Evaluation methodology of the potential of agricultural universities in the "experimental digital pilot farm" project

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Abstract. The digitization of agriculture needs the methodological support in comprehensive assessment of scientific and educational, experimental and industrial potential of agricultural universities. The article examines the methodology and criteria of this potential evaluation under the project “experimental digital pilot farm”. The findings include the evaluation scheme of such project’s development on the basis of the agricultural university. The integrated index of the evaluation has also been developed with the use of the statistics method, the sociological and expert survey. It is argued that the objective evaluation of the digitization efficiency on the level of a particular farm will help to choose differential strategies on digital transformation of agrarian enterprises.

1. Introduction
The implementation of the state development programms of the digital economy in the Russian Federation sets specific requirements to achive target idicators. In spite of the intensive research on the development of the digital economy [1, 2], there are a few studies on the conditions of efficient digital transformation of enterpises in agro-industrial complex. Special attention is paid to the management of digital transformation in production and organizational processess [3]. The purpose of the article is (1) to develop the methodology to evaluate scientific educational and experimental industrial potential of agricultural universities through the analysis of sociological expert survey, (2) to develop and replicate the project “experimental digital pilot farm”. The ongoing pilot projects under the “Digital Economy Program” like this one make it possible to adjust the action plan for digital agriculture to achieve positive effects [4] and formulate industry standards.

2. Materials and methods
As general research methods we use economic and statistical, abstract-logical ones, a comparative analysis, a sociological expert survey, a document analysis, grouping and systematization.

When evaluating the potential of an economic entity, the following problems arise:

1. the selection of the most important indicators to evaluate each component of the potential specifically for the agricultural sector and the digital component;
2. the development and testing of the evaluation methodology defining an integrated indicator; the use of not only quantitative indicators but also qualitative ones within this methodology on the base of the conducted sociological expert survey.

These problems can be successfully solved if we apply to statistical analysis methods, expert
assessments and normalized indicators.

To define the comprehensive indicator of the potential evaluation, the research team used the principles of universality, clear structuring, comprehensibility, an unambiguous interpretation, the possibility of assessment in time dynamics, a lack of subjective assessment, to have a limited number of components, to be expressed quantitatively.

3. Evaluation of the potential in the "experimental digital pilot farm" project

The evaluation of agricultural universities’ science and education, experimental and industrial potential in the project “experimental digital pilot farm” (hereinafter “potential”) is a multi-stage process [5], presented in Table 1.

| Stage   | Description                                                                 |
|---------|-----------------------------------------------------------------------------|
| Stage 1 | Definition and selection of indicators and characteristics of the potential as well as the reference model |
| Stage 2 | Setting the weight and importance of the constituent elements of potential indicators and their threshold values |
| Stage 3 | Integrated Potential Evaluation Indicator                                     |
| Stage 4 | Collection and analysis of source information using questionnaires           |
| Stage 5 | Analysis of the actual level of potential of the investigated object         |
| Stage 6 | Measuring of the potential’s total level and ranking                         |

In this study the comprehensive evaluation is used to compare its results in time dynamics on the base of sociological expert survey. The questionnaire of the survey included 35 questions.

The structural components of the potential were identified after the literature analysis [6, 7]. They included organizational and managerial components, technical-digital, production-technological, scientific, educational, personnel components and financial ones.

Considering the comprehensive approach as more reliable, we emphasize the importance of industry-specific functional subsystems (crop production, animal husbandry, construction, mechanization, vehicles, processing) in the activities and specialization of agricultural universities.

To build the index of potential’s evaluation we need to use 7 indicators. They correspond to the components of the potential and incude organizational and managerial ones (1/7), technical and digital (1/7), production and technology (1/7), scientific (1/7), educational (1/7), personnel (1/7), financial ones (1/7). Indicators contain sub-indicators.

So, the level of potential can be represented in formula 1:

\[ S = \frac{\alpha OM + \beta TD + \gamma PT + \delta S + \kappa E + \tau P + \upsilon F}{7} \]

where \(\alpha, \beta, \gamma, \delta, \kappa, \tau, \upsilon\) are the coefficients (weight) of the potential indicators

OM - organizational and managerial characteristic of the indicator,
TD - technical and digital characteristic of the indicator,
PT - production and technological characteristics of the indicator,
S - scientific characteristic of the indicator,
E - educational characteristic of the indicator,
P - personnel characteristic of the indicator,
F - financial characteristic of the indicator.

When calculating both the indicators themselves and the sub-indicators, all the values were normalized, i.e. were transformed into the score from 0 to 1.

The formation of a reference potential model itself is the calculation of indicators with the largest
and smallest values of the corresponding indicators. They depend on the given threshold values and can be represented in formula 2

\[ Sr = \frac{\alpha \text{OMr} + \beta \text{TDr} + \gamma \text{PTr} + \delta \text{Sr} + \kappa \text{Er} + \tau \text{Pr} + \upsilon \text{Fr}}{7} \]

where \( \alpha, \beta, \gamma, \delta, \kappa, \tau, \upsilon \) are the coefficients (weights) of the potential indicators,

- \( r \) means the reference level,
- \( \text{OMr} \) - the reference level of organizational and managerial characteristics of the indicator,
- \( \text{TDr} \) - the reference level of technical and digital characteristics of the indicator,
- \( \text{PTr} \) – the reference level of production and technological characteristics of the indicator,
- \( \text{Sr} \) – the reference level of the scientific characteristics of the indicator,
- \( \text{Er} \) - reference level of educational characteristics of the indicator,
- \( \text{Pr} \) - the reference level of personnel characteristics of the indicator,
- \( \text{Fr} \) - the reference level of the financial characteristics of the indicator,
- \( \text{Sr} \min \) - the value of the reference model with the smallest values,
- \( \text{Sr} \max \) - the value of the reference model with the highest values,
- \( \text{S actual} \) - the actual level of potential of an agricultural university.

Thus, the methodology for the comprehensive potential evaluation of agricultural universities under the project has a well-defined structure and can be adapted for any entities.

To calculate the potential indicators, the questionnaire was developed, its questions characterizing the components of the potential, in particular:
- organization and managerial potential which described the issues of size, profile, organization form, form of subordination;
- technical and digital potential includes the questions about computer equipment, the Internet, GLONASS / GPS systems, digitization;
- production and technological potential includes the questions about agricultural machinery, technologies and production processes;
- scientific potential – includes the questions about research and development in the field of agriculture digitization;
- educational potential - these are the issues about educational programs, training;
- personnel potential - these are issues about the number of employees on pilot farms and their competencies;
- financial potential - these are questions about the budget and the costs of digitization.

The results of the expert survey questionnaires can be analyzed in the form of tables (Table 2) or graphically for individual issues (Figure 1).

Table 2. The example of the response for the question “To what extent the boundaries of the contour lines of the experimental fields were digitized”.

| Answer options    | Results |
|-------------------|---------|
| not digitized     | 10      |
| up to 30%         | 60      |
| up to 50%         | 10      |
| up to 70%         | 10      |
| up to 100%        | 10      |

So, the questionnaire analysis and calculations of potential indicators allows one to get not only the values to assesss the potential of agricultural universities but also the typology of the universities’ potential according to the project “experimental digital pilot farm” (Table 3).

Based on the results of calculating the total potential and the typology of entities, ranking is carried out (Figure 2).
Figure 1. The example of the response for the question “To what extent the boundaries of the contour lines of the experimental fields were digitised” (a) and for the question “The share of agricultural machinery equipped with GLONASS / GPS systems in the total volume of agricultural machinery” (b).

Table 3. Threshold values and typology of agricultural university’s potential under the project “experimental digital pilot farm”.

| Composite indicator | Sr min | S1 | …………………..Sn | Sr max |
|---------------------|--------|----|------------------|--------|
| Integrated potential assessment | 0,00   | 25,0 | 50,0 | 75,0 | 100,00 |

| Type potential potential | of Negative | Below average | Average | Above the high average |
|--------------------------|--------------|---------------|---------|------------------------|
| 0% 0%                    | 11%          | 13%           | 76%     |

Figure 2. The example of the results of ranking objects by the types of agricultural university’s potential under the project “experimental digital pilot farm”.

Analysis of the results, assessment of opportunities, ranking and typology of research subjects
allow us to identify positive and negative factors that ensure the implementation of digital transformations of organizations, the adoption of informed management decisions and the implementation of development strategies.

4. Conclusion

Thus, this study allows us to clarify, analyze and to develop directions for the greater use of digital technologies in the practice of agricultural universities.

The findings show that an integrated assessment of the potential is calculated with the use of the set of indicators. They allow evaluating components of the scientific, educational and experimental-production potential of agricultural universities under the project "experimental digital experimental farm".

The potential management of agricultural universities with reference to digital innovation activity will expand the forms of the university’s functions.

As mainstreams of innovative activity of agricultural universities under the project “experimental digital pilot farm” we offer the following functions:

- An educational function - training and retraining of personnel for digital agriculture, inter-university interaction in forms and methods of training;
- A scientific function - joint research activity on the “triple helix model” (science-business-state);
- An applied function - commercialization of university developments, innovative university infrastructure, replication of digital enterprise practices in agriculture (smart farm, smart field);
- A social and economic function - the impact on the proficiency level of the labor resources of the region, the development of digital culture for various segments of the population.

We emphasize the direction of development and replication of digital enterprise practices in agriculture, which helps to increase productivity by means of digital technologies.

Digitalization of production processes is aimed at increasing productivity in the following areas: process optimization (e.g. value chain management efficiency), innovative products developed according to new process management models and new methods of interaction with customers, new markets (e.g. the formation and development of new niches based on research of data on needs), professional activity (development of remote work).

Finally it should be noted that the use of monitoring and the potential evaluation of entities on the basis of the proposed model ensures competitiveness and forms innovative production models in the long term.

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