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ECONOMETRIC ANALYSIS OF THE DEVELOPMENT OF LABOR POTENTIAL OF AGRO-INDUSTRIAL COMPLEX OF KAZAKHSTAN

ҚАЗАҚСТАННЫҢ АӨК ЕҢБЕК ӘЛЕУЕТІН ДАМЫТУДЫ ЭКОНОМЕТРИКАЛЫҚ ТАЛДАУ

ЭКОНОМЕТРИЧЕСКИЙ АНАЛИЗ РАЗВИТИЯ ТРУДОВОГО ПОТЕНЦИАЛА АПК КАЗАХСТАНА

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Abstract. *The goal* is to reveal the basis for the formation of labor potential in agriculture, its condition and role in socio-economic development of rural areas. Consider theoretical foundations of economic and mathematical modeling of dynamics of the formation of human resources in agro-industrial complex of Kazakhstan. *Methods* - application of methodology for carrying out forecast calculations based on econometric model in the form of a system of joint equations, tracing the connection of labor market with changes in demographic structure of the country's rural population. The study used statistical data series provided by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. An overview of government support measures aimed at increasing labor reserves in rural areas is presented. As a result of scientific research, calculation forecast models were obtained, on the basis of which the values of main statistical indicators characterizing the dynamics of labor activity in rural areas of the republic for the long-term period were determined. *Results* - ways to overcome negative trends that slow down labor activity and form effective labor

potential in rural areas are proposed: ensuring real growth in rural employment in all areas of activity; creation of additional high-performance jobs; improvement of social infrastructure. *Conclusions* - based on forecast calculations of indicators reflecting the directions of development of human capital in agricultural sector, opportunities for increasing GDP of products (services) of agriculture, forestry and fisheries have been identified. Studying the problems of rural labor economics makes it possible to note imbalances in the supply and demand of qualified specialists. In this regard, there is a need for active labor policy, stimulation of job search, training in professional skills, acquisition of a new profession.

Аңдатпа. *Мақсаты* – ауыл шаруашылығында еңбек әлеуетін қалыптастыру негіздерін, оның жай-күйін және ауылдық аумақтардың әлеуметтік-экономикалық дамуындағы рөлін ашу. Қазақстанның агроөнеркәсіптік кешенінің кадр ресурстарын қалыптастыру динамикасын экономикалық-математикалық модельдеуді жүргізудің теориялық негіздерін қарастыру. *Әдістері* – еңбек нарығының ел ауыл халқының демографиялық құрылымындағы өзгерістермен байланысын қадағалайтын бірлескен теңдеулер жүйесі түріндегі эконометрикалық модель негізінде болжамды есептеулер жүргізу әдістемесін қолдану. Зерттеу үшін Қазақстан Республикасы Стратегиялық жоспарлау және реформалар агенттігінің ұлттық статистика бюросы ұсынған деректердің статистикалық қатарлары пайдаланылған. Ауылдық жерлердің еңбек резервтерін өсіруге бағытталған мемлекеттік қолдау шараларына шолу жасалған. Жүргізілген ғылыми зерттеу нәтижесінде есепті болжамды модельдер алынған, олардың негізінде перспективалық кезеңге республиканың ауылдық аудандарының еңбек белсенділігінің серпінін сипаттайтын статистиканың негізгі көрсеткіштерінің мәндері айқындалған. *Нәтижелері* – ауылдық аумақтардың еңбек белсенділігін бәсеңдететін және тиімді еңбек әлеуетін қалыптастыратын жағымсыз үрдістерді еңсеру тәсілдері: қызметтің барлық салаларында ауылда жұмыспен қамтудың нақты өсуін қамтамасыз ету; қосымша жоғары өнімді жұмыс орындарын құру; әлеуметтік инфрақұрылымды жетілдіру ұсынылған. *Қорытындылар* – аграрлық сектордың адами капиталын дамыту бағыттарын көрсететін көрсеткіштердің болжамды есептеулерінің негізінде ауыл, орман және балық шаруашылығы өнімдерінің (көрсетілетін қызметтерінің) ЖІӨ ұлғайту мүмкіндіктері анықталған. Ауылдық еңбек экономикасының проблемаларын зерделеу білікті мамандардың сұранысы мен ұсынысының сәйкессіздігін атап өтуге мүмкіндік береді. Осыған байланысты еңбек саласында белсенді саясат жүргізу, жұмыс іздеуді ынталандыру, кәсіптік дағдыларды үйрету, жаңа мамандық алу қажеттілігі туындайды.

Аннотация. *Цель* – раскрыть основы формирования трудового потенциала в сельском хозяйстве, его состояние и роль в социально-экономическом развитии сельских территорий. Рассмотреть теоретические основы проведения экономико-математического моделирования динамики формирования кадровых ресурсов агропромышленного комплекса Казахстана. *Методы* – применение методики проведения прогнозных расчетов на базе эконометрической модели в форме системы совместных уравнений, прослеживающей связь рынка труда с изменениями в демографической структуре сельского населения страны. Для исследования использованы статистические ряды данных, предоставленные Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Представлен обзор мер государственной поддержки, направленных на рост трудовых резервов сельской местности. В результате проведенного научного исследования получены расчетные прогнозные модели, на основании которых определены значения основных показателей статистики, характеризующих динамику трудовой активности сельских районов республики на перспективный период. *Результаты* – предложены способы преодоления негативных тенденций, замедляющих трудовую активность и формирования эффективного трудового потенциала сельских территорий: обеспечение реального роста занятости на селе во всех сферах деятельности; создание дополнительных высокопроизводительных рабочих мест; совершенствование социальной инфраструктуры. *Выводы* – на основании прогнозных расчетов показателей, отражающих направления развития человеческого капитала аграрного сектора выявлены возможности увеличения ВВП продукции (услуг) сельского, лесного и рыбного хозяйства. Изучение проблем экономики сельского труда позволяет отметить диспропорции спроса и предложения квалифицированных специалистов. В связи с этим возникает необходимость активной политики в трудовой сфере, стимулирования поиска работы, обучения профессиональным навыкам, приобретения новой профессии.

Key words: rural areas, labor potential, employment, high-performance jobs, professional skills, social infrastructure, demographic factors.

Түйінді сөздер: ауылдық аумақтар, еңбек әлеуеті, халықты жұмыспен қамту, жоғары өнімді жұмыс орындары, кәсіптік дағдылар, әлеуметтік инфрақұрылым, демографиялық факторлар.

Ключевые слова: сельские территории, трудовой потенциал, занятость населения, высокопроизводительные рабочие места, профессиональные навыки, социальная инфраструктура, демографические факторы.

Introduction

High-quality strategic development of rural areas is becoming a key element for the state, since it has significant impact on ensuring food security. To achieve this important task, it is necessary to identify strategic priorities aimed at supporting the development of rural areas in Kazakhstan.

The study of rural areas remains a priority topic for many scientists around the world, including researchers from Kazakhstan. The concept of «rural development» is not only subject to different interpretations, but has also actively evolved in recent decades as a concept, reflecting different points of view.

The connection between labor potential and rural progress is a complex and significant interaction that has a significant impact on socio-economic situation of rural population and development of agricultural sector.

Labour migration is not insignificant in helping to develop rural areas. Thus, labour migration contributes to the abandonment of agricultural land by rural households, which has a negative impact on the development of rural areas (Dingde Xu, Xin Deng, Shili Guo et al.) [1].

In addition, labour force is the main part of agro-industrial complex because, rural labour force affects the willingness of farmers in different regions to influence the scale of exploitation of cultivated land and the adoption of agricultural machinery technology. At the same time, in the process of farming, the demonstration of income effect, extension ef-fect, the distribution of farmers' resources in the form of local labour, chemical fertilizers, pesticides, agricultural machinery, land and other factors affect the distribution of resource factors among farmers in other regions (Zhang Weikun, Liang Hanyuan, Chen Zhe et al.) [2].

The purpose of this study is to research the relationship between labour potential and rural development. This issue represents a complex balance between various economic, social and demographic factors, which requires careful and comprehensive analysis to ensure the sustainability and well-being of rural areas (Akimbekova Ch.U.) [3].

The government's employment policy has acquired an important social status in ensuring stability in the labour market. As part of the Kazakhstan-2050 strategy, the Employment Roadmap programme was an important step towards achieving the goals. It has created new jobs and increased incomes. It has also contributed to the creation of sustainable and productive employment for unemployed citizens, as well as for those who cannot find a job due to lack of means.

Literature Review

In general, significant attention has been paid to the development of agro-industrial complex in a number of studies. Some of the works focus on studying institutional changes in agricultural and industrial sectors.

The significance of labor potential and its role in public administration and regulation of the agro-industrial complex is the primary focus of scientific research.

These scientific studies were carried out in various periods by such scientists as (Lovchikova E.I., Zvereva G.P., Volchkova A.S.; Proka N.I; Cherdancev V.P.) [4-6].

The studies by Lovchikova E.I., Zvereva G.P., Volchkova A.S. [4], who pay much attention to the study of staffing of agricultural organizations, the peculiarities of motivation and stimulation of labour activity of personnel in agriculture, the study of the main trends in the development of personnel of agricultural organizations, who also formulated the main directions for improving the staffing of agriculture, are of no small importance

The significance of the problem of personnel potential development, its modern role in ensuring the competitiveness of the economy, aggravated by structural changes in the country's personnel potential, especially in agriculture is revealed in his works by (Proka N.I.) [5]

Cherdantsev's V.P. [6] studies are related to the problems of the quality of human resources and human resources potential of agro-industrial and fishery complexes

Kaliev G.A.; Moldashev A.B., Akimbekova Ch.U, Zhumasheva S.T. at al.; Belgibayeva A.S., Musina A.J., Volokhova M.A. [7-9] take active part in Kazakhstani research on the AIC and issues of labor potential and food security. Kerimova U.K., Kasenbaev G.S.; Nurzhanova G.I., Saparova G.K., Saginova S.A. [10, 11] are involved in study of the issues of agricultural development, including issues of ensuring its sustainability.

Numerous scientific studies are devoted to the issues of development and modernization of AIC. A number of works highlight issues of institutional changes in agricultural sector.

The article also considers and studies the work of Putsenteilo P., Klapkiv Y., Karpenko V. at al. [12] which is based on the study of the possibilities of institutional system reform of the agrarian sector, where the researchers studied the formation and development of agrarian institutionalism, which fulfils a key role in the agrarian economy of the region. According to researchers, it was these institutional changes, which arose as a side effect of industry modernization, that contributed to the evolution of the entire agro-industrial complex.

Research indicates that such changes are driven by fluctuations in relative input prices, as well as evolution of organizational structures and institutions between enterprises and agro-industrial production sectors.

Materials and methods

The modern process of modernization of agriculture is the result of the interaction of many factors, covering not only the introduction of innovations, but also physical, economic, organizational, cultural and motivational aspects. Despite the diversity and varying the importance of these factors, and the impossibility of achieving high level for all of them at the same time, it is possible for them to gradually accumulate and improve over a long period of time.

Specifics of agricultural modernization are associated with a high level of risks. Agricultural producers are limited in their ability to quickly adapt to changes in market conditions. In addition, agriculture is characterized by dynamic properties inherent in certain types of fixed assets, such as machines and tractors and vehicles. These elements change their spatial location and nature of work over time, which determines the high controllability of this part of fixed assets in agriculture.

At the end of 2022, the rate of depreciation of fixed assets in agricultural sector was 36.4%, while the rate of renewal of fixed assets was only 15.2%. Our estimates indicate that these figures are significantly underestimated, taking into account that the wear and tear of fixed assets in agriculture is one of the important problems of this industry (Bureau of National Statistics of the Agency…) [13].

In accordance with the existing Concept of the AIC, it's noted that the level of wear and tear of the machines and tractors in agricultural sector is on average 76% (80% for tractors and 72% for combines). The material and technical base of hydrogeological and reclamation services has remained without updates for more than 10 years, while almost all fixed assets in this area have almost 100% wear and tear - buildings and structures, vehicles are in poor conditions or unusable technical condition. Due to limited resources, many peasant and private farms cannot afford to update their machines and tractors and other fixed assets and key assets.

In our opinion, one of reasons for high level of wear and tear in agriculture is underdevelopment of investment lending and leasing market. As mentioned earlier, instead of solving problems in agricultural lending market, the state continues to provide preferential loans at low interest rates through development institutions. Since the volumes of preferential lending are limited, large agricultural enterprises are usually the main recipients of such loans.

Moreover, the lack of private ownership of agricultural land sharply reduces the availability of lending due to limited opportunities for providing land as collateral. In addition to this, it is worth noting general underdevelopment of the service system, including the limited efficiency of processes for restoring parts of agricultural machinery.

However, studies of the state, trends and prospects for development of agricultural production factors in conditions of active modernization of agricultural industry are not given due attention. The study of interaction of agricultural production factors is insufficiently studied area.

In addition, the shortage of agricultural workers limits access to quality agricultural products, which can be significantly exacerbated if there is an imbalance in the distribution of labour resources and affect the food security of the country (Rahmatullina L.I.) [14].

Practice requires clarification of the models proposed in scientific researches for forecasting the prospects for the development and modernization of the AIC in order to obtain results that are more adequate to current circumstances in the interests of solving the problems of preparation and development of the AIC, capable of making the transition to innovative model of agricultural production.

Result

In applied economic and mathematical analysis and forecasting, modelling of multidimensional time series is particularly emphasized with the use of regression and correlation analysis. The models developed in this area make it possible to represent with a sufficient degree of accuracy the relationships between the indicators under study, and also make it possible to assess the degree of influence exerted on the results.

We will use a multifactor data analysis to identify patterns in the change of the process being studied, with an example of this using forecasting of the indicators. Time series data of the factors studied for the period 2017-2022 is utilized in the following calculations (table 1).

Let's introduce symbols for constructing a system of equations for econometric multifactor model (table 2).

Table 1 – Factors that affect labour potential development in rural areas during the period of 2017 to 2022

	2017	2018	2019	2020	2021	2022
Gross output of products (services) of agriculture, forestry and fisheries, million tenge	3 817 237,1	4 497 585,4	5 177 893,7	6 363976,1	7 549827,9	9 521 002,3
Rural housing stock, total area of housing, at the end of the year, million sq. m.	127 332	130 297	132 877	134 494	137 481	141 237
Fixed assets in kind:						
Production of tractors for agriculture and forestry, pieces	292	350	1 047	2 398	5 160	5 384
Production of seeders, planters and transplanters, pieces	185	236	223	197	238	235
Mower production, including tractor-mounted mowers, not included into other groups, pieces	69	155	238	383	491	588
Average monthly nominal wage per employee by economic sector Agriculture, forestry and fisheries), tenge	70 959	97 929	115 371	130 178	150 705	190 086
Rural population, thousand people	3 840,1	3 861,4	3 830,7	3 768,6	3765,0	3 646,5
Rural population by level of education, higher, thousand people	835	906,5	886,6	1 054,5	959,6	1 121,1
Rural population by level of education, secondary specialized, thousand people	1 353,8	1 434,4	1 521,1	1 346,6	1 540,6	1 673,8
Rural population by level of education, general secondary, thousand people.	917,4	898,9	869,6	853,5	505,1	429,5
Note: the table is compiled according to the source data from (Bureau of National Statistics of the Agency…) [13]						

In our opinion, the presented factor characteristics cover the main components characterizing the dynamics of development of labor potential of rural areas, and by introducing the appropriate degree of detail into the selected numerical indicators of statistical data, the opportunity is provided for modeling and analyzing their development in the process of dynamics (1).

$$\begin{cases} Y = a_0 + a_1 \cdot X_1 + a_2 \cdot X_3 + a_2 \cdot X_7 \\ \mathrm{X}_1 = a_0 + a_1 \cdot X_2 \\ \mathrm{X}_3 = a_0 + a_1 \cdot X_4 + a_2 \cdot X_5 + a_2 \cdot X_6 \end{cases} \quad (1)$$

Table 2 – Symbols of main statistical indicators characterizing the dynamics of development of labor potential of rural areas in the Republic of Kazakhstan

Factor Designation	Name of factor	Unit of measurement
Y	Gross output of products (services) of agriculture, forestry and fisheries	mln tenge
X_1	Rural population	thous.people
X_2	Rural housing stock, total area of dwellings, at the end of the year	mln sq.m
X_3	Average monthly nominal wage per employee by economic sector (Agriculture, forestry and fisheries)	tenge
X_4	Rural population by level of education, higher	thous.people
X_5	Rural population by level of education, secondary specialized	thous.people
X_6	Rural population by level of education, secondary general	thous.people
X_7	Production of tractors for agriculture and forestry	pieces
Note: table compiled by the authors		

Based on the findings of several authors' research, the model built upon dynamics of economic processes provides quite satisfactory results for forecast values. It is appropriate to apply the methodology used in this study to construct a dynamic model of multifactor forecasting (Zamkov O.O., Tolsto-pyatenko A.V., Cheremnyh Yu.N.) [15].

On the example of the first equation of the multifactor model we will carry out a quantitative analysis and forecast of the selected factor indicators.

In each specific year, a multifactor model is created for each time period L under study, which should take into account the lack of dependence between the explanatory variables of the regression model and the rationale for the analytical type of the model. Estimates of the main factor should be not only comparable, but also efficient as well as wealthy in the time period under study (Garmash A.N., Orlova I.V., Fedoseev V.V.) [16] (2):

$$\hat{Y}_l = a_0 x_0 + a_1 x_1 + a_2 x_2 + ... + a_m x_m \quad (2)$$

where Y_l is modeled indicator of the l year;

x_i -factors influencing on this indicator, i= $\overline{0,m}$;

a_i – coefficients of model equation, i = $\overline{0,m}$;

m – number of factor characteristics.

The resulting regression equation has the following form (3):

$$Y = 8645748,16 + 225,05 \cdot X_1 - 8724,57 \cdot X_3 + 159,17 \cdot X_7 \quad (3)$$

Try to perform statistical analysis of the obtained regression equation, i.e. check the significance and value of the equation, its coefficients and identify absolute and relative errors of approximation.

To estimate the unbiased variance, we need to perform the following calculations:

Unbiased error ε = Y - Y(x) = Y - X*s (absolute approximation error) ULT (table 3).

Table 3 – Calculated parameters of regression equation

Y	Y(x)	ε = Y - Y(x)	$ε^2$	$(Y\text{-}Ycp)^2$	|ε : Y|
3 817 237,1	3 845 471,91	-28 234,81	797 204 121,93	5 463 204 944 588,3	0,0074
4 497 585,4	4 336 152,93	161 432,46	26 060 440 656,46	2 745 654 578 569,5	0,0359
5 177 893,7	5 295 575,97	-117 682,27	13 849 117 131,42	953 929 965 047,1	0,0227
6 363 976,1	6 416 321,76	-52 345,65	2 740 067 922,35	43 843 760 300,6	0,00823
7 549 827,9	7 559 592,45	-9 764,55	95 346 467,78	1 946 696 936 492,7	0,00129
9 521 002,3	9 474 407,48	46 594,82	2 171 077 292,92	11 332 751 411 005,0	0,00489
			45 713 253 592,86	22 486 081 596 003,0	0,0804
Note: calculated by the authors					

Calculated unbiased variance estimate (4):

$$s^2 = \frac{1}{n-m-1} \cdot s_e^2 = \frac{1}{6-3-1} \cdot 45713253592{,}8 = 22486081596003 \quad (4)$$

Next, the value of standard deviation (5) is assessed:

$$S = \sqrt{S^2} = \sqrt{22486081596003} = 151184{,}082 \quad (5)$$

The next step is to calculate standardized regression coefficients - β-coefficients (β_i). These coefficients show by what part of standard deviation of the variable Y will change when the factor X_i changes by one standard deviation (S_{xi}), provided that the remaining factors remain unchanged in the model.

Based on the β_i maximum value, it is possible to estimate which factor has a more significant impact on the Y variable.

Based on elasticity coefficients and β-coefficients, opposite conclusions can be drawn. This may be due to:

a) large variation in one of the factors;

b) various directions of influence of factors on the result.

The coefficient β_i can also be interpreted as a measure of the direct impact of the j- factor (xj) on the dependent variable (y). In multiple regression, the j- factor has not only a direct, but also indirect effect on the result (that is, through other factors in the model).

The indirect impact is assessed through the value: $\sum \beta_i r_{xj,xi}$, where m - factors in the model. The total influence of the j- factor on the result appears, which is equal to the sum of the direct and indirect impacts, and evaluates the linear pair correlation coefficient of this factor and the result - $r_{xj,xi}$.

In the ongoing analysis, it is important to note that the direct impact of the factor (X1) on the resulting sign (Y) in the regression equation is characterised by the value of the coefficient βj, which according to these calculations is 0.529 .

The next most important step in analysing the equation of a multifactor model is the calculation of the multiple correlation coefficient, which provides information about the degree of interrelation between the considered factor variables.

The calculated multiple correlation coefficient (R) (6) provides an estimate of the extent to which the factors involved in the model equation jointly influence the outcome:

$$R = \sqrt{1-\frac{S_e^2}{\sum(y_i-\bar{y})^2}} = \sqrt{1-\frac{45713253592{,}861}{22486081596003}} = 0{,}997 \quad (6)$$

Next, the hypotheses regarding the coefficients of the regression equation are tested to determine the statistical significance of the parameters of the multiple regression equation.

The result of the t-criterion obtained from the observations is compared with the tabulated value of the t-criterion, which is determined on the basis of Student's distribution tables. Such tables are usually found at the end of textbooks and workshops in statistics or econometrics. The tabulated value depends on the chosen significance level (*a*) and the number of degrees of freedom, which for linear paired regression is (*n-2*), where n is the number of observations.

If the observed value of the t-criterion exceeds the tabulated value (modulo), the main hypothesis is rejected. This means that with probability (*1-a*) the parameter or statistical characteristic in the general population has a significant difference from zero.

If the observed value of the t-criterion is less than the tabulated value (modulo), then there is no sufficient reason to reject the main hypothesis. That is, the parameter or statistical characteristic in the general population has no significant difference from zero at a given significance level *a.*

For our ongoing study, the results of calculations of statistical significance of estimates of regression coefficients b0, b1, b2, b3 do not fully correspond to the calculated values.

Next, we will make calculations to determine the confidence intervals of regression equation coefficients.

Let's define confidence intervals for regression coefficients with confidence level of 95%:

$$(b_i - t_{табл} \times S_{bi}; b_i + t_{табл} \times S_{bi})$$

b_0: (8645748,16 – 6,205×12350181,34; 8645748,16 + 6,205×12350181,34) = = (-67987127,07; 85278623,39)

Since calculated interval includes 0, the coefficient b_0 is not significant.

b_1: (225,053 – 6,205×46,151 ; 225,053 + 6,205×46,151) = (-61,312; 511,42)

Since calculated interval includes 0, coefficient b_1 is not significant.

b_2: (-8724,569 – 6,205×2120,525 ; -8724,569 + 6,205×2120,525) = (-21882,424; 4433,287)

Since calculated interval includes 0, the coefficient b_2 is not significant.

$$b_3: (159,17 – 6,205×86,244 ; 159,17 + 6,205×86,244) = (-375,971; 694,312)$$

Since the calculated interval includes 0, coefficient b_3 is not significant.

Therefore, the determination index will be calculated as follows (7):

$$R^2 = 1 - \frac{s_e^2}{\sum(y_i - \bar{y})^2} = 1 - \frac{45713253592,861}{22486081596003} = 0,998 \quad (7)$$

There is a significant connection between the Y variable and impact factors X_i. Assessment of the overall quality of multiple regression equation involves testing the hypothesis that the coefficient of determination calculated from the population data (R^2 или $b_1 = b_2 = ... = b_m = 0$) is zero. This test refers to identifying the degree of non-significance of regression equation based on population data.

The conducted analysis uses Fisher's F test to perform this test. In this context, actual (observed) value of the F-test is determined, which is calculated based on R^2 determination coefficient, obtained from specific observational data.

Additionally, one can consider joint significance assumption, which means that all regression coefficients associated with the explanatory variables are simultaneously equal to zero.

To test this hypothesis, the Fisher distribution F statistic is used for one-sided testing.

If $F < F_{кр} = F_{α : n-m-1}$, then in this case there are no proper grounds for completely rejecting the H_0 hypothesis.

The value for a certain number of degrees of freedom is tabulated: $k_1 = 3$ and $k_2 = n–m–1 = 6–3–1 = 2$, Fkp (3;2) = 19,1643.

Since the observed F value exceeds the critical value $F_{кр}$, this indicates the statistical significance of determination coefficient and reliability of regression equation. It is also confirmed that coefficients for X_i factors are statistically significant.

During the analysis, a multiple regression equation was obtained:

$$Y = 8645748,16 + 225,05 \cdot X_1 – 8724,57 \cdot X_3 + 159,17 \cdot X_7$$

The parameters of the resulting multifactor model can be explained from economic point of view as follows:

- when the factor characteristic “Rural population” increases by one unit, the average value of the variable “Gross output of products (services) of agriculture, forestry and fisheries” increases by average of 225.05 units;
- increase in the “Average monthly nominal wage of one employee by economic sectors (agriculture, forestry and fisheries)” by one unit leads to a decrease in the average value of “Gross output of products (services) of agriculture, forestry and fisheries” by 8724.57 units;
- increase in indicator “Production of tractors for agriculture and forestry” by one unit leads to average increase in value of the factor “Gross output of products (services) of agriculture, forestry and fisheries” by 159.17 units;
- based on maximum coefficient β1 = 0.529, we can conclude that factor “Rural Population number” itself has the greatest impact on the result of “Rural Population number” indicator.

The determination coefficient and Fisher's test confirm statistical significance of the equation. The analysis showed that in the considered case, changes in both X_i factors explain 99.81% of the total variability in the result.

The next step in using mathematical forecasting method based on time series was to carry out forecast calculations for the remaining key statistical indicators reflecting the dynamics of development of agricultural sector of Kazakhstan (table 4).

Table 4 – Forecast statistical data describing trends in the development of rural labour potential in the Republic of Kazakhstan for the period from 2023 to 2025

Year	Forecast	Equation Characteristics
Y – Gross output of agricultural products (services), forestry and fisheries, million tenge		
2023	10040750,67	Model equation: $Y = 8645748,16 + 225,05 \cdot X_1 – 8724,57 \cdot X_3 + 159,17 \cdot X_7$ $R^2 = 0,998$ F_ calc = 327,26 Sy = 151184,08
2024	11151083,13	
2025	12261415,58	
X_1 – Rural population number, thousand people		
2023	143222	Model equation:
2024	145871	

2025	148519	X_1 = 118922,65 + 0,1194 · X_2 R^2 = 0,995 F_calc = 820,51 Sy = 496,95
X_3 – Average monthly nominal wage per employee by economic sector (Agriculture, forestry and fisheries), tenge		
2023	202748	Model equation: Y = – 184101,93 + 206,87 · X_4 + 102,32 · X_5 – 53,64 · X_6 R^2 = 0,976 F_ calc = 28,09 Sy = 13407,83
2024	224713	
2025	246678	
Note: table compiled by the authors		

Thus, the models presented in Table 3 describe organizational and economic mechanism of functioning of agro-industrial complex at various levels: macro and micro levels. This mechanism can be abstracted and divided into several groups: administrative (managerial), financial-economic and material-technical. Each of these groups includes factors and mechanisms that influence both on current operational activities of AIC and its modernization.

Discussions

Based on a combination of demographic, economic and social factors, it is possible to determine the role of labour resources in the structure of resource potential of the agro-industrial complex. Demographic factors include such factors as: birth rate, mortality and migration of the population, the size of the population and its labour resources. Economic conditions play a huge role in the formation of labour resources. They include the level of wages, availability of jobs and prospects for their development, as well as housing and engineering infrastructure.

Social factors, including living conditions, benefits and availability of social infrastructure, have a significant impact on social support for workers (Kydyrbaeva E.O., Baidybekova S.K., Shomshekova B.K.) [17].

In recent years, the main problem of staffing in agricultural sector of economy has been the reduction in the number of people, in particular young people, who want to work in agriculture.

The agricultural industry is experiencing a shortage of qualified agricultural personnel and, as a result, low labor productivity, low wages, etc.

As a result, most people move from rural areas to cities in search of work (National project for the development of the agro-industrial complex…) [18].

According to a number of scientists and specialists, in the near future there will be an increase in the demand for workers who have not only competencies in the field of agricultural production, but also the knowledge which is necessary to work with digital devices and robotic systems. This, in turn, it creates an urgent need for the formation and constant updating of these competencies among existing and potential industry workers (Dolgushkin N.K., Novikov V.G.) [19].

It should be noted that the potential of rural labor market is enormous. Rural territories must combine both the economy and society, and also provide them with close relationship that promotes the sustainable development of these territories. However, it is necessary to take into account that only the presence of rural economy and its growth will increase the demand for labor of the rural population, provide rural residents with increased income, level and quality of life, and increase food independence of the republic (Gizzatov A.I., Esengalieva S.M., Chere-muhina O.V.) [20].

Both quantitative and qualitative methods of analysis were used in the course of the study. Indicators of labour potential can be presented in the form of the volume of its characteristic, which includes the number of able-bodied population, as well as the amount of wages per worker at the level of productivity and intensity of labour that is established. The net aspect covers all aspects that are relevant to the intensive characteristics. It depends on the physical condition of the working-age population, as well as their education and training. This may affect the quality of factors that characterise "Gross output of products (services) of agriculture, forestry and fisheries".

Conclusions

1. The research results show that the following indicators have a significant impact on the total output of goods (services) in agriculture, fisheries and forestry: population in rural areas, average wages of workers in the agriculture, fisheries and forestry sector, as well as the availability and condition of rural housing stock, including the total area of housing. Analyses and projections of these indicators show that the population of rural areas is declining and also the increase in wages may lead to a decrease in GDP in the agricultural sector.

2. Additional ways to develop labor potential in rural areas of Kazakhstan in the context of modernization of agro-industrial complex (AIC) may include the following aspects:

2.1. Personnel development and training:

* implementation of educational programs, the purpose of which is to improve qualifications of personnel in agricultural sector;

* creation and support of professional educational centers aimed at rural residents;

* development of distance learning system to provide wider access to educational resources.

2.2. Modern technological transformation:

- application of the latest technological solutions in agricultural sector in order to increase productivity and efficiency of work processes;

- dissemination of advanced agricultural methods and practices.

2.3. Creation of jobs:

● support for development of entrepreneurship of small and medium-sized enterprises in rural areas;

● promoting the creation of new jobs by providing financial and tax preferences.

2.4. Development of social infrastructure:

* increase the level of infrastructure in rural areas, including housing and utilities services, medical care, education and cultural centres;

* creating attractive conditions for attractting specialists to rural areas, providing benefits and bonuses.

2.5. Implementation of financial support:

- provision of financial instruments and loans for development of agricultural enterprises;

- support for government programs and investments in agricultural sector.

2.6. Implementation of social programs:

● implementation of programs to support families and youth living in rural areas;

● improving social protection of the rural population.

3. The improvement of rural housing stock will contribute to the increase in the rural population, and thus to the growth of labour potential in rural areas. Forecast calculations show an increase in fixed assets in rural areas, including its active part, which is characteristic of the intensification of moder-nisation of the agro-industrial complex and requires an increase in the quality of labour potential.

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References

[1] Dingde, Xu. Labor migration and farmland abandonment in rural China: Empirical results and policy implications /Xu Dingde, Deng Xin, Guo Shili, Liu Shaoquan [Electronic resource]. – 2019. - URL: https://www.sciencedirect.com/science/article/abs/pii/S0301479718314014// (date of reference: 02.12.2023).

[2] Zhang, Weikun. The Rural Labor Transfer with Respect to the Development of Farmland Leasing Market: Evidence from Rural China /Weikun Zhang, Hanyuan Liang, Zhe Chen, Jun Zhang //Man and the Economy. – 2021. - Vol. 8(1). - P. 99-128.

[3] Акимбекова, Ч.У. Трудовые ресурсы села в условиях цифровизации экономики казахстана / Ч.У. Акимбекова // АПК: Экономика, управление. - 2019. - № 10. - С. 87-95.

[4] Ловчикова, Е.И. Совершенствование кадрового обеспечения сельскохозяйственных организации на основе мотивационного механизма / Е.И. Ловчикова, Г.П. Зверева, А.С. Волчёнкова. - Орел: ФГБОУ ВО Орловский ГАУ, 2021. – 160с.

[5] Прока, Н.И. Компетентностный подход к развитию кадрового потенциала /Н.И. Прока //Вестник аграрной науки. - 2021. - № 6(93). - С. 125-130.

[6] Черданцев, В.П. Управление кадровым потенциалом агропромышленного и рыбохозяйственного комплексов [Электронный ресурс]. - 2022. - URL: https://www.cyberleninka.ru/ article/ n/ upravlenie-kadrovym-potentsialom-agropromyshlennogo-i-rybohozyaystvennogo-kompleksov (дата обращения: 20.11.2023).

[7] Калиев, Г.А. Стратегические приорите-ты развития АПК Казахстана /Г.А. Калиев //Никоновские чтения.-2019.-№24.-С.421-425.

[8] Молдашев, А.Б. Основные приоритеты социально-экономического развития сельских территорий, направленные на повышение уровня жизни жителей села (методические рекомендации) /А.Б. Молдашев, Ч.У. Акимбекова, С.Т. Жумашева, Ж.С. Досумова. - Алматы: КазНИИЭАПКиРСТ, 2020. - 34 с.

[9] Бельгибаева, А.С. Тенденции рынка труда в Акмолинской области Казахстана /А.С. Бельгибаева, А.Ж. Мусина, М.А. Волохова //Проблемы агрорынка. - 2021. - №1. - С. 163-171.

[10] Керимова, У.К. Ключевые проблемы развития агропромышленного комплекса в Казахстане и пути их решения /У.К. Керимова, Г.С. Касенбаев // Вестник университета «Туран». - 2021. - №4. - С. 85-92.

[11] Нуржанова, Г.И. Трудовой потенциал сельских территорий Казахстана в условиях цифровизации экономики /Г.И. Нуржанова, Г.К. Сапарова, С.А. Сагинова// Проблемы агрорынка.-2023.-№1. - С.190-198.

[12] Putsenteilo, P. The role of institutions in the development of agriculture / P. Putsenteilo, Y. Klapkiv, V. Karpenko, I. Gvozdecka

// Bulgarian Journal of Agricultural Science. - 2020. - №26 (1). - P. 23-33.

[13] Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан [Электронный ресурс]. – 2023. - URL: https:// www. stat.gov.kz (дата обращения: 22.11.2023).

[14] Рахматуллина, Л.И. Состояние кадрового обеспечения отраслей сельского хозяйства оренбургской области /Л.И. Рахматуллина. - Оренбург: АГЕНСТВО ПРЕСС, 2021. - 225 с.

[15] Замков, О.О. Математические методы в экономике /О.О. Замков, А.В. Толстопятенко, Ю.Н. Черемных. - Москва: Дело & Сервис, 2019. - 365 с.

[16] Гармаш, А.Н. Экономико-математические методы и прикладные модели /А.Н. Гармаш, И.В. Орлова, В.В. Федосеев. - Москва: Издательство Юрайт, 2022. - 328 с.

[17] Кыдырбаева, Э.О. Кадровый потенциал аграрного сектора Республики Казахстан: оценка сложившейся ситуации /Э.О. Кыдырбаева, С.К. Байдыбекова, Б.К Шомшекова //Проблемы агрорынка. - 2022. - №4. - С. 190-196.

[18] Национальный проект по развитию АПК Республики Казахстан на 2021–2025 гг. [Электронный ресурс].-2021.-URL: https:// www.https://akorda.kz/assets/media/files/porazvitiyu-apk.pdf (дата обращения: 02.02. 2024).

[19] Долгушкин, Н.К. Развитие кадрового потенциала сельского хозяйства как базового фактора обеспечения продовольственной безопасности страны /Н.К. Долгушкин, В.Г. Новиков //Международный сельскохозяйственный журнал. - 2023. - №1 (391). - С. 8-15.

[20] Гиззатова, А.И. Трудовые ресурсы казахстанского села / А.И. Гиззатова, С.М. Есенгалиева, О.В. Черемухина //Проблемы агрорынка. – 2023. - №3. – С. 169-178.

References

[1] Dingde, Xu, Xin, Deng, Shili, Guo, Shaoquan, Liu. (2019). Labor migration and farmland abandonment in rural China: Empirical results and policy implications. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0301479718314014// (date of access: 02.12.2023)

[2] Zhang, Weikun, Liang, Hanyuan, Chen, Zhe, Zhang, Jun. (2021). The Rural Labor Transfer with Respect to the Development of Farmland Leasing Market: Evidence from Rural China. *Man and the Economy,* 8(1), 99-128.

[3] Akimbekova, CH.U. (2019). Trudovye resursy sela v usloviyah cifrovizacii ekonomiki Kazahstana [Rural labour resources in the conditions of digitalisation of Kazakhstan's economy]. *APK: Ekonomika, upravlenie,* 10, 87-95 [in Russian].

[4] Lovchikova, E.I., Zvereva, G.P., Volchyonkova, A.S. (2021). Sovershenstvovanie kadrovogo obespecheniya sel'skohozyajstvennyh organizacii na osnove motivacionnogo mekhanizma: monografiya [Improvement of staffing of agricultural organisations on the basis of motivational mechanism: monograph]. *Orel: FGBOU Orlovskij GAU,* 160 [in Russian].

[5] Proka, N.I. (2021). Kompetentnostnyj podhod k razvitiyu kadrovogo potenciala [Competence-based approach to the development of human resource potential]. *Vestnik agrarnoj nauki - Bulletin of Agrarian Science,* 6(93), 125-130 [in Russian].

[6] Cherdancev, V.P. (2022). Upravlenie kadrovym potencialom agropromyshlennogo i rybohozyajstvennogo kompleksov [Management of human resources potential of agro-industrial and fishery complexes]. Available at: https://www.cyberleninka.ru/article/n/upravlenie-kadrovym-potentsialom-agropromyshlennogo-i-rybohozyaystvennogo-kompleksov (date of access: 20.11.2023) [in Russian].

[7] Kaliev, G.A. (2019). Strategicheskie prioritety razvitiya APK Kazahstana [Strategic priorities for the development of the agro-industrial complex of Kazakhstan]. *Nikonovskie chteniya - Nikonov Readings,* 24, 421-425 [in Russian].

[8] Moldashev, A.B., Akimbekova, CH.U., ZHumasheva, S.T., Dosumova, ZH.S. (2020). Osnovnye prioritety social'no-ekonomicheskogo razvitiya sel'skih territorij, napravlennye na povyshenie urovnya zhizni zhitelej sela (metodicheskie rekomendacii) [The main priorities of socio-economic development of rural areas aimed at improving the living standards of rural residents (methodological recommendations)]. *Almaty: KazNIIEAPKiRST,* 34 [in Russian].

[9] Bel'gibaeva, A.S., Musina, A.ZH., Volohova, M.A. (2021). Tendencii rynka truda v Akmolinskoj oblasti Kazahstana [Labour market trends in Akmola region of Kazakhstan]. *Problemy agrorynka – Problems of AgriMarket,* 1, 163-171 [in Russian].

[10] Kerimova, U.K., Kasenbaev, G.S. (2021). Klyuchevye problemy razvitiya agropromyshlennogo kompleksa v Kazahstane i puti ih resheniya [Key problems of agro-industrial complex development in Kazakhstan and ways of their solution]. *Vestnik universiteta «Turan» - Bulletin of the University "Turan",* 4, 85-92 [in Russian].

[11] Nurzhanova, G.I., Saparova, G.K., Saginova, S.A. (2023). Trudovoj potencial sel'skih territorij Kazahstana v usloviyah cifrovizacii ekonomiki [Labour potential of rural areas of Kazakhstan in the conditions of digitalisation of the economy]. *Problemy agrorynka – Problems of AgriMarket,* 1, 190-198 [in Russian].

[12] Putsenteilo, P., Klapkiv, Y., Karpenko, V., Gvozdecka, I. (2020). The role of institutions in the development of agriculture. *Bulgarian Journal of Agricultural Science,* 26 (1) 23–33.

[13] Byuro nacional'noj statistiki Agentstva po strategicheskomu planirovaniyu i reformam Respubliki Kazahstan [Agency for Strategic

planning and reforms of the Republic of Kazakhstan Bureau of National statistics] (2023). Avaitable at: https://stat.gov.kz (date of access: 22.11.2023) [in Russian].

[14] Rahmatullina, L.I. (2021). Sostoyanie kadrovogo obespecheniya otraslej sel'skogo hozyajstva orenburgskoj oblasti [The state of staffing of agricultural industries in the Orenburg region]. *Orenburg: AGENTSTVO PRESSA - Orenburg: AGENCY PRESS,* 225 [in Russian].

[15] Zamkov, O.O., Tolstopyatenko, A.V., CHeremnyh, YU.N. (2019). Matematicheskie metody v ekonomike [Mathematical methods in economics]. *M.: Delo i Servis,* 365 [in Russian].

[16] Garmash, A.N., Orlova, I.V., Fedoseev, V.V. (2022). Ekonomiko-matematicheskie metody i prikladnye modeli [Mathematical methods in economics]. *M: Izdatel'stvo YUrajt - Moscow: Publishing House Yurayt,* 328 [in Russian].

[17] Kydyrbaeva, E.O., Baidybekova, S.K., Shomshekova, B.K. (2022). Kadrovyi potencial agrarnogo sektora Respubliki Kazahstan: ocenka slozhivcheisja situacii [Personnel potential of agricultural sector of the republic of Kazakhstan: assessment of the current situation]. *Problemy agrorynka - Problems of AgriMarket,* 4, 190-196 [in Russian].

[18] Nacional'nyj proekt po razvitiju agropromyshlennogo kompleksa na 2021-2025 gody [National project for the development of the agroindustrial complex for 2021-2025]. Avaitable at: https://www. https://akorda.kz/assets/media/files/po-razvitiyu-apk.pdf (date of access: 02.12.2023) [in Russian].

[19] Dolgushkin, N.K., Novikov, V.G. (2023). Razvitie kadrovogo potenciala selskogo hozjaistva kak factor bazovogo obespechenija prodovolstvennoi bezopasnosti strany [Development of the human potential of agriculture as a basic factor in ensuring the country’s food security]. *Mezhdunarodnyi selskohozjastvennyi zhurnal - International agricultural journal,* 1 (391), 8-15 [in Russian].

[20] Gizzatova, A.I., Esengalieva, S.M., Cheremuhina, O.V. (2023). Trudovye resursy kazahstanskogo sela [Labor resources of Kazakhstan villages]. *Problemy agrorynka – Problems of AgriMarket,* 3, 169-178 [in Russian].

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