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LABOR POLARIZATION IN THE CONTEXT OF AGRICULTURAL ROBOTIZATION IN THE MIDDLE URALS

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ABSTRACT

The digital transformation of agriculture in the Urals causes a major change in the qualitative and quantitative composition of the industry's workforce and its structure. This study determines the demand for highly qualified professionals in the industry who are appropriately trained to interact with digital products and technologies. This study identifies patterns of labor resource formation, including labor polarization, in the context of the digital transformation of the companies operating in agricultural sectors of Urals. To study labor polarization, the rate of decline (increase) in employment by profession depending on the wage grade in agricultural organizations was analyzed. Analysis of the effects of agricultural robotization on the labor force shows that 17 jobs were created between 2013-2020, 76.5% of them are occupied by men and 23.5% by women, the largest share of workers (47.1%) is in the age 18-29 years old, and 52.9% of workers have higher education. The analysis shows an increase in employment in the professions with the highest wage grades, while the employment growth rate of robot maintenance technicians and robotic milking operators was 16.7% per year. Several professions with average wage grades experienced no changes in employment during the period under review, while those with low wage grades and high routine operations experienced a drop in the employment rate. A conclusion has been made on labor polarization in the industry to reduce routine operations (ALM hypothesis).

Disciplinary: Labor, Employment, and Occupation Studies, Technology and Machine in Agricultural Economics, Public Policy and Administration.

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1 INTRODUCTION

Digital transformation in agriculture is manifested in continuous improvement of tools, objects of labor, production and organization technology, as well as labor resource development. The aforementioned are presently undergoing progressive changes in numerical and qualitative composition. The digitalization process is at present associated with various technological breakthroughs in the field of digital products and technologies, including data analysis and processing technologies (ERP systems), the Internet of Things (IoT), artificial intelligence (AI), as well as robotics. These technologies and their application outputs deserve special attention as they are highly likely to lead to drastic changes and transformations of existing social, political and economic systems. The application of these technologies in the production of goods and services is called the digital economy or economic digital transformation. Economist and Nobel Prize winner Wassily Leontief stated in 1983 that "man's role as the most important factor in the production process will decrease just as the role of horses in agricultural production decreased to the point where they were all replaced by tractors" (Leontief, 1983). It should be acknowledged that digital transformation is an objective process involving scientific and technological progress.

Many studies have been recently done reflecting the effects of changes in workforce composition in the context of digital transformation (Bluestone et al., 1988) and predicting both a global decline in employment (Kapelyushnikov, 2017) and a positive impact involving the creation of jobs in the digital sector (Frey & Osborne, 2013). The large-scale increase in employment in high-skill and low-skill professions compared to middle-skill professions has been named labor polarization. Labor market polarization – the growth of the share of high-paying and low-paying jobs at the expense of average-wage jobs, has contributed to an increase in income inequality in many countries. Sometimes referred to as the "disappearance of the middle class", labor market polarization affects a wide range of economic policy issues, including employment, education, trade and taxation.

There are various estimates of factors affecting labor polarization. Several polarization models have been used to explain wage inequality given the rapid growth in the relative demand for technical skills (the SBTC hypothesis). Therewith, the demand for labor resources with high and low wages is growing due to jobs having an average wage level (Manyika et al, 2017; Acemoglu & Autor 2011; Autor et al, 2008). However, some authors argue that the “routinization” hypothesis (ALM hypothesis) explains labor polarization much better (Autor et al, 2003; Goos & Manning, 2007; Spitz, 2003). The ALM hypothesis states that industries with a widespread application of routine skills subsequently adopted digital technologies at the fastest rate, which reduced the degree of routine skills in these industries.

Digital technology application in production brings significant advantages over traditional technologies. Researchers found that the transition from traditional technology to robotics in agriculture significantly reduces production labor intensity, increases labor productivity (Ivanov & Lapkin 2013), and increases product quality (Wauters & Mathijs, 2004; Mikulova, 2011). However, many aspects related to labor resource formation in agriculture in the context of digital transformation have not been theoretically and methodically explored. This makes it necessary to study the problems of forecasting labor resource development and the influence of the main laws of

the labor sphere under the digital transformation of agriculture.

The purpose of this study is to identify patterns of labor resource formation, including labor polarization, under the digital transformation of agricultural organizations in the region. This study analyzes the impact of agricultural robotization in the Ural on the gender and age composition of workers and their education level, builds a model of the demand for labor resources in agricultural organizations using digital technologies, identifies agricultural profession groups by the nature of changes in employment, and investigates labor polarization in agricultural organizations using digital technologies.

The digital transformation of agriculture has a significant impact on labor resource formation. This is reflected in the departmental program "Digital Agriculture", according to which it is planned to increase labor productivity by 2 times per worker in the period from 2019-2024. The share of trained specialists of agricultural enterprises having competencies in the field of the digital economy in handling digital products and technologies shall reach 50% by 2024. From 2019-2024, RUB 5,368.0 million will be allocated towards the creation of a system of continuous training of specialists of agricultural enterprises to gain competences in the field of the digital economy. RUB 650.0 million will be allocated towards research to determine the demand for highly qualified agriculture specialists with competencies in the field of the digital economy, to create an institutional framework for the digital transformation of agriculture, to force a technological breakthrough in the agro-industrial complex through the introduction of digital technologies and platform solutions. RUB 3,300.0 million is planned to be allocated towards the creation of an industry-wide electronic educational environment called "Land of Knowledge" for remote training of specialists of agricultural enterprises in Russia. RUB 62.5 million has been allocated for carrying out activities on vocational guidance of schoolchildren, for training in agricultural areas, at the secondary professional and higher professional education level. Under this program, RUB 1355.5 million will be set aside for retraining specialists of agricultural enterprises, including those who were earlier dismissed as a result of the introduction of digital products and technologies between 2019-2024.

2 METHODOLOGY

It seems relevant to study labor resource formation in agricultural organizations using digital technologies. The main hypothesis is that digital technology application in agriculture has a significant impact on the nature of the labor resource formation in agriculture. First, job creation (reduction) dynamics in the departments of agricultural organizations using robotics in production must be studied. This will reveal the impact of robotics on the workforce quantitative composition (by gender, age, and education level) in organizations in the industry. In turn, the analysis will allow us to draw reasonable conclusions on the degree of influence of labor polarization under agricultural digitalization.

The research methods include expert interviews with managers and specialists of 100% agricultural organizations using robotics in production, which allows considering the sample representative. All of all, 15 agricultural organizations from the Sverdlovsk Region were involved

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in the study. To study labor polarization in the industry, an analysis of the rates of decline (increase) in employment by profession depending on the wage grades in agricultural organizations using digital technologies was made. Dialectical and abstract-logical methods were used to achieve the above objective. The monographic method was used to highlight scientists' opinions on the research problem. The comparative and analysis method and the graphic method were used to analyze trends in labor resource formation under digitalization.

Data on labor intensity for various categories of workers were used to study the effects of labor polarization in agriculture. Thus, data from agricultural organizations were used to calculate labor intensity for various professions. Service norms of the wildlife population per capita were used to calculate the change in the share of the profession under robotization. Thus, data on labor intensity reduction (increase) modeled for people working in functional locations with robotics was obtained.

Solving the research problems will contribute to the development of appropriate public policy measures aimed at forming the industry's labor resources, using the technological breakthroughs associated with digital technology development. This will also help identify potential threats to the formation of agricultural labor resources and develop appropriate measures on the part of the state and economic entities, develop and implement a strategy to combat these threats.

3 DIGITAL TECHNOLOGY APPLICATION IN THE REGION'S AGRICULTURE

At present, digital transformation is significantly changing the nature of social reproduction. Depending on the specialization area, level and size of agricultural production, various digital technologies are under development or are already applied. Those can be classified into different groups.

Firstly, fundamentally new types of tools are appearing in agriculture. These include robotics, artificial intelligence and the Internet of Things technologies, as well as data collection and analysis technologies. Their application will significantly increase labor productivity and agricultural production and management efficiency. Objects of labor are undergoing significant transformations. If previously, the main objects were raw materials, under the influence of scientific and technological progress, information and big data sets are becoming the main objects of labor in agriculture. The main digital products and technologies in agriculture at the present stage can be summarized as presented in Table 1.

Scientific and technological progress is causing agricultural production and management technology to undergo significant changes. At present, digital technologies emerge at an increasing rate, which allows applying precision technologies in agriculture, precision animal husbandry, etc. Digital technology application, particularly robotics in agriculture, increases labor productivity (Castro et al., 2012; Gustafsson, Benfalk, 2004) and reduces production costs (Tse et al., 2018; Aykut et al., 2018).

There is a need to clarify the concept of the digital transformation of agriculture. In our view, digital transformation of agriculture is an objective process of continuous improvement and quality upgrade of production using digital technologies, especially technologies of the Internet of Things, artificial intelligence, big data analytics and robotics, reflected in the creation and development of new knowledge, tools and objects of labor, technical means of control, and influencing the

formation of labor resources.

Table 1: Main digital products and technologies used in agriculture at the present (compiled by the authors).

Technology	Fundamentals
Robotics	technical means, i.e., a set of automatic programmable equipment performing agricultural production operations or other operations with high accuracy and repeatability independently or via operator commands (Skvortsov, 2018)
Internet of Things, IoT (Ashton, 2009)	they are a set of equipment and sensors connected to the Internet, tools for collecting and storing data in real time, means of processing this data into useful information and providing it to users via appropriate interfaces
Artificial Intelligence, AI	technical means, i.e., separate technical solutions based on computer programs having some features of intelligent systems, capable of self-learning and aimed at solving specific agricultural production problems (Skvortsov et al., 2019)
ERP (Enterprise Resource Planning) systems	standardized software packages, organizational strategy for integrating production and operations, human resources management, financial management and asset management, focused on continuous balancing and optimization of enterprise resources via a specialized integrated application software package providing a shared data and process model for all areas of activity (Haddara & Elragal, 2013; Akkermans & Van Helden, 2002; Peng & Gala, 2014)

It is known from empirical observations that these technologies are mainly represented in agricultural organizations by robotics, including those used in milking. The Ministry of Agriculture and Food of the Sverdlovsk Region reports that as of January 1, 2019, 43 robotic milking units and two feed equalizer robots have been installed and are in use (Figure 1).

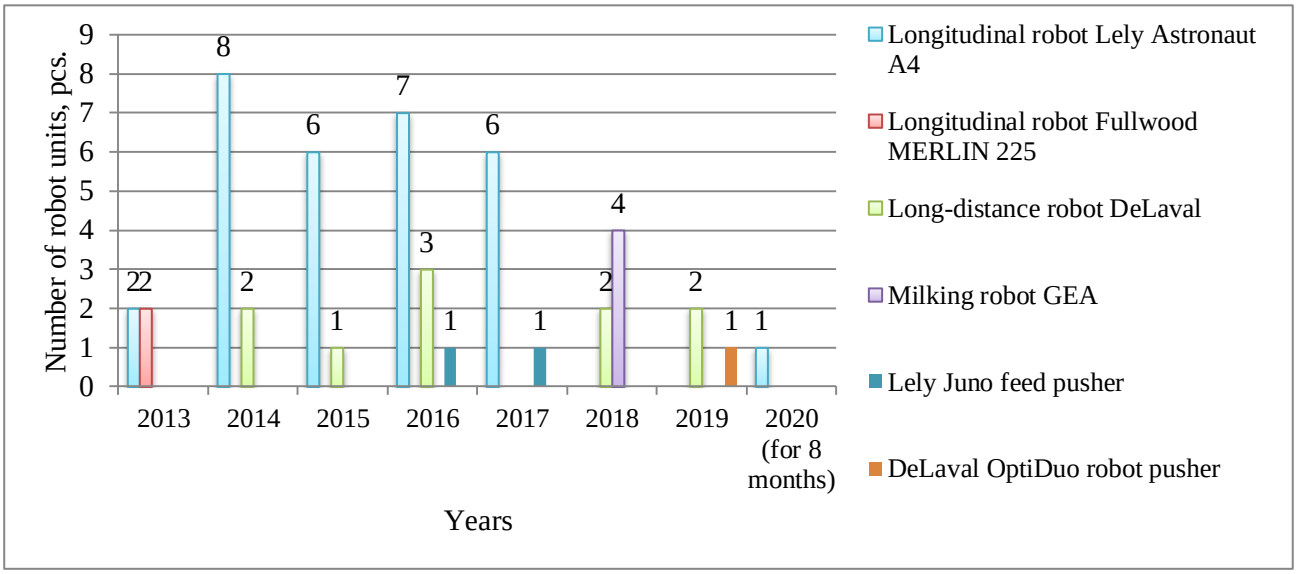

Figure 1: Dynamics of the introduction of robotics in agriculture in the Sverdlovsk Region (Compiled by the authors).

As can be seen from the figure, various brands of robotics are used in agricultural organizations. These are mainly milking robots; however, feed-trimmers are also being used. The most common brand is the milking robots of the Dutch company Lely because of their attractiveness to farmers in terms of price. A significant share is taken by milking robots of the Swedish company DeLaval due to the quality of its equipment and its high level of service.

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4 POLARIZATION OF LABOR IN AGRICULTURE IN THE REGION

Data from agricultural organizations in the Sverdlovsk Region for 2013-2020 (for 8 months), allows drawing a reasonable conclusion on labor polarization in the industry. The period under review experiences an intensive introduction of robotics into production. Data on business entities reveals exactly how polarization occurs during the period under review at the level of agricultural organizations. This becomes particularly relevant since it is the business entities that make decisions in the field of employment. Previous studies on labor market polarization mainly used labor force surveys; these are relevant for studying workers and wages but provide little information about firms directly employing workers.

The total labor intensity is highlighted in cyan, data from agricultural organizations are highlighted on the chart in green; the decrease in labor intensity for a specific case in which workers occupy functional locations with robotics is highlighted in red (Figure 2).

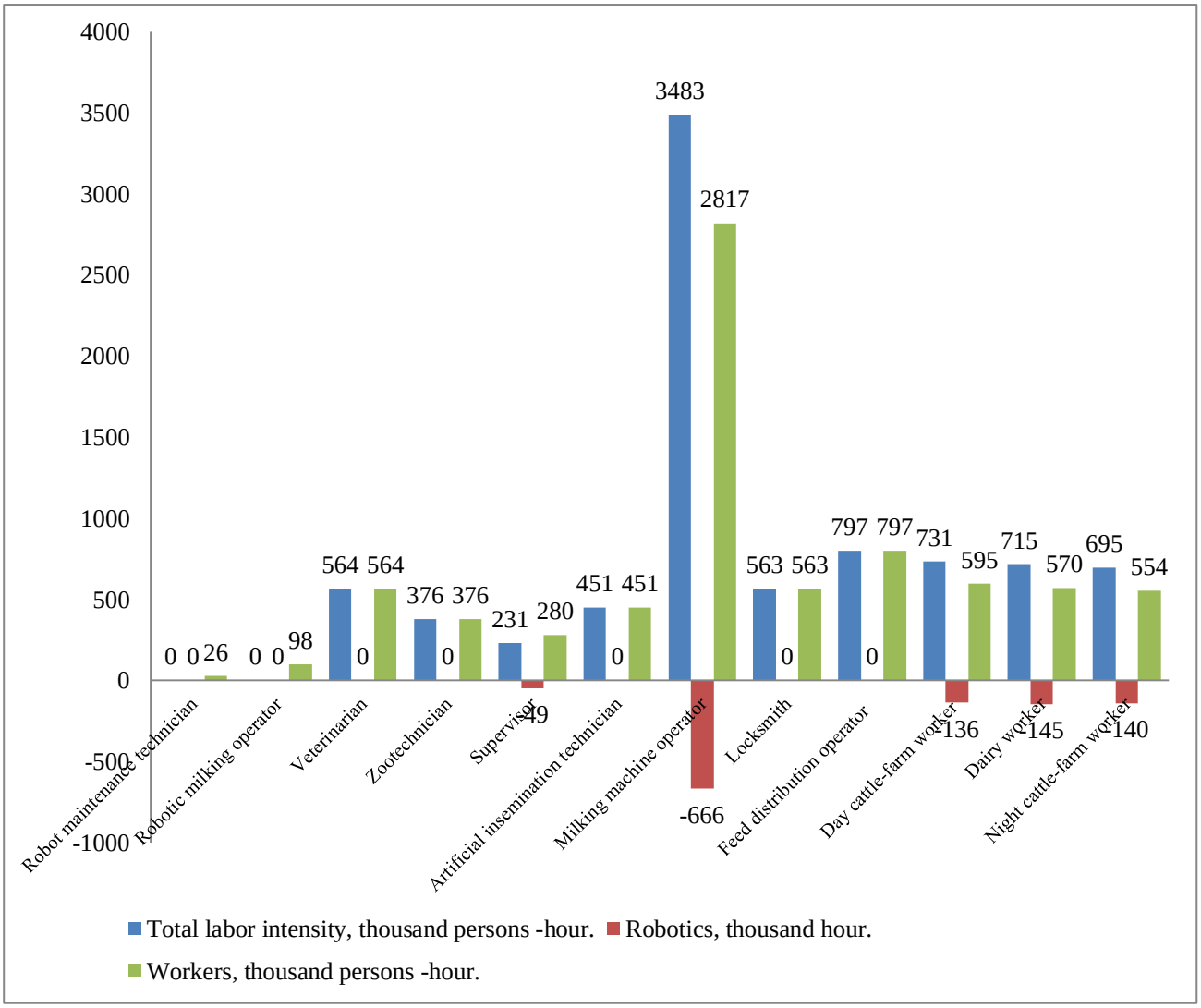

Figure 2: Time invested in agricultural organizations in the Sverdlovsk Region for 2013-2020 (2020 for 8 months) (Compiled by the authors).

The number of hours worked for some categories of workers increased, as additional jobs were created in agricultural organizations in these specialties. This primarily applies to technical specialties – robotic milking operator (98 thousand people per hour) and robot maintenance

technician (26 thousand people per hour). The largest decrease in labor intensity occurred for the position of milking machine operator (666 thousand people per hour). A significant decrease in labor intensity is noted for the positions of day cattle-farm worker (136 thousand people per hour) night cattle-farm worker (140 thousand people per hour) and dairy worker (145 thousand people per hour). A significant reduction in labor intensity is observed in the supervisor category – 49 thousand people per hour. Several categories of workers did not undergo changes in labor intensity under farm robotization. These include veterinarians, animal husbandry technicians and artificial insemination technicians.

Assessment of the rate of decline (increase) in employment by profession depending on the wage grade in agricultural organizations using digital technologies will allow drawing objective conclusions on labor polarization in the industry (Figure 3).

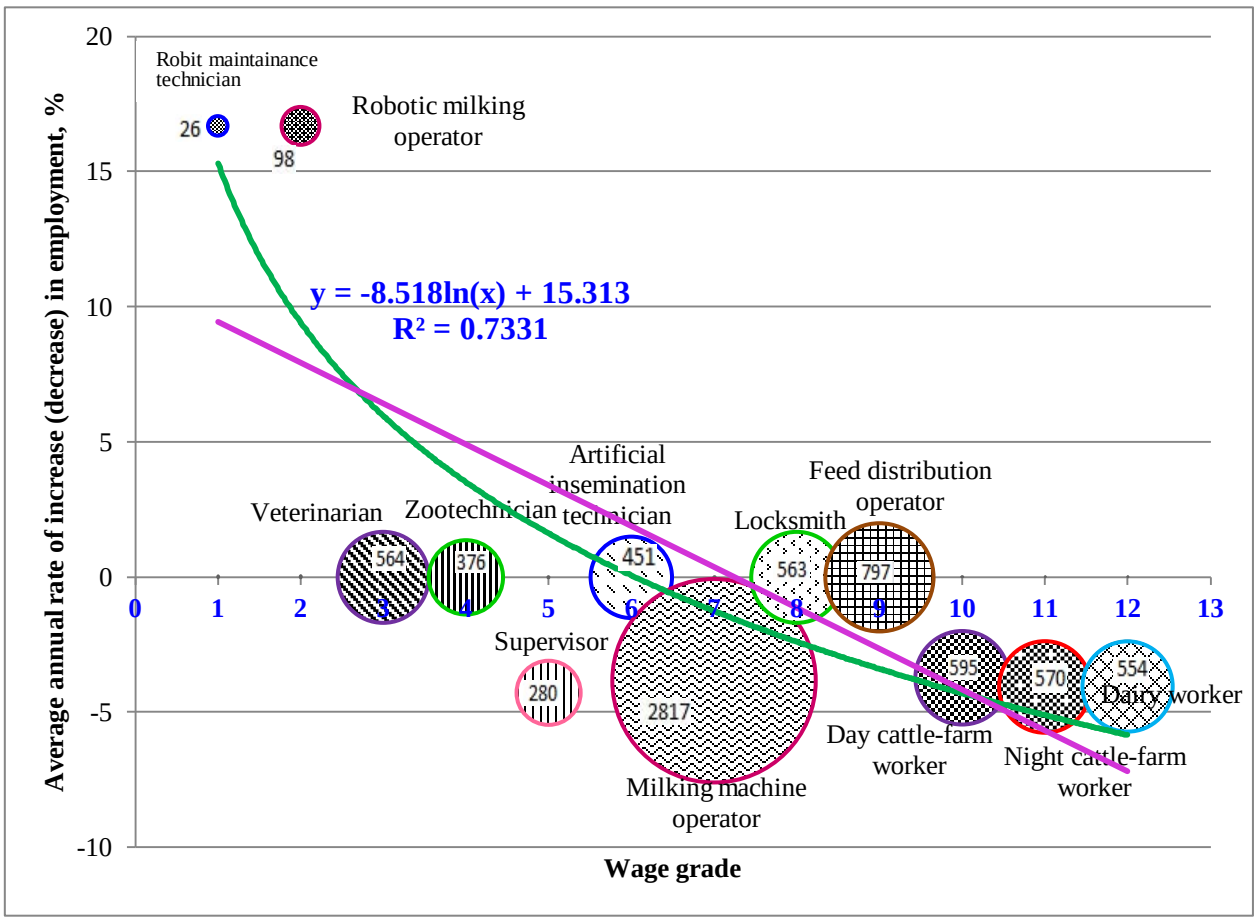

Figure 3: Change in the share of the profession depending on wage grade in agricultural organizations of the Sverdlovsk Region using robotics for 2013-2020 (2020 for 8 months), a thousand people per hour. (Compiled by the authors).

Figure 4 shows an increase under agricultural robotization for professions with the highest wage grades. Thus, the average increase in the employment of robot maintenance technicians and robotic milking operators made 16,7%, respectively. Many professions with average wage grades experience no changes in employment during the period under review. For example, veterinarians (veterinarian surgeons and paramedics) perform complex types of work involving hand manipulation that presently cannot be replaced by robots. Artificial intelligence and robotics technologies can relatively

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easily mimic the intellectual and computational abilities of an adult, but it is quite difficult to algorithmize perception and sensorimotor skills. In other words, robotics is currently not able to replace humans in such jobs as artificial insemination technician, animal technician and locksmith as their activities are difficult to algorithmize. A significant reduction in employment for the group of agricultural organizations using robotics is observed for the position of supervisor (4.3% per year). As it has already been mentioned, a significant part of this worker's functionality can be performed automatically or is no longer necessary.

Thus, it is possible to distinguish the following groups of workers (Table 2).

Table 2: Characteristics of dairy-food subcomplex workers as related to changes in the employment type. (Compiled by the authors).

Nature of employment change	Group of workers	Characteristic
Decline in employment	Foreman Milking machine operator Day cattle-farm worker Dairy worker Night cattle-farm worker	Performing operations that can be described by algorithms, monotonic, repetitive operations.
Stable employment	Veterinarian Zootechnician Artificial insemination technician Locksmith	Performing operations involving hand manipulations that are difficult to describe by algorithms
Increase in employment	Robotic milking operator Robot maintenance technician	Performing robotics maintenance operations, having engineering competencies

Thus, three groups of workers can be distinguished by the nature of the change in employment. The first group includes agricultural workers, the requirement for whom will soon decrease. This is firstly because being monotonic, repetitive operations, the operations they perform can be described by algorithms. Further scientific and technological progress and mass application of digital technologies, including robotics, will lead to the replacement of monotonic, repetitive operations performed by these workers with intelligent mechanisms and algorithms.

The second group must include workers with stable employment, the requirement for which will not decrease in the near future. This is because these categories of workers perform operations involving hand manipulations that are quite difficult to describe algorithmically. In some cases, this may be associated with the movement of objects or movement in an open area or indoors. Scientific and technological progress may result in these types of activities being described algorithmically, which will allow replacing people with robotics. However, this will not happen in the short and medium-term.

The next groups of workers are those with a projected increase in the number of workers. These categories of workers perform robotics maintenance operations and are suitably qualified to handle digital technologies. It is expected that with more rapid scientific and technological progress, workers in engineering specialties who are suitably qualified to handle digital technologies will become more and more in demand, including in agriculture.

It should be noted that this list of categories of workers is not exhaustive; it is compiled taking into account the current stage of development of digital technologies and the specifics of agriculture in the Middle Urals. Firstly, these observations relate to the dairy-food subcomplex workers;

however, with the development of digital technologies and the emergence of commercially available solutions for farmers, especially in crop production and service industries, there is reason to believe that the labor polarization process in the industry will continue to develop.

5 CONCLUSION

The general trend in the formation of agricultural labor resources under digital transformation at the present stage is to increase the professional qualification level of workers. This is due to the gradual dwindling of the functions of manual labor and the development of labor skills of interaction and casing of artificial intelligence technologies and the Internet of Things, robotics, and data processing tools. The role of mental labor is significantly increasing in comparison with physical labor, there is an increase in the creative content of labor, a decrease in working time expenditures, a significant simplification of labor and an increase in its productivity.

Empirical observations show a disappearance of old types of labor and the emergence of new ones, the complexity and strengthening of connections between specific types, which has an impact on the agricultural labor resource formation process. This subsequently leads to the need to improve workers' skills and their overall level of development to enable them to meet the high requirements imposed on them when using digital technologies. Workers must be well-versed in engineering, technology and production organization. They must also possess relevant labor skills allowing them to not only understand the entire process, but also to be able to control and, where necessary, regulate it, independently reconfigure equipment, detect problems and fix them, as well as perform routine repairs.

Digital transformation leads to a systematic reduction in the demand for unskilled labor resources and the growth of skilled labor. There is an increasing need to bring workers' skills in line with the increasingly complex production process. Therefore, the reproduction of labor resources under digital transformation, which is characterized by the active introduction of robotics, serves as an expanded reproduction of a predominantly skilled workforce.

6 AVAILABILITY OF DATA AND MATERIAL

Information can be made available by contacting the corresponding author.

7 CONFLICT OF INTERESTS

The authors confirm that the revealed information does not contain a conflict of interest.

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