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Formation of a Creative Model of Human Capital Management and Social Responsibility of Agribusiness under Conditions of Ensuring Food Supply for the Population of Ukraine

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Abstract: The article is devoted to the development of a creative model for managing human capital and social responsibility of agricultural business, taking into account the tasks of food stability. The research focuses on the interaction of personnel parameters, technological development and production results, which is interpreted as a multidimensional system of dependencies. Methodologically, the work is based on a combination of the index approach, integral estimation and econometric modeling. A system of internal human capital indices is proposed, covering qualification, digital, motivational and analytical components, as well as the intensity of reskilling. The indicators are integrated into the generalized assessment index. The results showed that the impact of human capital and social responsibility on productivity is non-linear and enhanced by their interaction with technological parameters. It has been established that the main increase in production results is due to an interaction between the level of competencies and the digitalization of personnel work. It has been proven that human capital has an impact on food stability directly through the structure of production and the level of specialization. The practical significance of the study lies in the fact that the proposed toolkit predicts the results of the activities of agricultural enterprises based on the input parameters of human capital assessment. The developed model increases the manageability of agricultural business and contributes to the strengthening of the food supply system. The scientific novelty of the work is combined with the parameterization of human capital with the econometric analysis of production and food indicators, which makes it possible to move from descriptive estimates to quantitatively based management.

Keywords: agricultural enterprises, econometric modeling, food security, human capital, labor productivity, social responsibility, strategic management.

Introduction

The functioning of the agricultural sector of Ukraine increasingly clearly shows that the results of production depend not only on resource provision, but also on the quality of human capital and social responsibility. Production processes in agriculture are becoming more complex, technological solutions are updated quickly, and the structure of personnel competencies often does not keep up with these changes. A situation arises when the potential of enterprises is used only partially, despite the formally sufficient resource base (Kozik, 2025). This explains why human capital management is gradually acquiring the status of a strategic priority of the state agrarian policy.

The relevance of the study is due to the fact that the food security of Ukraine is formed not only through production volumes, but also through the stability and predictability of this process. And such stability largely depends on the

ability of personnel to adapt to changes, master new technologies and maintain the continuity of production cycles. In other words, human capital becomes a factor that determines not only the efficiency of an individual agricultural enterprise but also the sustainability of food supply to the population as a whole.

The problem of the study is the lack of a holistic approach to the integration of human capital into the system of strategic management of agricultural enterprises. The available solutions focus on individual aspects, without taking into account their interdependence. There is still a lack of a formalized model that would combine personnel parameters, production results, and food consequences into a single analytical system (Saienko, 2024). As a result, management decisions remain fragmented, which limits the possibilities of forecasting and control.

Literature review

In scientific publications on human capital management in agriculture, attention is gradually shifting from a purely resource view to integrative models. These models combine personnel, technological and production parameters. Agustina and Rosalia (2025) analyze the role of HR management in agribusiness development and conclude that production efficiency directly depends on the quality of HR decisions. Alokhin (2025) defends a similar position, considering human resources as an object of strategic management of agricultural enterprises and emphasizing the need to integrate them into long-term planning.

Baiyegunhi (2024) cites empirical evidence according to which human capital and innovation produce a synergistic effect that increases farm productivity. Jin and Liu (2025) develop this view, and suggest that human capital affects food security indirectly. This influence occurs through the specialization of production. Ogunjobi et al. (2025) show that investments in personnel development increase agricultural productivity, but this effect does not occur immediately, but with a certain time lag. Hoichuk and Lyubomudrova (2024) draw attention to the strategic dimension of human capital management, noting that its impact is realized through the competitiveness of the enterprise. The works of Polishchuk (2024), as well as Ptashchenko and Shersheniuk (2024) deal with the transformation of the HR policy of agricultural enterprises in the digital economy; The authors emphasize that the role of analytical tools and digital competencies is growing. This echoes the findings of Krysovatyy (2025), which links human capital development to digitalization and inclusion in the agricultural sector.

Lippsmeyer et al. (2024) argue that human capital, together with information technology, forms the basis of future agricultural production. Qorri et al. (2024) show that HR management is becoming a decisive factor in the adoption of labor-saving technologies. A similar logic is followed by Verma and Shrivastava (2026), who explore how HR practices affect the implementation of precision farming. At the same time, Stehnei et al. (2025) and Ostrovska et al. (2025) emphasize that HR strategies need to be transformed through innovative approaches and the development of the intellectual potential of enterprises. In their opinion, without the coordination of personnel and business processes, innovation activity remains scattered.

Hence, most research focuses either on the assessment of human capital or on its impact on productivity. At the same time, the issues of integrating these approaches into a single analytical model remain unaddressed. The reason is the complexity of quantifying the interaction between personnel, technological and production parameters, as well as the limited data for multifactorial models. However, the combination of the econometric approach with the parameterization of human capital makes it possible to overcome these limitations. Therefore, it seems appropriate to conduct a study aimed at developing a creative model of strategic management of human capital of an agricultural enterprise, taking into account its impact on food stability.

The purpose of the article is to develop a creative model of strategic management of human capital and social responsibility of agricultural enterprises aimed at meeting the food needs of the population of Ukraine.

Research methods

At the first stage of the study, index analysis was applied. With its help, the primary statistical data of the enterprise is transformed into normalized indicators. Indices that reflect different facets of human capital are calculated. This method of approach made it possible to compare indicators with different units of measurement and create a single information base for further calculations.

The method of integral estimation is used when individual indices are aggregated into an integral indicator of human capital (HCt) through a system of weighting factors. On this basis, there was a transition from a multidimensional description to a generalized characteristic of human capital and the requirements of social responsibility of business. The econometric analysis used made it possible to establish quantitative dependencies between human capital,

technological level and production results. Several interactive members have been introduced to take into account the effect of the interaction of factors and to identify the nonlinear nature of the influence.

Results

1. Methodological Foundations of Strategic Management of Human Capital in Agricultural Business

The realities of working with the personnel of agricultural enterprises are gradually shifting from intuitive solutions to structured approaches, although this transformation looks uneven. Some agricultural enterprises already have a system for measuring human capital, but it usually remains fragmented. The logic of assessing human capital in the agricultural sector cannot be limited to simple productivity indicators (Mabaso & Ontong, 2025). It requires a multi-level design, which simultaneously takes into account resource characteristics, dynamics of competence development, labor intensity and the ability of personnel to adapt to technological changes. Thus, the problem of measuring human capital as a single value arises. Formally, this is possible, but in fact, human capital is always a set of interrelated parameters, where a change in one indicator inevitably affects others (Hitka et al., 2019).

It is expedient to formulate a methodological approach not as a list of indicators, but as an integrated system. In it, indicators will perform different functions. Some will record the state, others will reflect the dynamics, and still others will signal risks (Table 1).

The proposed structure allows you to go beyond static evaluation. For example, the human capital utilization rate shows not just the result, but the gap between the possible and the actual. In this gap, in fact, the managerial reserve is concentrated. And marginal labor productivity allows you to see whether the expansion of the number of personnel is justified, or, on the contrary, it is more efficient to work with process optimization. But the indicator system itself does not yet form management, but only sets coordinates.

Table 1: Integrated System of Assessment of Human Capital of an Agricultural Enterprise, Taking into Account the Functional Differentiation of Indicators

Function block	Indicator	Calculation formula	Type of impact	Analytical interpretation
1. Resource	Staffing ratio	Actual number / normative	Direct	Reflects the correspondence of human resources to production needs
2. Resource	Index of educational structure	Σ (proportion × level of education)	Structural	Characterizes the quality of the personnel base
3. Dynamic	Skill growth rate	$(Kv_1 – Kv_0) / Kv_0$	Dynamic	Reflects the intensity of the development of competencies
4. Efficient	Marginal productivity	$\Delta Q / \Delta L$	Marginal	Shows additional returns from the change in numbers
5. Efficient	Human Capital Utilization Rate	Actual Performance / Potential	Relative	Determines the level of underutilization of potential
6. Investment	Intensity of HR investments	Development costs / payroll	Direct	Reflects a strategic orientation towards development
7. Stabilization	Staff retention rate	1 – turnover rate	Reverse	Characterizes the stability of the personnel system
8. Innovative	Digital Adaptability Index	Employees with digital competencies / total number	Direct	Determines the ability to technological transformation

Source: Developed by authors based on Biloshkurska et al. (2019); Omelyanenko et al. (2019); Sridevi & Kishore Babu (2025); Yekimov et al. (2023).

It is in the agricultural sector that these dependencies are often non-linear. Skill growth does not always give a proportional increase in productivity. Conversely, small investments in training sometimes lead to a sharp increase in efficiency. This is due to the fact that human capital interacts with technology, labor organization, and management decisions. Then a complex system of interdependencies will be formed (Iastremska et al., 2025). To take these features into account, the methodological approach should include not only assessment, but also impact analysis. In other words, it is necessary to move from fixing parameters to identifying cause-and-effect relationships (Table 2).

Table 2: Matrix of Analytical Relationship of Human Capital Parameters with Performance Indicators of Agricultural Enterprise

Human capital parameter	Dependent indicator	Type of communication	Expected effect	Managerial interpretation
1. Skill Level	Labor productivity	Direct, nonlinear	Production growth	Advanced training has a point effect
2. Educational structure	Added value	Direct	Deepening of recycling	Higher education promotes technologization
3. HR investments	Profitability	With a delayed effect	Increasing profitability	Investments have an impact lag
4. Staff turnover	Production costs	Reverse	Rising costs	High turnover reduces efficiency
5. Digital competencies	Efficiency of the use of equipment	Direct	Process optimization	Digitalization reduces losses
6. Work experience	Production stability	Direct	Risk reduction	Experience builds predictability
7. Employment structure	Yield	Indirect	Increase in results	Staff balance affects quality
8. Learning Intensity	Innovation	Direct	Implementation of new solutions	Learning drives change
9. Staff motivation	Overall efficiency	Direct	Productivity growth	Motivation reinforces all factors

Source: Developed by the authors based on Biloshkurska (2010); Klimkiewicz (2023); Marwah et al. (2024); Ponomarenko et al. (2019); Prokopenko et al. (2021); World Bank (2024).

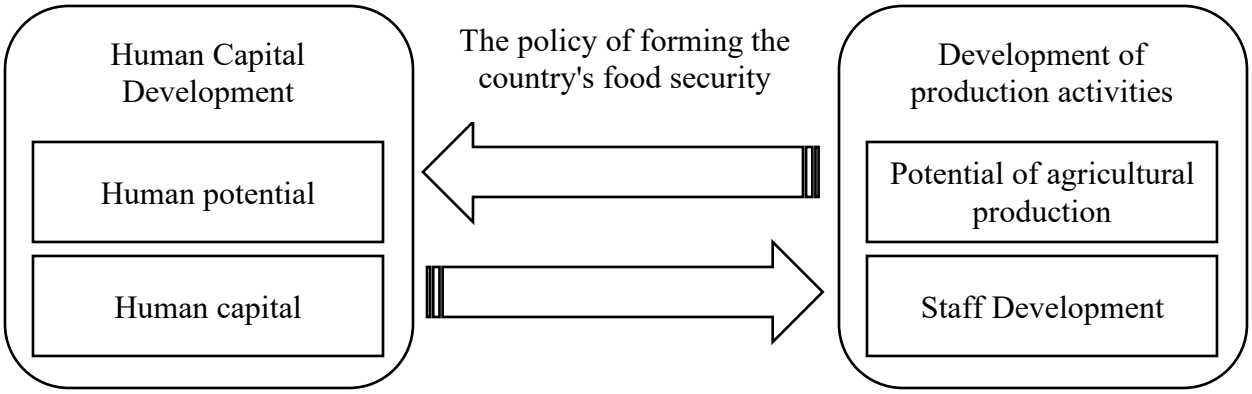
The above matrix sets the contour for further econometric analysis. It does not just describe the relationships, but structures them according to the types of impact. The results help to separate direct effects from indirect ones, short-term from long-term ones. On this basis, a fairly clear logic arises. First, the structure of human capital is measured. Then, its functional characteristics are determined. And only then are the connections with the results of activity analyzed, and after that, a system of managerial influences (Merafong Local Municipality, 2025).

2. Formation of a creative model of strategic management of human capital of an agricultural enterprise

Agricultural enterprises in Ukraine are beginning to rebuild the practice of personnel management. It goes beyond the classical approaches and becomes more technological. The new practice touches on the logic of decision-making, the structure of responsibility, and even the rhythm of the production process. And this is where a complex configuration

arises. Human capital is no longer considered a static resource; it enters a dynamic system, where each element affects the others, sometimes indirectly, and with a delay, but always due to close interactions (Fig. 1) (Kucharčíková et al. 2024).

Figure 1: The Relationship Between the Development of Human Capital and the Efficiency of an Agricultural Enterprise in the System of Food Supply of the Country



Source: Developed by the authors.

In the model, the strategic block sets a vector, but it does not work in isolation. Its parameters are adjusted through analytical signals that come from the evaluation unit. The number block, in turn, is not limited to automation. It creates an environment where data becomes the basis of management. But the problem is that this data often remains undisclosed, it is there, but it is not integrated into the solution. As a result, the whole system does not function at full capacity. This is due to the fact that the interconnections between the blocks require computational formalization with clear parameters and measurability (Makedon et al. 2025b). The integral indicator of the effectiveness of human capital management is as follows:

$$E_{HC} = \frac{\sum_{i=1}^{n} w_i \cdot \left(\frac{P_i^{fact}}{P_i^{base}} \right)}{1 + \sigma_{var}}. \quad (1)$$

where:

EHC is an integral indicator of the effectiveness of human capital management;

wi is the weight coefficient *of the i-th* indicator;

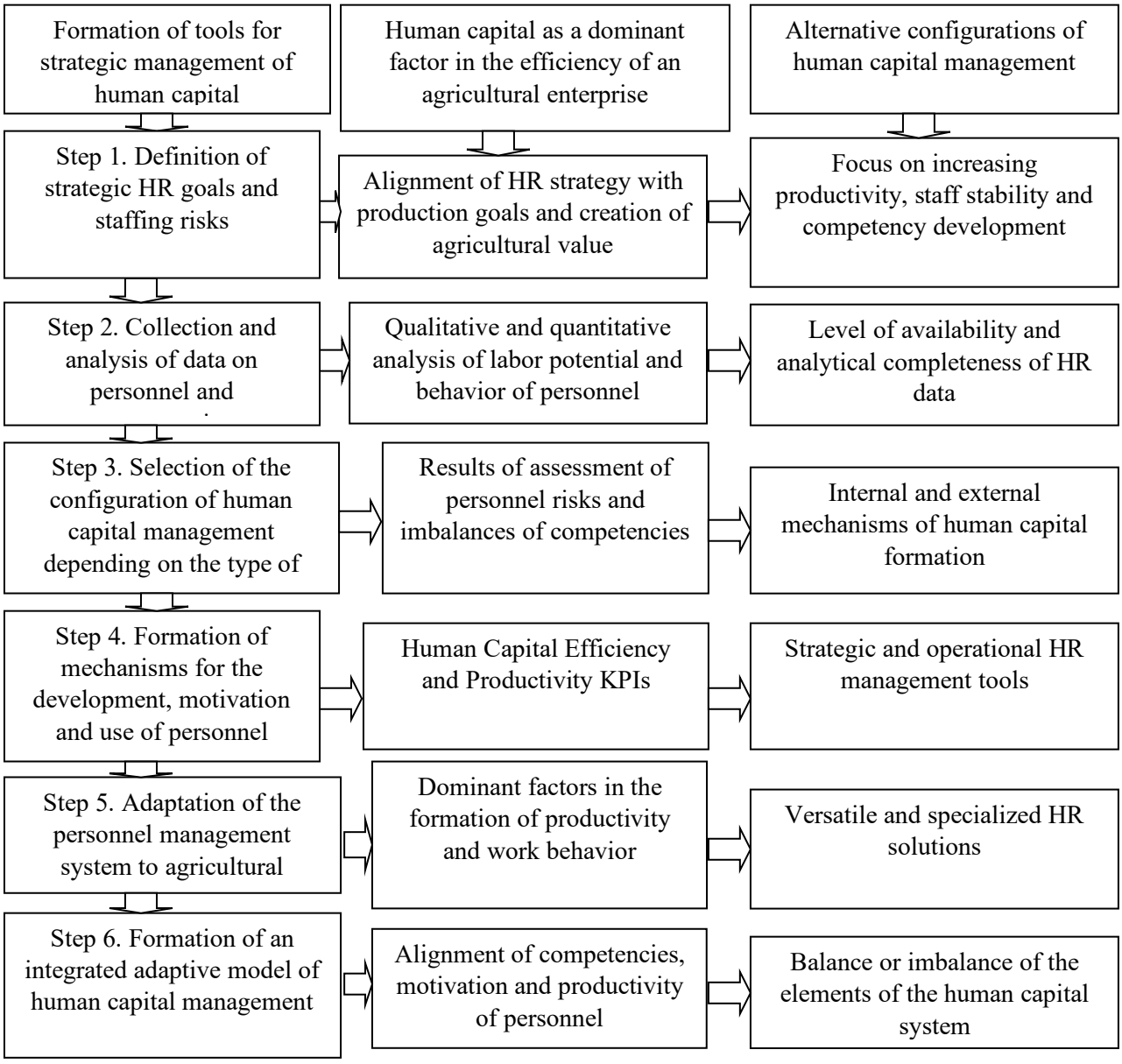
Pifact is the actual value of the indicator;

Pibase – basic or normative value;

σvar is the coefficient of variation of indicators, which takes into account the instability of the system.

Formula (1) not only aggregates indicators, but also introduces an adjustment for instability, which, in fact, distinguishes a real system from an idealized one. As a result, we get not just an index, but a model of the manageability of the system for assessing the competencies of personnel in the environment of agricultural enterprises (Fig. 2).

Figure 2: Creative Model of Strategic Management of Human Capital of an Agricultural Enterprise



Source: Developed by the authors.

Figure 2 consolidates the internal logic of the model and demonstrates that no block can be considered separately. For example, the level of digital integration without the appropriate development of competencies does not give the expected result. Conversely, a high level of skill without digital tools does not translate into productivity. And here the next level of complexity manifests itself. The integration of human capital and social responsibility into the food stability system is not direct. It passes through several intermediate links. And in each of them, there are losses or, conversely, the effects of amplification.

The dependence of productivity on the parameters of human capital is described by the formula:

$$Q = \alpha_0 + \alpha_1 HC + \alpha_2 D + \alpha_3 S + \alpha_4 (HC \cdot D) + \varepsilon. \quad (2)$$

where:

Q is the volume of production or productivity;

HC – integral index of human capital;

D is the level of digitalization;

S is the degree of specialization;

$(HC \cdot D)$ – interactive interaction effect;

ε is a random component.

This equation, if interpreted, shows that human capital does not work on its own. Its effect is strengthened or weakened depending on the digital environment. The result is a nonlinear dependence, which is difficult to detect without formalization (Table 3) (Kumar et al., 2025).

Table 3: Components of Integration of Human Capital into the Production and Food System of an Agricultural Enterprise

Human Capital Component	Intermediate effect	Production result	Food Result	Type of interaction
1. Qualifications	Optimization of operations	Productivity growth	Volume increase	Direct
2. Education	Improving accuracy	Loss reduction	Production stability	Direct
3. Digital skills	Automation	Cost reduction	Product Availability	Indirect
4. Experience	Predictability	Stability of results	Reliability of supply	Direct
5. Training	Innovation	Increased efficiency	Quality improvement	Lagovoy
6. Motivation	Labor intensity	Increase in production	Expansion of the offer	Direct

Source: Developed by the authors.

The outlined structure shows one more detail. The influence of human capital is not limited to production. It passes into the sphere of providing for the population, forming the stability of supply, product quality, predictability of results. And here a block of creative tools appears. They, in fact, determine how flexibly the system responds to changes. People analytics, for example, transforms data into solutions. HR dashboards are changing the way information is perceived. Flexible forms of employment reshape the structure of work (Thangaraju & Palani, 2025). The complex function of human capital management takes the form of:

$$U_{HC} = \int_{t_0}^{t_n} \left[\beta_1 L(t) + \beta_2 C(t) + \beta_3 M(t) + \beta_4 A(t) \right] dt. \quad (3)$$

where:

UHC – cumulative management effect;

$L(t)$ is the level of learning in time;

$C(t)$ – development of competencies;

$M(t)$ – motivational parameters;

$A(t)$ – analytical tools;

βi are the coefficients of influence.

Formula (3) introduces the temporal dimension of the model. The reason is that the control effect is not instantaneous. It accumulates, transforms, and sometimes changes its direction (Table 4).

Table 4: Creative management tools and their parametric evaluation

Tool	Evaluation parameter	Measurement method	Expected effect	Management result
1. People analytics	Forecast accuracy	Model error	Decision Enhancement	Optimization
2. HR dashboards	Access speed	Processing Time	Reaction acceleration	Flexibility
3. Reskilling	Adaptation level	Competencies achieved	Restructuring skills	Stability
4. Talent Management	Development Index	Δ competencies	Growth of potential	Development
5. Flexible employment	Utilization rate	Actual Time/Plan	Resource optimization	Efficiency
6. Inclusive approaches	Integration level	Share of involved	Expansion of the personnel base	Sustainability
7. HR analytics	Depth of analysis	Number of parameters	Improved control	Predictability

Source: Developed by the authors.

The system of tools highlighted in Table 4 forms an adaptive control mechanism, in which individual elements mutually reinforce each other's actions.

3. Econometric modeling of the impact of human capital and social responsibility on the efficiency of an agricultural enterprise (case of Agro-Region LLC)

We record the processes of the integration of human capital and social responsibility into the system of strategic management at the level of the agricultural enterprise of Agro-Region LLC. The process is manifested through a gradual shift in emphasis from resource accounting to the management of their qualitative characteristics. This shift, if you look closely, is not declarative. It is reflected in the change in the structure of data, in the way they are aggregated, in the depth of analytical interpretation. And as a result, a new management circuit is formed, where human capital is not fixed as a separate element, but is embedded in the production function of the enterprise (Lu et al., 2025).

Within the econometric model, human capital is described as a multidimensional process that changes over time and interacts with other parameters. Its formalization is carried out through an extended vector:

$$H_t = \{K_t; D_t; M_t; A_t; R_t\}. \quad (4)$$

where:

Kt is an integral indicator of the qualification level;

Dt – index of digital competencies;

Mt – staff motivation index;

At – level of analytical support of management;

Rt is the intensity of rekilling.

Each of these indicators is calculated separately through normalized indices. The integral indicator of qualification is defined as:

$$K_t = \frac{0.4 \cdot Edu_t + 0.35 \cdot Exp_t + 0.25 \cdot Cert_t}{1}. \quad (5)$$

where:

Edut – standardized level of education;

Expt – average length of service;

Certt is the share of certified employees.

The Digital Competency Index is as follows:

$$D_t = \frac{N_{dig,t}}{N_{tot,t}}. \quad (6)$$

where:

Ndig,t is the number of employees with digital skills;

Ntot,t is the total number of personnel.

Motivational index:

$$M_t = \frac{Prod_t}{Wage_t} \cdot \eta. \quad (7)$$

where:

Prodt – labor productivity;

Waget – average salary;

η is the rationing coefficient.

Analytical component:

$$A_t = \frac{HR_{anal,t}}{HR_{total,t}}. \quad (8)$$

where:

HRanal,t is the number of analytical tools;

HRtotal,t is the total number of HR processes.

Reskilling intensity:

$$R_t = \frac{Train_t}{N_{tot,t}}. \quad (9)$$

where:

Traint is the number of employees who have been trained.

This set of variables is not random. Each of them corresponds to a separate channel for the transformation of human capital. For example, qualifications form the basic ability to perform operations, while digital competencies determine the ability to work in an automated environment (Makedon et al., 2025a). Motivation affects the intensity of labor use,

and the analytical component ensures the adaptability of the system. And as a result, all these variables interact, forming an integral effect. After that, an integral indicator of human capital is formed:

$$HC_t = \sum_{j=1}^{5} \gamma_j \cdot \ln(1 + H_{j,t}). \quad (10)$$

where:

γj are the weight coefficients normalized to one.

Let's perform the appropriate calculations of intermediate indicators for the agricultural enterprise Agro-Region LLC (Table 5).

Table 5: Calculation of internal human capital indices of Agro-Region LLC, 2020–2025

Year	K_t	D_t	M_t	A_t	R_t
2020	0.58	0.39	0.54	0.31	0.22
2021	0.61	0.45	0.57	0.38	0.27
2022	0.60	0.49	0.52	0.46	0.34
2023	0.65	0.58	0.60	0.59	0.41
2024	0.69	0.64	0.63	0.67	0.48
2025	0.72	0.69	0.67	0.73	0.55

Source: Calculated by the authors.

These values demonstrate that the most dynamic component is reskilling, which, in fact, reflects the adaptation of the enterprise to changes in the external environment (Ogrezeanu et al., 2025). At the same time, the qualification level changes more slowly, which creates a certain inertia of the system. After aggregation, we get an integral indicator for Agro-Region LLC (Table 6).

Table 6: Integral Human Capital Index HCt for Agro-Region LLC for the period 2020–2025

Year	HC_t	Growth rate	Contribution K	Contribution D	Contribution M	Contribution A	Contribution R
2020	0.462	–	0.18	0.11	0.12	0.07	0.05
2021	0.501	+8.4%	0.19	0.13	0.13	0.09	0.07
2022	0.512	+2.2%	0.19	0.14	0.12	0.10	0.09
2023	0.589	+15.0%	0.21	0.17	0.14	0.13	0.12
2024	0.634	+7.6%	0.22	0.19	0.15	0.15	0.13
2025	0.671	+5.8%	0.23	0.20	0.16	0.16	0.14

Source: Calculated by the authors.

Here it is clearly seen that the growth of the HCt index is due to digital and analytical components. Thus, the structure of human capital shifts from the traditional to the intellectual-analytical position (Table 7) (Stryzhak et al., 2025).

Table 7: Calculation of the parameters of the production function of the agricultural enterprise Agro-Region LLC for the period 2020–2025

Year	HC_t	T_t	$HC \times T$	Q_t	Performance
2020	0.462	0.51	0.236	1.12	0.84
2021	0.501	0.54	0.271	1.18	0.89
2022	0.512	0.57	0.292	1.19	0.91
2023	0.589	0.63	0.371	1.29	1.03
2024	0.634	0.68	0.431	1.36	1.12
2025	0.671	0.72	0.483	1.45	1.18

Source: Calculated by the authors.

Next, the model moves on to the production function:

$$Q_t = \beta_0 + \beta_1 HC_t + \beta_2 T_t + \beta_3 (HC_t \cdot T_t). \quad (11)$$

where:

Tt is a technological index.

And here it becomes obvious that the interactive effect grows faster than all other parameters. This means that human capital begins to work in the enterprise as a technology amplifier.

The next stage is integration into the food system:

$$FS_t = \delta_0 + \delta_1 Q_t + \delta_2 HC_t + \delta_3 S_t. \quad (12)$$

The final calculations regarding food stability on the part of the agricultural enterprise Agro-Region LLC will be entered in Table 8.

Table 8: Dynamics of the Food Stability Index, 2020–2025

Year	Q_t	HC_t	S_t	FS_t	Elasticity
2020	1.12	0.462	0.51	0.58	0.94
2021	1.18	0.501	0.54	0.62	0.98
2022	1.19	0.512	0.56	0.64	1.01
2023	1.29	0.589	0.61	0.71	1.12
2024	1.36	0.634	0.65	0.76	1.18
2025	1.45	0.671	0.67	0.81	1.24

Source: Calculated by the authors.

The practical value of the proposed econometric model in the context of food security is that it makes agricultural production at the macro level more manageable. Due to the way the integral index of human capital interacts with production factors and specialization, it becomes possible to make forecasts for the provision of the population with food. Therefore, management decisions are no longer focused on actual volumes, but on the expected dynamics of production, taking into account the quality of labor resources and the requirements of social responsibility.

The developed approach is due to the fact that the model makes it possible to identify critical thresholds of human capital: if they fall below a certain limit, production loses stability. And this, in turn, opens up the opportunity to identify the risks of a possible shortage of products in advance. At the same time, analytical indicators help to optimize the structure of production. There is a redistribution of resources to those segments where the combination of knowledge, skills and technologies gives the best food effect.

Discussion

The proposed econometric model of integration of human capital into the production system of an agricultural enterprise makes it possible to directly compare the results obtained with scientific approaches available in modern literature. Agustina and Rosalia (2025) consider human capital as a factor in improving agribusiness efficiency through management decisions. This conclusion is consistent with our data on the positive impact of the *HCt index* on labor productivity. At the same time, we clarify this relationship through the introduction of an interactive parameter that reflects the interaction of human capital and the technological level.

Baiyegunhi (2024) shows that human capital and innovation generate synergistic effects in agriculture. Our results support this thesis, but extend it by quantifying said effect through the *HC·T parameter,* which makes it possible to move from qualitative reasoning to numerical estimates. Jin and Liu (2025) interpret human capital as an indirect factor in food security. This thesis coincides with the results of modeling the *FSt index*. However, in the current work, this relationship is specified through the addition of a specialization indicator, which makes it possible to describe the mechanism of influence in more detail.

Lippsmeyer et al. (2024) and Omelyanenko et al. (2021) emphasize the role of information technology in the transformation of agricultural production. This position is consistent with our conclusions on the significance of the digital component (*Dt*). However, in the model we propose, this component is integrated into the overall structure of human capital, and this forms an assessment of its impact not in isolation, but in interaction with other parameters. Qorri et al. (2024) analyze the impact of technology on the workforce, but do not take into account the inverse impact of human capital on technology efficiency. In our study, this feedback has become a fundamental factor.

The scientific novelty of the work lies in the construction of an integrated econometric model that combines an index approach to assessing human capital with a regression analysis of production and food results. Unlike existing approaches, where these aspects are considered separately, in our study, they are combined into a single analytical system, taking into account nonlinear effects and interactions.

The contribution to the scientific discourse is to expand the methodology for evaluating human capital by taking into account its interactive role in production functions. This becomes a city of transition from static models to dynamic dependencies that better reflect real processes in agriculture. In practical terms, the results of the study provide tools for making managerial decisions aimed at increasing the productivity and stability of agricultural production, and therefore directly related to ensuring food security.

Conclusions

Within the framework of the study, a methodical approach to assessing the human capital of an agricultural enterprise is proposed, which shifts the emphasis from individual indicators to their integrated interaction. The developed index system does not just record the state, but allows you to identify internal imbalances between qualifications, digital competencies, motivation and analytical support. This creates the basis for a more accurate measurement of the effectiveness of the use of labor potential and opens the way from descriptive analysis to parametric control. Each component of human capital is considered as a manageable factor of production efficiency.

The developed creative model of strategic management of human capital reproduces a complex configuration of connections between personnel, digital and production parameters of an agricultural enterprise. It is not just a set of separate tools, but forms a holistic system in which strategic goals, competence development and analytical mechanisms act in concert. Efficiency does not arise at the level of individual solutions, but precisely due to their integration. As a result, the model increases the adaptability of management, when an agricultural enterprise gains the ability to quickly respond to changes in the technological and market environment.

Econometric modeling based on the parameterization of human capital of the agricultural enterprise Agro-Region LLC substantiates its impact on production results and food stability. The obtained dependencies show that the greatest effect is achieved through the interaction of human capital with the technological and structural characteristics of production. Isolated growth of individual indicators, therefore, does not give a systemic result. The proposed model offers a predictive toolkit that allows you to determine critical thresholds and timely adjust management decisions taking into account the risks of food supply.

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APPENDICES

APPENDIX A

Initial data for the calculation of human capital components of Agro-Region LLC (2020–2025)

Year	Number of personnel, persons	Employees with higher education, persons	Average experience, years	Certified employees, persons	Employees with digital skills, individuals	Employees who have been trained, persons
2020	420	168	8.2	54	164	92
2021	435	181	8.5	62	196	118
2022	440	185	8.7	70	216	150
2023	455	205	9.1	86	264	186
2024	470	226	9.4	102	301	226
2025	485	247	9.8	121	334	267

APPENDIX B

Initial financial and economic data for calculating the motivation and productivity of Agro-Region LLC

Year	Revenue, UAH million	Payroll, UAH million	Average salary, UAH.	Production volume, thousand tons t	Cultivation area, thousand tons huh
2020	875	162	32100	1120	24.5
2021	912	178	34100	1180	25.2
2022	934	189	35800	1190	25.8
2023	1015	214	39200	1290	26.4
2024	1098	236	41800	1360	27.1
2025	1186	259	44500	1450	27.8

APPENDIX B

Initial data for the assessment of digitalization and analytical management of Agro-Region LLC

Year	Total number of HR processes	Automated processes	HR-analytical modules used	Total number of management decisions	Analytics-based solutions
2020	18	6	3	124	32
2021	20	8	5	138	47
2022	22	10	7	146	61
2023	24	13	10	158	89
2024	26	16	13	171	112
2025	28	19	16	186	136

APPENDIX G

Initial data for the technological level and specialization of Agro-Region LLC

Year	Number of units of equipment	Share of modern technology, %	Technology costs, UAH million	Share of specialized crops, %	Manufacturability coefficient
2020	210	42	98	51	0.51
2021	218	46	112	54	0.54
2022	225	49	126	56	0.57
2023	237	55	149	61	0.63
2024	248	59	168	65	0.68
2025	260	63	187	67	0.72

APPENDIX D

Intermediate Calculation Indicators for the Econometric Model of Agro-Region LLC

Year	Labor productivity (thousand UAH/person)	Proportion of digital workers	Learning Rate	Motivation index (calculated)	Analytic Index
2020	2083	0.39	0.22	0.54	0.26
2021	2096	0.45	0.27	0.57	0.34
2022	2123	0.49	0.34	0.52	0.42
2023	2231	0.58	0.41	0.60	0.56
2024	2336	0.64	0.48	0.63	0.65
2025	2446	0.69	0.55	0.67	0.73