A technique for the estimation of the effect of investments in the digitalisation of the dairy subcomplex entities

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Abstract. The paper outlines the results of the analysis made to study the possibilities of using digital technologies to estimate the effect of investments in the digitalisation of dairy subcomplex entities. A review of academic literature revealed an insufficient number of publications on the dairy subcomplex digitalisation. The technique used to estimate the index of dairy subcomplex entities engaged the principles for constructing composite information indicators recommended by the European Commission. The proposed approach connects the system of state programmes and the digitalisation level of the dairy subcomplex for the first time. Taking into account the industry specifics, an attempt has been made to integrally estimate the digitalisation in dairy cattle breeding. It is recommended to introduce two criteria to assess the informational support level of dairy cattle breeding entities: the share and the index of dairy cattle breeding digitalisation. The correlation between the digitalization index of dairy cattle breeding and the return on equity has been established. An author's technique has been developed for a preliminary estimation of the effect of investments in digitalisation. The proposed approach develops the existing methods for estimating the effectiveness of government programs and policies, taking into account the industry digitalisation.

1 Introduction

The dairy industry develops under digitalisation influence along with the development of economic and mathematical theories, and their impact on the national economy by forming recommendations and suggestions in the field of public administration. Today, leading economists agree that state economic policy has been formed under the influence of developing economic and mathematical theories. However, there are disagreements concerning scales, mechanisms, and goals of such influence. Therefore, there is a problem

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of considering characteristics of forming main theoretical approaches to public administration problems, taking the dairy industry as an example [1].

Some milk and dairy producers are also involved in the digitalisation process. Producers of both milk and meat products use similar digital technologies. Digital technologies have already been partially implemented. In particular, extended sales analysis has been done in the field of big data analytics. Software interaction between pieces of equipment has been implemented in IoT. Besides, robot automation is implemented in some entities [2].

However, not all technologies are used; for example, machine learning and AI are not used. There are no ready-made solutions provided by major vendors, which could be easily put to work. It is rather expensive and time-consuming for milk and meat processing companies to develop from scratch.

There are risks in the implementation of digital technologies. The main one is a possible loss of time and money. There are no typical projects in the field of IoT or robot automation; it is always about search, research, in which researchers can go partway on the wrong track.

To increase the efficiency of digitalization of dairy subcomplex state regulation, the authors offer some recommendations:
- to introduce criteria for estimating the level of informational support of economic entities in the dairy subcomplex;
- to propose a method for estimating the effect of investments in digitalization.

According to the results of previous studies [3-9], it is required to introduce criteria for estimating the level of informational support of economic entities in the dairy subcomplex.

2 Materials and Methods

The method of assessing the index of dairy subcomplex entities has used the principles recommended by the European Commission for constructing composite information indicators given in the 2008 OECD / JRC Guidelines [10]. To justify the hypothesis, correlation and regression analysis methods are used.

The principles of constructing composite information indicators are used to develop digitalization indices of countries [11], business [12-14] (Fig. 1); in general, it can be expressed by the following formula:

$$I_d = (I_1 + I_2 + \dots + I_i + \dots + I_n) / n, \qquad (1)$$

where n is a number of subindices included in the integral, measured in shares or per cent.

The Business Digitization Index (BDI), which is calculated by researchers from Otkrytie, Google, Mail.Ru Group, Skolkovo Moscow School of Management, RAEC and NAFI in accordance with five subindices: information transmission and storage channels, use of the Internet in sales, information security, digital learning [12]. Institute for Statistical Studies and Economics of Knowledge (ISSEK) of the Higher School of Economics has developed another analogue - the Business Digitalization Index [13] for an integral estimation of the digitalisation in the business sector [13]. It describes the rate of adaptation to digital transformation, the level of use of broadband Internet, cloud services, RFID technologies, ERP systems, and the involvement of business sector entities in e-commerce. The content of the "digitalisation index" term is shown in Fig. 1.

E-Government Development Index [11]	• I_1 - Government web presence subindex • I_2 - Telecommunication infrastructure subindex • I_3 - Human capital assets subindex
Business Digitization Index, BDI [12]	• I_1 - Information transfer channels subindex • I_2 - Information storage channels subindex • I_3 - Use of Internet in sales subindex • I_4 - Information security subindex • I_5- Digital education subindex
Business Digitalisation Index (ISSEK) NRU HSE [13]	• I_1 - Broad band WL subindex • I_2 - Cloud services subindex • I_3 - RFID technologies subindex • I_4 - ERP systems subindex • I_5- E-sales using special forms on the site/extra net, EDI systems subindex
Evaluation of the digital economy efficiency [14]	• I_1 - Readiness for digital economy subindex • I_2 - Readiness for e-commerce subindex • I_3 - Readiness for e-government subindex • I_4 - Readiness for society digitalisation subindex
Digital Spillover [15]	• I_1 - Accelerating knowledge exchange subindex • I_2 - Innovations in business subindex • I_3 - Productivity increase subindex
Boston Consulting Group [15]	• I_1 - Infrastructure development subindex • I_2 - Online costs subindex • I_3 - User engagement subindex

Fig. 1. Content of the "digitalisation index" term, [11-15]

3 Results

It is problematic to apply the indices (Fig. 1) to all economic entities of the dairy subcomplex since other digitalisation criteria are used in their estimation in cattle breeding and milk processing (Table 1). It should be noted that the characteristics listed in Table 1 can be applied in economic entities both comprehensively and partially; they can differ or coincide in terms of numbers.

Taking into account the industry specifics, an attempt has been made to integrally assess the level of digitalisation in dairy cattle breeding using two parameters: share (I_{s_dcb}) and digitalisation index (I_{d_dcb}). The first indicator characterizes the share of an economic entity among all entities involved in the digitalisation of the dairy herd, and the second one characterises four indicators (Table 1) of the rate of adaptation to digital transformation in terms of the level of use. Examples of calculating the proposed indicators of digitalization for the districts and economic entities of the Novosibirsk region (Table 1) are shown in Figures 2-5; they are performed according to expression (1) by the formula:

$$I_{d\_dcb} = (\, I_1 + I_2 + I_3 + I_4) \, / \, 4 \qquad (2)$$

Table 1. Characteristics of precision livestock farming in the Maslyanino district of the Novosibirsk region, heads.

Entity	Livestock product quality monitoring (I_1)	Electronic production process database (I_2)	Identification and monitoring of individual animals (I_3)	Herd health monitoring (I_4)
Sibirskaya Niva LLC	8391	18699	17025	17025
Sibirskiy Pakhar LLC	423			
Individual Entrepreneur A.I. Gerasimov, Head of the farm	160			
Individual Entrepreneur Gasymov Ch.R.O.	20			

The data shown in Figure 2 show a low rate of adaptation to the digital transformation of the dairy industry in the Novosibirsk region. Only 12 of 29 districts of the Novosibirsk region are being digitalised, which is less than half. The index shown in Figure 1 shows that 15.6% of the Novosibirsk region's dairy herds have been digitised in general. Moreover, the Maslyanino district is the leader (digitalisation index = 82.5%), and the Tatarsk district is the outsider (digitalisation index = <1%). The wide scatter of the obtained index values (82%) is indicative of a significant differentiation in the digitalization level even in the districts where it is being performed.
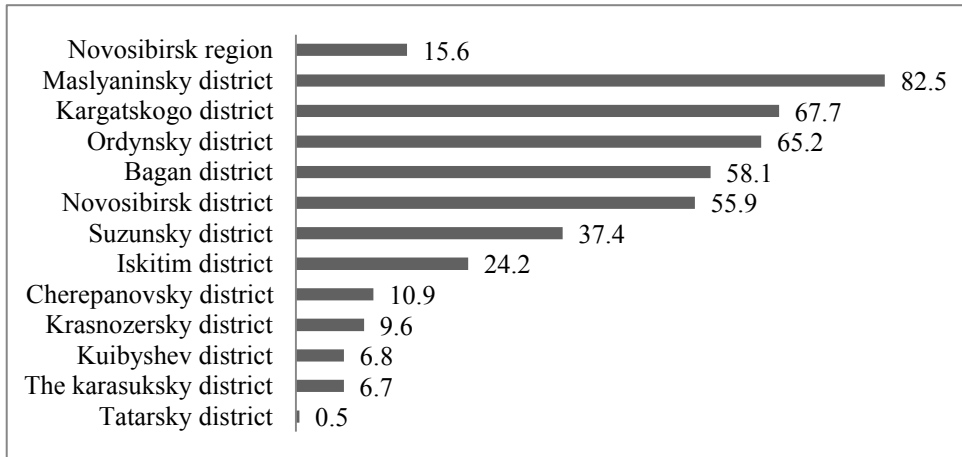
Fig. 2. Digitalisation index of dairy cattle breeding in districts of the Novosibirsk region

The digitalisation index of dairy cattle breeding in economic entities is calculated in the same way (Fig. 3). Figure 3 shows the top-10 of leaders with more than 70% of the digitalised dairy herd. The second indicator of the integral estimation, which describes the share of the economic entity among all subjects involved in the digitalisation of the dairy herd is shown in Fig. 4-5.
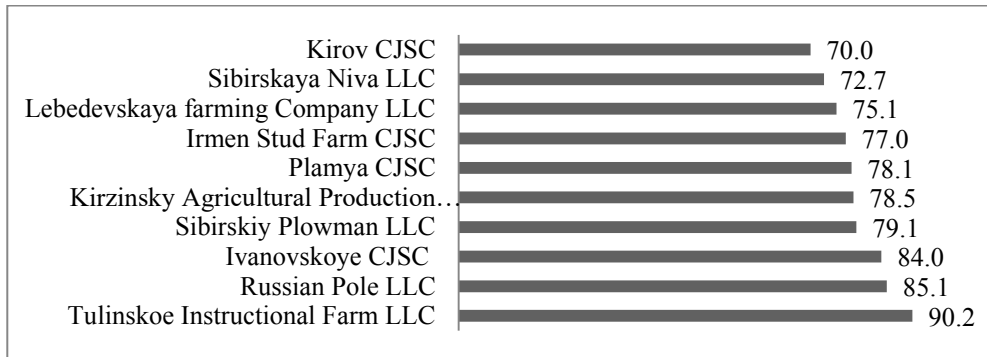
Fig. 3. Digitalisation index of dairy cattle breeding in entities of the Novosibirsk region

Data shown in Figure 4 confirm the conclusions obtained earlier. According to the digitalisation share, top-3 of the leaders includes the same districts of the Novosibirsk region as for the digitalisation index: the Maslyanino, Kargat, and Ordynskoe districts. The digitalisation share in these districts is more than 65%. As shown in Figure, only five of twelve districts of the region have more than half of the dairy cattle breeding digitalised. In the other seven districts, the digitalisation share is even lower than 40%, and this share is lower than 10% in four of these seven districts. It shows that the districts are not ready for the digital transformation.
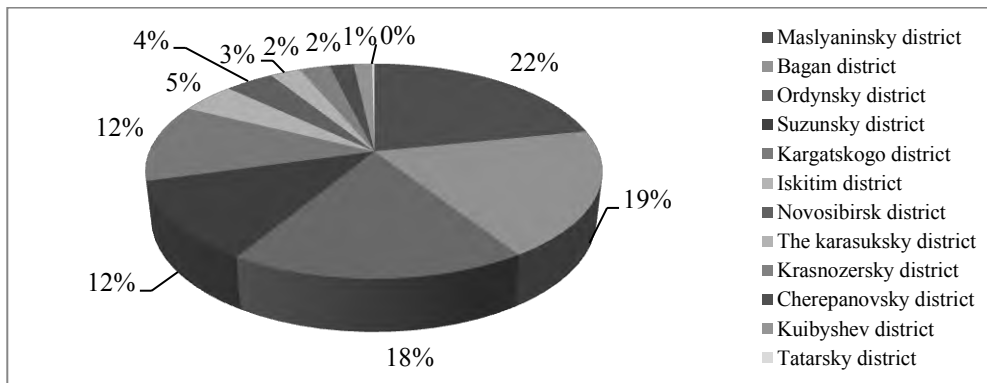

Fig. 4. Digitalisation share of dairy cattle breeding in the districts of the Novosibirsk region

Twenty-nine economic entities (Fig. 5) including two individual entrepreneurs are digitalising the dairy cattle breeding in 12 districts of the Novosibirsk region. Moreover, Top-3 makes almost half of the share in the field of dairy cattle breeding digitalisation.

Of special interest is the possibility to make a connection between financial parameters and digitalisation index proposed by authors. Comparative characteristics of financial indicators of three economic entities of the Novosibirsk region with digitalisation parameters are shown in Table 2, and the correlation analysis 10 (Fig. 3) is shown in Table 3. The correlation analysis has shown that financial indicators (except for net profit, equity and profitability) have a strong correlation (correlation ration $R > 0.7$) with the digitalisation share, especially the "current assets" parameter ($R = 0.98$). The digitalisation index of dairy cattle breeding has shown a close correlation only with ROE ($r = 0.77$) and the absence of correlation even with the digitalisation share ($R = -0.29$), which indicates that the proposed digitalisation parameters do not duplicate, but complement each other. It should also be noted that the correlation of digitalisation index of dairy cattle breeding with ROE components (net profit ($R = -0.13$) and equity ($R = -0.19$)) is also absent.
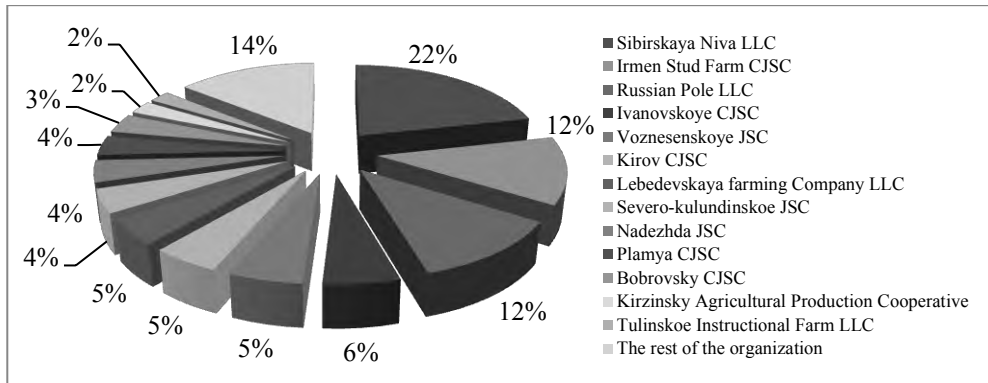
Fig. 5. Share in dairy cattle breeding digitalisation of economic entities in the Novosibirsk region

Table 2. Comparative characteristics of financial indicators of 3 economic entities of the Novosibirsk region with digitalization parameters*

	Indicator	**Irmen stud farm CJSC**	**Sibirskaya Niva LLC (EcoNiva-APK Holding Group)**	**Russkoe pole farm LLC**
Y1	Revenue	2495091	2023843	1463589
Y2	Cost of sales	2071171	1732180	1353470
Y3	Profit on sales	406496	289214	-1969
Y4	Net profit	486133	62982	26975
Y5	Equity	3286493	445131	43654.5
Y6	Capital assets	1754369	6214146.5	5531414.5
Y7	Current assets	1716231	3882333	2021256
Y8	The total value of assets	3470600	10096479.5	7552670.5
Y9	Return on sales by net profit	19.48	3.11	1.84
Y10	Return on equity	14.79	14.15	61.79
Y11	Return on assets	14.01	0.62	0.36
Y12	Digitalisation, %	12.252	21.556	11.708
Y13	Digitalisation volume	34752	61140	33208
Y14	Digitalisation index of dairy cattle breeding, %	77.0	72.7	85.1

The correlation of the digitalisation index of dairy cattle breeding with ROE, with a relative error >10%, which is less than the allowed 15%, may be represented as the following regression equation:

$$Y_{14} = 0.17 * Y_{10} + 74.258 \quad or \quad I_{d\_dcb} = 0.17 * ROE + 74.258. \qquad (3)$$

Table 3. Correlation analysis of comparative financial indicators of 3 economic entities of the Novosibirsk region with digitalization parameters*

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14
Y1	1.00	1.00	0.88	0.73	0.69	0.74	0.85	0.79	0.14	0.05	0.25	0.87	0.87	0.23
Y2	1.00	1.00	0.85	0.70	0.66	0.77	0.86	0.81	0.18	0.05	0.28	0.88	0.88	0.23
Y3	0.88	0.85	1.00	0.84	0.83	0.44	0.69	0.53	0.19	0.15	0.01	0.73	0.73	0.31
Y4	0.73	0.70	0.84	1.00	0.99	0.10	0.31	0.18	0.44	0.10	0.14	0.38	0.38	0.13
Y5	0.69	0.66	0.83	0.99	1.00	0.05	0.26	0.12	0.43	0.20	0.09	0.35	0.35	0.19
Y6	0.74	0.77	0.44	0.10	0.05	1.00	0.94	0.99	0.52	0.12	0.44	0.89	0.89	0.10
Y7	0.85	0.86	0.69	0.31	0.26	0.94	1.00	0.97	0.38	0.01	0.38	**0.98**	**0.98**	0.26
Y8	0.79	0.81	0.53	0.18	0.12	0.99	0.97	1.00	0.48	0.07	0.42	0.94	0.94	0.16
Y9	0.14	0.18	0.19	0.44	0.43	0.52	0.38	0.48	1.00	0.06	0.60	0.37	0.37	0.22
Y10	0.05	0.05	0.15	0.10	0.20	0.12	-0.01	0.07	0.06	1.00	0.72	0.05	0.05	**0.77**
Y11	0.25	0.28	0.01	0.14	0.09	0.44	0.38	0.42	0.60	0.72	1.00	0.38	0.38	0.58
Y12	0.87	0.88	0.73	0.38	0.35	0.89	**0.98**	0.94	0.37	0.05	0.38	1.00	1.00	0.29
Y13	0.87	0.88	0.73	0.38	0.35	0.89	**0.98**	0.94	0.37	0.05	0.38	1.00	1.00	0.29
Y14	0.23	0.23	0.31	0.13	0.19	0.10	0.26	0.16	0.22	**0.77**	0.58	0.29	0.29	1.00

The mathematical model analysis (3) shows that the average digitalization index of dairy cattle breeding in business entities of the Novosibirsk region, which perform the chipisation of dairy herds, is 74%; its deviations with a ratio of 0.17 depend on the ROE. Hence, the entities which plan to chipise their dairy herds can predict a rational digitalisation index of dairy cattle breeding.

The authors of digital spillover [14] have empirically proved that investments in digital assets are significantly more profitable than in non-digital ones. Every US dollar invested in digital technologies over the past three decades has generated an average of USD 20 to GDP. This is a huge return compared to non-digital investments, which generate an average income of between USD 3 to USD 1. The investment of USD 1 is 6.7 times more profitable for digital investments than for non-digital ones. Therefore, the investment efficiency ratio (K_e) based on empirical data can be equal to 6.7 for the digitalisation index $I_d = 1(100\%)$. The expected economic effect (E_x) of investments (X_i) in digitalisation, taking into account the digitalisation index, can be calculated using the formula:

$$E_x = X_i \bullet I_d \bullet K_e .$$

(4)

4 Discussion

Twenty-nine economic entities (Fig. 5) including two individual entrepreneurs are digitalising the dairy cattle breeding in 12 districts of the Novosibirsk region. Moreover, Top-3 makes almost half of the share in the field of dairy cattle breeding digitalisation.

Of special interest is the possibility to make a connection between financial parameters and digitalisation index proposed by authors. Comparative characteristics of financial indicators of three economic entities of the Novosibirsk region with digitalisation parameters are shown in Table 2, and the correlation analysis 10 (Fig. 3) is shown in Table 3. The correlation analysis has shown that financial indicators (except for net profit, equity and profitability) have a strong correlation (correlation ration $R > 0.7$) with the digitalisation share, especially the "current assets" parameter ($R = 0.98$). The digitalisation index of dairy cattle breeding has shown a close correlation only with ROE ($r = 0.77$) and the absence of correlation even with the digitalisation share ($R = -0.29$), which indicates

that the proposed digitalisation parameters do not duplicate, but complement each other. It should also be noted that the correlation of digitalisation index of dairy cattle breeding with ROE components (net profit (R = -0.13) and equity (R = -0.19)) is also absent.

5 Conclusions

It is recommended to introduce two criteria to assess the informational support level of dairy cattle breeding entities: the share and the dairy cattle breeding digitalisation index. The first indicator describes the share of the economic entity among all entities, which participate in the digitalisation, and the second one describes the rate of adaptation to the digital transformation by the level of use of precision livestock farming characteristics.

The study results indicate the presence of general patterns and correlation between the elements of digital technologies provided by government programmes and the efficiency of the dairy industry entity functioning. The analysis allows us to assert that digital technologies, which are elements of state regulation of the dairy industry introduced into the activities of corporations, have a significant impact on business efficiency.

This indicates a possibility of managing the digitalisation with the given parameters of business performance and a possibility to predict the key indicator: the digitalisation index based on the constructed regression equation.

The authors propose a formula based on empirical data from the preliminary estimations of the expected economic effect of investments in digitalisation, which shows that the most excellent effect can be achieved with full (100%) digitalisation. Partial digitalisation will not have the desired effect and may even be unprofitable under certain conditions. Therefore, it is recommended to digitalise business entities comprehensively. In case of a lack of funds, they should be digitalised pointwise, without spreading the financial asset over many entities.

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