

Digital twin of livestock production in unified digital platform of Russian agriculture management

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Abstract. The purpose of this paper is to analyze the conditions for the formation of digital twins of animal husbandry, to develop mechanisms for their integration into a single digital platform for agricultural management, and to assess the consequences of such integration. Against the background of the haphazard nature of the introduction of digital technologies in Russia, which often do not provide the expected economic benefits, the paper considers effective mechanisms for the formation of a single digital twin of animal husbandry, providing fundamentally new opportunities for digital transformation: The emergence of an effective digital tool for traceability of all types of products of the industry, in demand due to the increased attention to health and ecology in the world; integration of data in the form of digital standards from different farms into a common global oblast; integration of data in the form of digital standards from different farms into a single digital platform for the management of livestock farming. The novelty of the work lies in the originality of the scientific approach to the formation of a single digital twin of livestock production in the form of joint ownership of it by all industry enterprises, from large to small, because the realization of such a twin leads to a multiple reduction in the cost of its formation.

1 Introduction

New digital technologies, including mathematical modeling related to agriculture, have made it possible to obtain detailed information about the state of soil, animals, crops, weather, to control the composition and the necessary amount of chemical application; to conduct operational monitoring of livestock farms, fields and agricultural machinery [1, 2]. At the same time, these technologies have sharply expanded the potential range of solutions to a variety of objectives for managing the production activities of enterprises. Such trends have created a temptation to create a set of integrated information models describing completely any enterprise, leading to the concept of digital twin (DT), based on the following digital technologies: precision livestock farming, precision agriculture, remote sensing of the earth, geoinformation systems, precision production. It is shown that the

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need to develop integration procedures for combining a large number of structured data and technologies for their processing of the above technologies has led to the formation of a unified digital platform for agricultural management.

Therefore, the presented work considers the place of the digital twin of livestock farming in the specified digital platform on the basis of a system analysis of previous Russian and Western experience of informatization of the industry.

2 Materials and Methods

The concept of DT is most fully disclosed in research [3], the essence of which can be conceptually expressed in the unity of the following main subsystems: a real physical object, a virtual model of it in some information space, data and algorithms describing the object. DT is created in order to simulate the behavior of the physical original in predicted possible situations. It is believed that such a DT should significantly save financial, material and time resources. Based on this premise and on the properties of models, systems theory, created to achieve some goals, numerous different models can be built for the same object to meet different modeling goals. For instance, we can take as an example a large number of DTs of citizens of many states reflected in the databases (DB) of various ministries and departments (police, education, health, motor transport, taxes, etc.), the DBs of which are most often not compatible and work on different platforms. However, the requirement of the basic principle of the digital economy (DE) in the form of data and information systems (IS) integration has led to the need to develop a set of models and data collection that meet all the main objectives of DT. At the same time, some research imposes rather strict requirements on the DT performance error, which should not exceed 5% [4]. These limitations on adequacy impose certain requirements on the completeness, reliability of data and accuracy of the applied models included in DT.

The first successful results of DT implementation show that their development required significant expenditures of finances, time, quality human resource, since the basis of DT design and modeling are complex interdisciplinary mathematical models with a high degree of adequacy to real characteristics. Thus, in [4] the value of financial expenses in this case is indicated in the amount of 100\$ billion. At the same time, tens of thousands of target indicators and various resource constraints are taken into account in the design process.

Due to these large costs, it becomes practically impossible to develop individual DT for each enterprise in almost any industry. The way out in this case is to look for the design of such a DT, which could be jointly owned by a large number of enterprises. But for this purpose, it would be necessary to create ontologically unified conceptual, informational and algorithmic spaces.

In order to solve the integration problems of DT formation, which allow to implement an integrated approach in the digital transformation of agriculture, in [5, 6] a mathematical model of the formation of a unified direct digital control (DDC) of agriculture is presented, based on which the following were obtained: cloud sub-platform (the first digital standard) of collection and storage of primary accounting information in a unified cloud database (DB); cloud sub-platform (the second digital standard) of technological DB; cloud sub-platform of knowledge base in the form of implemented algorithms of managerial and information management. If the first standard has a universal cross-sectoral character for most industries of the country, the second is only sectoral. These sub-platforms have been confirmed in the recent implementation of integration procedures in the digital transformation of agriculture. Thus, it follows from the analytics of J'son & Partners Consulting that only at this moment in this industry of the USA two special sub-platforms are beginning to be used: sub-platforms-aggregators of primary data and sub-platforms of algorithms with appropriate tools for data collection and accumulation.

3 Results and Discussion

In this section, based on the unified DDC of agriculture of the first digital standard obtained by mathematical modeling (Fig. 1), we will consider the place of DT livestock breeding, mechanisms and consequences of its integration into the unified digital platform of the industry. For this purpose, we will demonstrate the possibility of describing any primary accounting operation in livestock farming from the point of view of the unity of its ontological description in the terms specified in Fig. 1, where an operation is understood as a specific complete part of the technological process, which, as a rule, is performed by one type of tools and one or more performers (a brigade, a link, a unit).

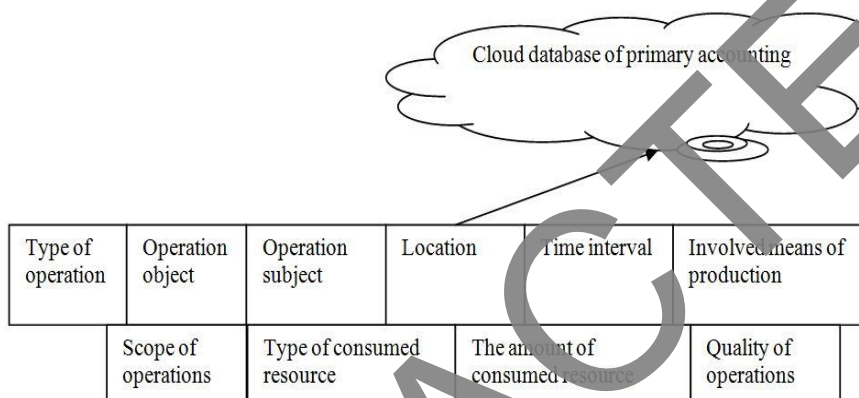


Fig. 1. Cloud-based sub-platform for collecting and storing primary accounting information. "Compiled by the author".

In livestock farming the following operations are distinguished: milking, feeding of livestock, weighing, accounting of animal litter, feed consumption, etc. As an example, let's take the operation "Milking". Then the structure of DB of primary accounting of livestock production on the example of description of this operation will look as follows.

- 1.1 Classifier of types of operations:
 - 1.1.1 Milking.
- 1.2 Classifier of operation objects:
 - 1.2.1. cow (identification with parameters in accordance with the classifier).
- 1.3 Classifier of place of operations:
 - 1.3.1. farm, machine (identification of farm and milking machine in accordance with the conceptual information model of the enterprise, industry).
- 1.4 Classifier of subjects of operations:
 - 1.4.1. milkmaid, machine milking operator (identifier in the form of a report card number, TIN, etc.).
- 1.5 Time intervals are selected from the relevant data models.
- 1.6 Classifier of labor inputs involved:
 - 1.6.1. milking machine (type, inventory number, make, capacity, year of manufacture, etc.);
 - 1.6.2. milk pipeline with measuring equipment (type, stock number, brand, etc.).
- 1.7. operation volume classifier:
 - 1.7.1. volume (type of measurement, liter, etc.);
- 1.8 Classifier of types and volumes of consumed resource:
 - 1.8.1. electricity, biologics, medicines, miscellaneous materials, etc. (type, code, composition and its identification in accordance with the classifier).

1.9. Milk quality classifier:

1.9.1. fat content, acidity, etc. (type, quality code, composition and its identification in accordance with the classifier);

Then, based on the definition of DT, the scheme of its realization for livestock farming, taking into account inter-sectoral links with crop production, processing, logistics, product, labor and financial markets, will look as shown in Fig. 2.

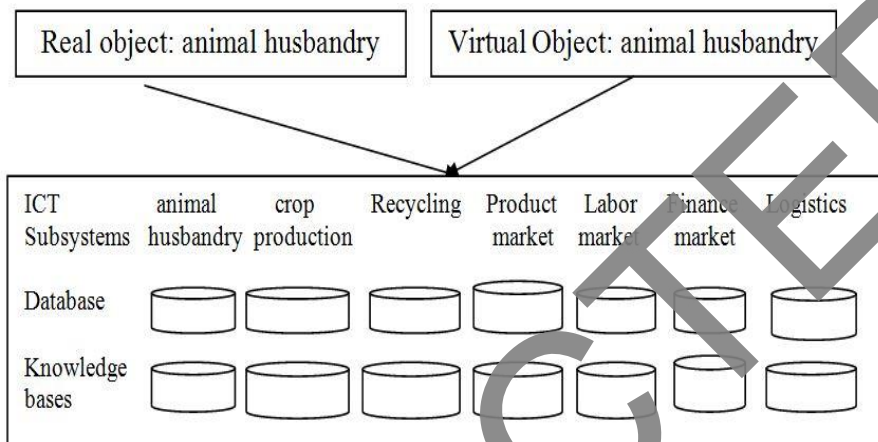


Fig. 2. Schematic of the digital twin of livestock production. "Compiled by the author".

In this context, we will analyze new opportunities for the digital transformation of livestock farming. Integration of DT livestock with DT crop production and processing, which interact very closely through the fodder base, the products obtained in the form of raw materials, common finances in the whole enterprise and a number of less important factors. Up to now, the digitalization of these sectors has mostly been done in a fragmented way, without considering the possibilities of integration. A single DDC is also an effective digital traceability tool for all products in the industry, which is in high demand due to the increased global focus on health and the environment. As a result, the DDC and traceability tool for the industry is in line with global trends in food sourcing and regulation, and is focused on global harmonization of these requirements across the entire product lifecycle, from field to fork. For example, sustainability requirements for animal products are tracked by the reliability of data on the sustainability of all technological operations in crop production and processing.

Moreover, the huge amount of data received from most livestock farms within the framework of a single DDC will allow significant progress in breeding activities - from the traditional scheme of semen selection in passive mode, where only the characteristics of bulls and their progeny are taken into account, to selection on a much larger sample of animals, i.e., analysis of the characteristics of all calves and cows.

4 Conclusion

In the paper, based on the developed mathematical model of DDC formation by Russian production sectors, in particular, agriculture, the economic feasibility of DT implementation of livestock breeding is shown. It is shown that its realization on the basis of digital DDC standards leads to complete identity between the DT and the digital sub-platform of animal husbandry, which is possible only in the case of a comprehensive, systematic approach to the digital transformation of the industry.

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