–0.49	0.79	–0.41	–0.14	–0.05	–0.25	0.87	0.87	–0.23
Y2	1.00	1.00	0.85	0.70	0.66	–0.36	0.37	0.77	0.52	0.86	–0.52	0.81	–0.46	–0.18	–0.05	–0.28	0.88	0.88	–0.23
Y3	0.88	0.85	1.00	0.84	0.83	0.00	–0.13	0.44	0.18	0.69	–0.18	0.53	0.01	0.19	–0.15	–0.01	0.73	0.73	–0.31
Y4	0.73	0.70	0.84	1.00	0.99	0.31	–0.12	0.10	0.08	0.31	–0.08	0.18	0.24	0.44	–0.10	0.14	0.38	0.38	–0.13
Y5	0.69	0.66	0.83	0.99	1.00	0.37	–0.19	0.05	0.10	0.26	–0.10	0.12	0.29	0.43	–0.20	0.09	0.35	0.35	–0.19
Y6	–0.32	–0.36	0.00	0.31	0.37	1.00	–0.58	–0.71	–0.34	–0.57	0.34	–0.67	0.93	0.76	–0.39	0.20	–0.50	–0.50	–0.18
Y7	0.33	0.37	–0.13	–0.12	–0.19	–0.58	1.00	0.69	0.49	0.41	–0.49	0.60	–0.77	–0.46	0.37	–0.32	0.36	0.36	0.31
Y8	0.74	0.77	0.44	0.10	0.05	–0.71	0.69	1.00	0.59	0.94	–0.59	0.99	–0.80	–0.52	0.12	–0.44	0.89	0.89	–0.10
Y9	0.49	0.52	0.18	0.08	0.10	–0.34	0.49	0.59	1.00	0.51	–1.00	0.57	–0.62	–0.50	–0.53	–0.88	0.51	0.51	–0.40
Y10	0.85	0.86	0.69	0.31	0.26	–0.57	0.41	0.94	0.51	1.00	–0.51	0.97	–0.60	–0.38	–0.01	–0.38	**0.98**	**0.98**	–0.26
Y11	–0.49	–0.52	–0.18	–0.08	–0.10	0.34	–0.49	–0.59	–1.00	–0.51	1.00	–0.57	0.62	0.50	0.53	0.88	–0.51	–0.51	0.40
Y12	0.79	0.81	0.53	0.18	0.12	–0.67	0.60	0.99	0.57	0.97	–0.57	1.00	–0.74	–0.48	0.07	–0.42	0.94	0.94	–0.16
Y13	–0.41	–0.46	0.01	0.24	0.29	0.93	–0.77	–0.80	–0.62	–0.60	0.62	–0.74	1.00	0.78	–0.20	0. 47	–0.54	–0.54	–0.07
Y14	–0.14	–0.18	0.19	0.44	0.43	0.76	–0.46	–0.52	–0.50	–0.38	0.50	–0.48	0.78	1.00	0.06	0.60	–0.37	–0.37	0.22
Y15	–0.05	–0.05	–0.15	–0.10	–0.20	–0.39	0.37	0.12	–0.53	–0.01	0.53	0.07	–0.20	0.06	1.00	0.72	–0.05	–0.05	**0.77**
Y16	–0.25	–0.28	–0.01	0.14	0.09	0.20	–0.32	–0.44	–0.88	–0.38	0.88	–0.42	0.47	0.60	0.72	1.00	–0.38	–0.38	0.58
Y17	0.87	0.88	0.73	0.38	0.35	–0.50	0.36	0.89	0.51	**0.98**	–0.51	0.94	–0.54	–0.37	–0.05	–0.38	1.00	1.00	–0.29
Y18	0.87	0.88	0.73	0.38	0.35	–0.50	0.36	0.89	0.51	**0.98**	–0.51	0.94	–0.54	–0.37	–0.05	–0.38	1.00	1.00	–0.29
Y19	–0.23	–0.23	–0.31	–0.13	–0.19	–0.18	0.31	–0.10	–0.40	–0.26	0.40	–0.16	–0.07	0.22	**0.77**	0.58	–0.29	–0.29	1.00

Development of Methods for Preliminary Evaluation of Companies' Digitalisation Efficiency

The correlation analysis showed that financial indicators, except for net profit, equity, ratios, shares and profitability are closely correlated (correlation ratio R >0.7) with the extent of digitalisation, especially current assets (R = 0.98). The digitalisation index of dairy cattle breeding showed a strong relationship only with return on equity (R = 0.77) and no relationship at all with the extent of digitalisation (R = –0.29). We can assume that the offered digitalisation parameters do not duplicate, but rather complement each other. The strength of relationship between return on equity and digitalisation index is to a greater extent caused by dependency on the asset turnover ratio and leverage (over 0.5) than on return on sales (a little over 0.2). The obtained results confirm our hypothesis and suggest that there is a dependency of assets utilisation efficiency and financial risk on the digitalisation index in dairy cattle breeding.

The interrelation of the digitalisation index of dairy cattle breeding with return on equity with a relative accuracy of less than 10% (Table 6) which is fewer than the admissible value of 15% may be presented as the following regression equation:

$$Id = 0.17 \times ROE + 74.258. \quad (1)$$

Discussion of Results

Analysis of mathematical model (1) showed that corporations of the Novosibirsk Region which chip their dairy herd have a minimum digitalisation index of dairy cattle breeding of 74%, which deviations with the ratio of 0.17 depend on return on equity, which in its turn, is related to the velocity of assets circulation and leverage.

Table 6. Checking the adequacy of the relationship between the dairy cattle digitalisation index and return on equity

Parameter	CJSC Plemzavod Irmen	Sibirskaya Niva LLC (GK EcoNiva - AIC Holding)	Peasant Farm Enterprise Russkoe Pole LLC	JSC Agricultural Firm Lebedevskaya	JSC Ivanovskoe	CJSC Kirov	APC Kirzinsky	CJSC Plamya	JSC Instructional Farm Tulinskoe	Sibirsky Pakhar LLC
Return on equity,%	14.79	14.15	61.79	0.86	8.67	7.56	8.49	5.07	108.55	13.63
Digitalisation index of dairy cattle breeding (estinated), %	76.77	76.67	84.77	74.40	75.73	75.54	75.70	75.12	92.73	76.58
Digitalisation index of dairy cattle breeding (actual), %	77.0	72.7	85.1	75.1	84.0	70.0	78,5	78.1	90.2	79.1
Absolute deviation, %	–0.225	4.007	–0.373	–0.696	–8.295	5.583	–2.818	–3.002	2.570	–2.541
Relative deviation, %	–0.29	5.,51	–0.44	–0.93	–9.87	7.98	–3.59	–3.84	2.85	–3.21

The presented model allows us to forecast with a sufficient degree of confidence (deviation not exceeding 10%) a probable value of the digitalisation index of dairy cattle breeding for 10 prospective economic entities of the Novosibirsk Region (Table 7). Consequently, the organisations which plan 'chipping' of their dairy herd may consider the digitalisation index of dairy cattle breeding a reasonable reflection of an attractive business format for them.

Conclusion

In this paper we have considered the influence of government digitalisation policy on the state and development of corporations of the dairy industry. We have revealed an integrated system approach to evaluation of influence of state programs related to digitalisation of the dairy industry on corporations' performance, as exemplified by economic entities of the Novosibirsk Region.

The research results are indicative of general consistent patterns and interrelations between components of digital technology provided for in state programs and performance of dairy industry corporations. The statistical analysis (Figure 7) allows to assert that digital technology which is a part of government regulation of the dairy industry implemented in corporations has a significant impact on business performance. The offered digitalisation criteria and revealed consistent patterns of their interrelation with performance and expected efficiency, in their turn, are indicative of the possibility to manage the digitalisation process based upon preset parameters of business performance and the possibility to forecast the key indicator – the digitalisation index on the basis of a derived regression equation.

The research makes a contribution to development of theoretical approaches to evaluation of influence of state programs on business performance in the dairy industry. This is performed under the conditions of the digital economy, by means of development of a common methodology of evaluation of influence of government regulation on the performance of the dairy industry. The basis of the methodology is the calculation of a digitalisation index used to assess the efficiency of government support of the industry corporations. The practical value of our presented research consists in the possibility to use the offered approach for evaluation and forecasting of performance of dairy industry corporations, taking into consideration the impact of government regulation via the offered digitalisation parameters.

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