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EFFECTIVE METHODS OF MANAGEMENT OF AGRICULTURAL ENTERPRISES IN KAZAKHSTAN

Métodos efectivos de gestión de empresas agrícolas en Kazajistán

Métodos efetivos de gestão de empresas agrícolas em Cazaquistão

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ABSTRACT
The agricultural sector of the economy of the Republic of Kazakhstan is one of the essential branches of the national economy. The level of provision of the social and industrial agriculture infrastructure in Kazakhstan remains extremely unstable. The purpose of the study is to examine the effective methods of agricultural enterprise management in Kazakhstan. The main methods of examining this issue are economical, mathematical, and modelling since these groups of methods allow considering the most extensive range of endogenous and exogenous factors affecting the activities of agricultural enterprises, thus confirming the effectiveness of the management methods. The presented analysis of enterprise management using the economic method demonstrates the need to introduce innovative components in the development of agricultural enterprises. This statement is demonstrated by the study results, indicating the relationship between the volume of output of agricultural products and Internet coverage in the agricultural sector of Kazakhstan. The forecast of the growth dynamics of these indicators shows an increase in the volume of agricultural output with an increase in the use of the internet by agricultural enterprises. The presented analysis dynamically demonstrates the effectiveness of current management methods and helps to adjust agricultural enterprises' current development course.

KEYWORDS
VAR-model, ARIMA, agricultural output, national economy, technological innovation.

RESUMEN
El sector agrícola de la economía de la República de Kazajistán es una de las ramas esenciales de la economía nacional. El nivel de provisión de infraestructura agrícola social e industrial en Kazajistán sigue siendo extremadamente inestable. El objetivo del estudio es examinar los métodos eficaces de gestión de empresas agrícolas en Kazajistán. Los principales métodos para examinar esta cuestión son los económicos, los matemáticos y los modelos, ya que estos grupos de métodos permiten considerar la gama más amplia de factores endógenos y exógenos que afectan las actividades de las empresas agrícolas, confirmando así la eficacia de los métodos de gestión. El análisis presentado de la gestión empresarial utilizando el método económico demuestra la necesidad de introducir componentes innovadores en el desarrollo de las empresas agrícolas. Dicha afirmación queda demostrada por los resultados del estudio, que indican la relación entre el volumen de producción de productos agrícolas y la cobertura de internet en el sector agrícola de Kazajistán. La previsión de la dinámica de crecimiento de estos indicadores muestra un aumento en el volumen de producción agrícola con un aumento en el uso de internet por parte de las empresas agrícolas. El análisis presentado demuestra dinámicamente la eficacia de los métodos de gestión actuales y ayuda a ajustar el curso actual de desarrollo de las empresas agrícolas.

PALABRAS CLAVE
Modelo VAR, ARIMA, empresas agrícolas, economía nacional, innovación tecnológica.

RESUMO
O setor agrícola da economia da República de Cazaquistão é uma das ramas essenciais da economia nacional. O nivel de provisão de infraestrutura agrícola social e industrial em Cazaquistão continua sendo extremadamente inestável. O objetivo do estudo é examinar os métodos eficazes de gestão de empresas agrícolas em Cazaquistão. Os principais métodos para examinar essa questão são os econômicos, os matemáticos e os modelos, pois esses grupos de métodos permitem considerar a gama mais ampla de fatores endógenos e exógenos que afetam as atividades das empresas agrícolas, confirmando assim a eficiência dos métodos de gestão. O análise apresentado da gestão empresarial utilizando o método econômico demostra a necessidade de introduzir componentes inovadores no desenvolvimento das empresas agrícolas. Tal afirmação fica demostrada pelos resultados do estudo, que indicam a relação entre o volume de produção de produtos agrícolas e a cobertura de internet no setor agrícola de Cazaquistão. A previsão da dinâmica de crecimento destos indicadores amostra um aumento no volume de produção agrícola com um aumento no uso da internet por parte das empresas agrícolas. O análise apresentado demostra dinâmicamente a eficiência dos métodos de gestão atuais e ajuda a ajustar o curso atual de desenvolvimento das empresas agrícolas.

PALAVRAS-CHAVE
Modelo VAR, ARIMA, empresas agrícolas, economia nacional, inovação tecnológica.

Introduction

The study of the management of agricultural enterprises in Kazakhstan is a priority area of development in the country, as evidenced by the National Project for the Development of the Agro-Industrial Complex of the Republic of Kazakhstan for 2021-2025 (Republic of Kazakhstan, 2021b). In general, the development of agriculture in any state is the most crucial component of food policy. The choice of effective management methods for the agricultural enterprises individually will result in the growth and development of the agricultural industry. Consequently, the identification of effective methods of managing agricultural enterprises occupies a central place in agricultural economics. The development of an environment favourable for the development of effective forms of management that stimulate the introduction of industrial and innovative technologies implies the need to change macroeconomic regulators. That is why the issue of development and management of agricultural enterprises becomes the most urgent. Agricultural enterprises produce a large share of agricultural goods, which creates the gross domestic product (GDP). In this context, it is vital to consider the management methods of agricultural enterprises and identify the most effective ones.

Many studies consider innovation as a key factor in the effective functioning of an enterprise (Sinaj and Vela, 2022). In this context, the studies of Su and Wang (2021) are notable, who propose to analyse and manage agricultural entities based on the construction of "smart agriculture" and the analysis of "big data", that is, the processing of a large array of data. The sources of such data are complex due to the specific features of agriculture, which reduces the accuracy of data mining (Ruan et al., 2019).

By examining a large array of data, it is possible to analyse the conditions of crop growth, analyse ways to avoid damage, adjust the growth environment, and ensure maximum benefit of crops. Since agricultural products circulate in production and life, the source and safety of each product can be ensured through traceability (Mahalik and Li, 2019). In other hand, Ray suggests actively using the Internet and digital technologies to implement rapid modernisation and transformation of agriculture, which contributes to constructing "smart" agriculture (Ray, 2017). Moreover, Cooper and Sommers (2018) advanced their research, suggesting using a flexible enterprise management system based on an Agile system, widely used in information technology industry management. The above studies have several limitations, the main of which is the lack of their application in the agricultural sector and the Kazakh market since this industry has a number of its features. In addition, the complexity of big data analysis is also a large volume and their real-time occurrence. It is proposed to use innovative management methods and integrate them into the management system of agricultural enterprises in Kazakhstan.

The objective of this study is to ascertain efficient techniques and resources for overseeing agricultural businesses in Kazakhstan, with a particular emphasis on the economic approach to enterprise management and the impact of innovation on improving agricultural output. The study seeks to offer valuable insights to regulators, policymakers, and agricultural enterprise owners in order to foster economic growth and technological innovation in Kazakhstan's agricultural sector.

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Materials and methods

The economical method of managing agricultural enterprises was chosen for the analysis because it allows considering exogenous factors, through the introduction of additional variables, and levelling their influence on the quality of analysis. As a methodological basis, the way of synthesising innovative approaches and economical methods of managing agricultural enterprises was chosen. Such a synthesis is the most effective because economic methods enable the assessment of optimality of specific actions, including when introducing an innovative approach into the management system. In addition, the presented model will determine whether innovations are being used effectively or whether it would be more optimal to stimulate staff by changing wages. The calculation includes the variable of inflation and unemployment as a set of exogenous factors that can affect the activities of agricultural enterprises.

For this study, a vector autoregressive model (VAR model) is being constructed, which displays the interaction of the resulting factor, endogenous, and exogenous variables. The VAR model is used because it optimally describes time series in dynamics; also, this model is free from the limitations of structural models. The chosen methodology allows analysing the effectiveness and identifying ways to improve the management methods of agricultural enterprises. The data of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan Bureau of National Statistics (Republic of Kazakhstan, 2021a) is used as the research foundation. The resulting factor is the dynamics of agricultural production in Kazakhstan, which is influenced by wages in agricultural enterprises, inflation and unemployment in the republic, Internet coverage, and the cost of using the Internet, as key indicators of the use of innovations (e.g. drones, satellites, and enterprise management systems) for the period 2018-2021. Formalised view of the autoregression model (1):

$$si = Aisi - 1 + \cdots + Aesi - e + Bni + \alpha i, i = 1, 2, \ldots., T \qquad (1)$$

This model can be expressed in terms of equations (2) and (3):

$$yi = e1yi - 1 + e2yi - 2 + f1xi - 1 + f2xi - 2 + \varepsilon 1i \qquad (2)$$

$$xi = a1yi - 1 + a2yi - 2 + b1xi - 1 + b2xi - 2 + \varepsilon 2i \qquad (3)$$

The next stage of the study will use an autoregressive integrated moving average model (ARIMA). Standard agricultural product forecasting methods include the conventional methods of time series, intelligent, and combined forecasting. Based on dynamic data, the conventional method of predicting time using quantity identifies the dynamic structure and regularity of the object under study. The ARIMA model can predict future values based on past and present values, and its expression is shown in formula (4):

$$wi = b + \varphi 1zi - 1 + \cdots + \varphi pzi - p + \varepsilon i + \theta 1\varepsilon i - 1 + \cdots \theta q\varepsilon i - q, i = 1, 2, \cdots T, \qquad (4)$$

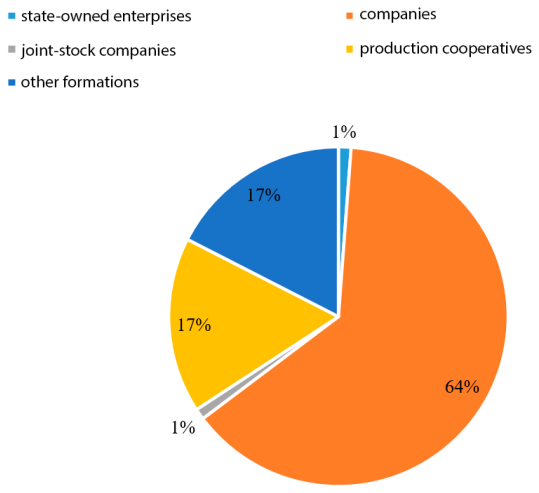
Where: (*p, q*) is the differential moving average model; *p* – free member; *q* – member of the moving average; *θ* – difference fraction of stationary time series.

Intelligent forecasting methods include artificial neural networks, grey systems theory, and machine learning. Support vector machines can be used to solve problems of small sample size, nonlinearity, and pattern recognition. The combined forecasting method uses two or more forecasting methods to predict the same. In practice, a combination of qualitative and quantitative methods is mainly used to take full advantage of various forecasting methods, using both strengths and compensating for weaknesses so that problems can be predicted more comprehensively and systematically.

Results

In the ever-changing sector of agricultural businesses in Kazakhstan, the need for effective management techniques and strategies has become increasingly vital. This study investigates the management of agricultural enterprises, with a specific emphasis on the tools and techniques that can shape the future of this industry. The aim of the study is to explore the intricate dynamics of agricultural production in Kazakhstan, specifically examining the economic approach to enterprise management and the vital importance of innovation. There are 201,890 units of agricultural enterprises in Kazakhstan (Republic of Kazakhstan, 2021a). Figure 1 shows a diagram of the forms of ownership of agricultural enterprises in Kazakhstan.

Figure 1. The ratio of agricultural enterprises by ownership forms
Figura 1. Proporción de empresas agrícolas por formas de propiedad



Source: own elaboration. Fuente: elaboración propia.

It can be concluded that 64% of agricultural enterprises in Kazakhstan are companies, and 17% are production cooperatives. That is why the factor of Internetisation should be used as one of the most effective techniques for managing agricultural enterprises in Kazakhstan.

The state programme for developing the Republic of Kazakhstan agro-industrial complex for 2017-2021 is focused not on large agricultural holdings but small enterprises. This is because

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they supply a substantial share of all agricultural products produced in Kazakhstan to the market. In general, private subsidiary farms in Kazakhstan produce almost half of agricultural products, peasant households and farms produce about 30%, and slightly more than 20% are produced by agricultural enterprises (Republic of Kazakhstan, 2021a). Thus, one of the ways of cooperation is the creation of a new cooperative structure. Uniting various agricultural producers within a certain region (administrative district) is advisable. Such a compact location for agricultural producers allows the use of premises for relatively small processing enterprises (workshops) in close proximity to all cooperative members. The availability of raw materials and consumer demand will determine the range and production volumes of the cooperative. The share contributions of the founders form the basis of the newly formed agro-industrial cooperative. Mutual contributions in the form of premises, technological equipment, and technical means can become the basis of the production base of the cooperative and provide a wide range of services (cargo transportation, mechanised field work, repair of equipment, etcetera).

The Dickey-Fuller test (ADF test—augmented Dickey-Fuller test) for the unit root was performed to analyse the results of the VAR model, which is the first stage of the calculation. This analysis was conducted for all variables—both endogenous and exogenous. The null hypothesis suggests that the series under study is non-stationary. The result of the study of the null hypothesis is displayed in Table 1.

Table 1. Evaluation results of the ADF test
Tabla 1. Resultados de la evaluación de la prueba ADF

Indicator	ADF	t-statistics	Results
Agricultural output, USD million	-0.689	-2.665	The null hypothesis is rejected
Average monthly salary, USD	-0.532	-2.4461	The null hypothesis is rejected
Internet coverage in agriculture, %	-0.048	-0.368	The null hypothesis is rejected
The cost of using the Internet	-0.0538	-0.564	The null hypothesis is rejected
Unemployment rate, %	-0.587	-2.515	The null hypothesis is rejected
Inflation	-0.136	-2.599	The null hypothesis is rejected

Source: own elaboration. Fuente: elaboración propia.

Based on the results of the ADF test analysis, it can be concluded that all variables are first-order integrated. This confirms the need to use the VAR model. The next step in calculating the VAR model is the Granger causality test, thus, it is possible to identify the presence of a causal relationship between exogenous and endogenous factors and to determine the main statistical characteristics (Table 2).

Table 2. Results of calculation of the Granger causality test
Tabla 2. Resultados del cálculo de la prueba de causalidad de Granger

Variables	Granger Test	Standard error	t-statistics	p-value
Average monthly salary, USD	30.279	3.59463	8.423	0.0011
Internet coverage in agriculture, %	-15.3785	78.1654	-0.1967	0.8536
The cost of using the Internet	-5001.66	5010.41	-0.9983	0.3747
Unemployment rate, %	250.917	3868.22	0.06487	0.9514
Inflation	13.0141	106.119	0.1226	0.9083

Source: own elaboration. Fuente: elaboración propia.

Based on the calculation in Table 2, it can be concluded that there are causal relationships between the model's factors. Since all calculated values for the Granger test are greater than 1, this indicates the presence of causal relationships between the resulting factor (agricultural output) and all dependent factors. Table 3 shows the results of calculations based on the VAR model.

Table 3. Calculation results of the VAR model
Tabla 3. Resultados del cálculo del modelo VAR

Equation 1	Coefficient	Standard error	t-statistics	p-value
Constant	234180	167223	1.400	0.2964
Production of agricultural products	2.02571	1.63306	1.240	0.3406
Average monthly salary, USD	-35.2814	53.4856	-0.6596	0.5773
Internet coverage in agriculture, %	26689.7	15625.3	1.708	0.2297
The cost of using the Internet	-779.115	349.788	-2.227	0.1558
Unemployment rate, %	-338.896	239.248	-1.417	0.2923
Inflation	-26154.3	15034.7	1.740	0.2241
The mean of the dependent variable	14902.66	Standard deviation of the dependent variable		2772.245
Sum of squares of remainders	8669028	Standard model error		2081.950
R-square	0.859001	Corrected R-square		0.436002
F(6, 2)	2.030743	P-value		0.366159
Correlation	-0.316167	Durbin-Watson statistics		2.603492
Equation 2	Coefficient	Standard error	t-statistics	p-value
Constant	6472.54	5927.43	1.092	0.3888
Production of agricultural products	0.0677666	0.0578858	1.171	0.3623
Average monthly salary, USD	-1.13567	1.89586	-0.5990	0.6100

Internet coverage in agriculture, %	705.655	553.858	1.274	0.3307
The cost of using the Internet	-24.2772	12.3987	-1.958	0.1893
Unemployment rate, %	-10.5543	8.48045	-1.245	0.3394
Inflation	-669.184	532.924	-1.256	0.3360
The mean of the dependent variable	54.5556	Standard deviation of the dependent variable		101.3165
Sum of squares of remainders	10892.09	Standard model error		73.79732
R-square	0.867364	Corrected R-square		0.469456
F(6, 2)	2.179813	P-value		0.347464
Correlation	-0.392999	Durbin-Watson statistics		2.726737

Source: own elaboration. Fuente: elaboración propia.

Table 3 shows that both equations are 86% significant (Rquadrate – 0.859001; 0.867364), and the results of Darbin-Watson statistics indicate that autocorrelation tends to 0. The results of the evaluation of the ARIMA model are shown in Table 4.

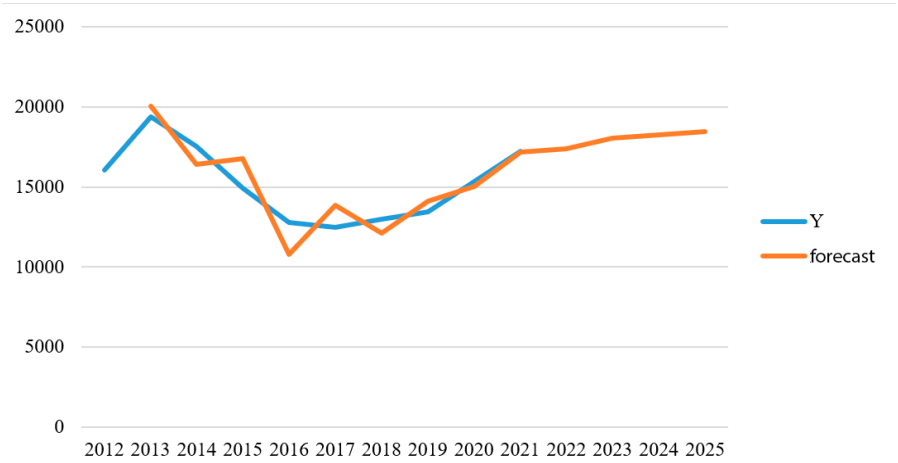
Table 4. Evaluation results of the ARIMA model
Tabla 4. Resultados de la evaluación del modelo ARIMA

Observation	Y	Forecasting	Stand. error	95% confidence interval
2012	16052.7	Not defined	307.325	(1.#QNAN, 1.#QNAN)
2013	19387.9	20029.6	625.270	(18804.1, 21255.1)
2014	17543.8	16434.5	753.396	(14957.8, 17911.1)
2015	14914.6	16783.4	820.267	(15175.7, 18391.1)
2016	12768.0	10786.7	857.629	(9105.77, 12467.6)
2017	12487.5	13881.6	879.133	(12158.5, 15604.7)
2018	12979.3	12127.8	891.697	(10380.1, 13875.5)
2019	13458.3	14113.8	899.098	(12351.6, 15876.0)
2020	15340.0	15015.1	903.479	(13244.3, 16785.9)
2021	17244.5	17189.7	906.078	(15413.8, 18965.6)
2022	-	17391.8	1085.966	(15263.3, 19520.2)
2023	-	18032.4	-	(15904.0, 20160.9)
2024	-	18246.0	-	(16117.5, 20374.4)
2025	-	18459.5	-	(16331.1, 20588.0)
Mean Error (ME)			-26.474	
Root of Mean Square Error (RMSE)			1167.5	
Mean Absolute Error (MAE)			986.88	
Mean Percentage Error (MPE)			-0.11527	
Mean Absolute Percentage Error (MAPE)			6.968	
Theil's U statistics			0.001	

Note: QNAN – "quiet" Not-a-Number. Source: own elaboration. Fuente: elaboración propia.

Based on the above calculations, the forecast of agricultural output is constructed (Figure 2).

Figure 2. Forecast of agricultural output
Figura 2. Previsión de la producción agrícola



Source: own elaboration. Fuente: elaboración propia.

Based on the forecast, it can be concluded that, provided that the level of wages, unemployment, inflation, and the cost of using the Internet do not change, and the use of the Internet in agricultural enterprises increases to the maximum level, the volume of agricultural output will increase by 1215 million USD by 2025. Thus, the proposed methodology proves that using innovative tools to manage agricultural enterprises, the indicator of which is the use of the Internet, is effective. The constructed forecast can be considered successful since Taylor's statistics almost reach 0. According to experts, the central area of increasing the efficiency of economic and investment activities of agricultural enterprises is the introduction of measures to financially support rural credit and insurance cooperatives. The state can support these processes by providing the initial capital of credit and insurance cooperation, attracting Kazakh and foreign investments and technical support, and increasing the innovation component in the direct management of agricultural enterprises. In this case, the state will contribute to the accumulation and use of available funds to strengthen the economy and intensify agricultural production. The diversity of agricultural production complicates innovative processes in agricultural business but also confirms the feasibility of creating cooperative associations, including with the involvement of private investment. It is necessary to establish cooperative relations with local self-government bodies, including the creation of its own database on the activities of farms of districts and regions.

Discussion

The whole study can be divided into the choice of an effective method of managing agricultural enterprises, considering the specific features of the functioning of agricultural enterprises in Kazakhstan and the introduction of innovative tools to improve the efficiency of agricultural enterprises' management. Regarding the specific features of the development

of agriculture in Kazakhstan, the pace of change in the family and kinship institutions is considered slow by specialists in development economics (Kerimkhulle et al., 2022). That is why researchers often assume that they are stable, examining the impact of changes in the economic environment on individual economic behaviour, limited by agreements at the family or kinship level. However, introducing innovative tools into the management methodology of agricultural enterprises at the present stage substantially impacts increasing competitive advantages in the market. In oher hand, Luo et al. (2017) indicate the presence of spatial and temporal environmental degradation in Kazakhstan, resulting from the interaction of various factors. In this context, special attention should be paid to abandoned agricultural land, it is this component that is overlooked when forecasting using the ARIMA model. This omission is partially covered in the study of Dara et al. (2018). It shows the possibility of assessing the trends of abandonment of arable land and the timing of reclamation in pasture regions. The use of such lands is critically necessary to increase the volume of food production, and future research may be directed to developing a methodology for using such areas.

Considering the choice of an effective method of managing agricultural enterprises, attention should be paid to Hamza and Kortas (2019), exploring the relationship between the management of real and accounting income, but in a Tunisian context, which can also be an example of choosing an economic method of managing an agricultural enterprise. In general, the most acceptable is the classification of management methods of an economic entity, which is reduced to five main groups, namely (Mukoviz et al., 2022): organisational and administrative methods (characterised by the regulation of the effective structure of the enterprise, strict rationing, very dynamic and allow situational changes in the production process); economic methods (allow optimally balancing the relationship between the company and the state based on a system of norms, prices, and personnel incentives, etc.); socio-psychological methods (personnel management); legal methods (labour and economic legislation); ideological and corporate (increasing productivity at the enterprise through the development of the corporate spirit, etcetera).

In contrast to the previous literature, the relationship between income management alternatives is analysed, separately focusing on tools for manipulating real activity. Using a model of simultaneous equations, the results indicate a complementary relationship between discretionary accruals and sales manipulation. Tunisian companies are not subject to more scrutiny by regulators and share two alternatives to profit management. Thus, the Tunisian context relating to the Middle East and North Africa (MENA) region is similar to the Asian context. The size of the company and the flexibility of accounting are the main factors influencing the decisions of income management workers. Tunisian small firms are more involved in managing accounting profits than larger companies. More effective corporate governance in large companies constrains accrual-based profit management. The latter are focused on real management tools through sales manipulation. In addition, accrual management is due to the flexibility of accounting. In addition, Hoang and Phung (2019) considers the choice of an enterprise management method based on the Vietnamese experience. This study empirically examines the influence of leverage on the forms and levels of profit management in Vietnamese companies listed on the stock exchange. Using a sample of Vietnam stock market data, researchers report a correlation between leverage and the absolute value of discretionary accruals and manipulation of real incomes. This confirms the "debt hypothesis" that in the presence of leverage, profit management is used to prevent violations of the debt contract and achieve more favourable contract terms (Ketners, 2015).

The observation of this study is the opposite preference in the group of highly leveraged firms compared to all the observed samples.

The main limitation of this study is that the impact of the debt repayment structure is not considered. In the future, the focus should be on the impact of debt repayment periods on the levels and forms of profit management and other tools of the economic management method. In particular, income management areas (rising or falling income) can also be considered in a specific context. Moreover, despite the direct impact on the company's cash flow, manipulating real activities is preferable in high leverage to avoid scrutiny by capital suppliers and outsiders. This suggests to researchers that isolated income management based on accrual or real income is not enough to cover the complex practice of income management. The forms and extent of income management should be considered comprehensively, while the substitution effects should be considered in different contexts. For capital providers, paying sufficient attention to both forms of profit management in the presence of borrowed funds is recommended. In addition, close attention to capital providers may limit the opportunistic choice of accounting options but increase the use of tactics for managing income from real activities (Trusova et al., 2021). In Kazakhstan, it is worth examining the market awareness of the impact of accrual earnings management and real earnings management on the company's subsequent performance, which may be a suggestion for future research.

Moreover, Ray (2017) assumes a ready-made IoT (internet of things) model for inclusion in the management as it would be helpful in developing agriculture and farms through introducing new measurements. The author's analytical paper provides a comprehensive overview of IoT deployment for advanced agricultural applications. An IoT-based agricultural structure is proposed to use a full-fledged combination between agriculture and IoT. This model is a specific case of use for agricultural enterprises and requires additional analysis of the effectiveness of its use. In terms of the relevance of management, the study is a starting point for filling a gap in the management literature directly in African organisations. In general, the specific features of choosing a management method in African companies differ from managerial decisions in Kazakhstan in that there is no formal audit mechanism to measure the levels of Human Capital (HC), Structural Capital (SC), and Relational Capital (RC) in the organisation, there are no formulated indicators of staff performance, and insufficient investment in targeted training and development to increase the HC level of employees, mainly because HC is a critical factor of both RC and SC, where such investments can increase productivity. This confirms the choice of the economic management method of the enterprise for this study.

The introduction of innovative tools into the management methodology of agricultural enterprises is considered more widely in the scientific literature. Combined with expert opinion (Zhumadilova et al., 2023), ecoinformatics (is the science of information in ecology and environmental science) tools can provide insight into relationships that were not visible at the beginning of the research. Although agricultural enterprises may be unusually receptive to recommendations based on research from data collected in real-world commercial agriculture, most farmers are also entirely unfamiliar with research methods in the ecoinformatics field, creating problems for coverage. Knowledge dissemination specialists will have to explain research in the field and create information tools that maximise the usefulness of ecoinformatics analysis, for example, when making recommendations for specific

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sites (Niyazbekova et al., 2021). In addition, there are potential difficulties in distinguishing associations that reflect true cause-and-effect relationships from ones that simply reflect false correlations. This is eliminated using the Granger causality test. Therewith, methods of eco-informatics used uncritically can easily do more harm than good in entomological research. Eco-informatics methods can create hypotheses, which can then be tested with targeted experiments combining the best of both worlds. Another valuable approach would be to use data sets created by researchers (small data) and their inherent advantages and combine them to achieve the benefits of large data sets. The approaches of ecoinformatics and big data in applied entomological research are not new, will not stop and will continue to improve over time. An entomologist of the future working on applied issues would have to be able to plan and conduct experimental research and have the skills of quantitative methods necessary to work with observational data.

The results of the study show that the use of innovative tools in the management of agricultural enterprises is effective. However, this study considers only the factors of using the Internet and the cost of using the Internet in Kazakhstan. Besides, Mahalik and Li (2019) argue that the use of big data will maximise the efficiency of management of agricultural enterprises. The volume of big data includes publicly available and private information of individuals and organisations, including physical and digital traces, transaction histories, search queries, service registrations, audio and video communications, and messages. Structured and unstructured data that people leave on the Internet, information systems and converter devices identify information about social status, health status, financial situation, purchasing trends, travel locations, and even about future needs and events of future consumers (Ketners, 2020).

In other hand, Su and Wang (2021) partially agree with that. However, the authors consider the development of "smart" agriculture as a critical link in the transformation of agriculture directly based on the widespread use of big data technology. Such tools in agriculture would allow efficient processing of big data in agriculture, identify many potential opportunities for optimisation, provide effective management for decision-making by agricultural producers and managers, and provide recommendations on consumer behaviour. Such studies confirm the conclusions of this one regarding the need to introduce innovative components for managing agricultural enterprises in Kazakhstan. However, the study by Su and Wang (2021) has some limitations: a short period and limited research methods that need further development. In addition, data collection is incomplete, and experimental errors easily occur during data processing. The types of big agricultural data are complex and include a wide range of categories, so researchers should have sufficient knowledge in data mining to improve the accuracy of mining analysis. Another substantial drawback is the use of big data only for large agricultural enterprises, while the analysis in this study is based on data from all agricultural enterprises in Kazakhstan—small, medium, and large.

In addition, Ruan et al. (2019) tried to fill this blank, offering a granular predictor Genetic Algorithm-Support Vector Machine (GA-SVM) for big data in agricultural cyber-physical systems. The granulation method is used to overcome the low efficiency of SVM for large-scale data, and big data is used to help SVM find optimal parameter values. This approach was considered for Shaanxi Province, China. The research shows that calculations' efficiency is substantially reduced using equivalent prediction accuracy. This provides farmers with a useful tool to know future growth conditions and make suitable planting and management

decisions. One of the limitations of this study is that corporate governance variables are not included in the empirical model because there was no data available for them. However, such variables can influence the behaviour of companies in the field of profit management and, consequently, whether firms replace or complement profit management methods. In addition, the limitations of this study are more general access to data on the implementation of innovations, and it is the results of this implementation that can show higher forecast calculations. Another limitation is the presence of a condition in constructing a forecast in the ARIMA model, namely, the immutability of all variables except Internet coverage. The forecast would have more accurate data by changing the constant values of variables to possible ones.

Conclusions

The study determined effective methods and tools for managing agricultural enterprises in Kazakhstan. Based on various opinions of researchers-economists, the economic method of enterprise management was chosen since it systemises management. Moreover, the study established that in current economic and innovation development conditions, the latter constitutes a vital tool for the effective management of agricultural enterprises. The analysis of this statement was conducted in two stages. The first stage was constructing a VAR model, which identified that the dependent variable of agricultural production has causal relationships with endogenous independent variables – wages, Internet coverage, and the cost of using the Internet in Kazakhstan. This relationship was evaluated using the Granger causality test. Notably, the increase in agricultural production is closely related to the use of the Internet in the production process and an increase in wages. This result indicates that the economic method is quite effective.

The second stage was the calculation of the forecast using the AMIRA model. The forecast was built for the period 2022-2025, subject to the invariance of all independent variables, except for the increase in Internet coverage. The calculation showed an increase in agricultural production by agricultural enterprises by US$1215 million, which proves the need for innovation as a key tool for managing agricultural enterprises. The results presented in this study are essential for regulators, politicians, and auditors. Regulators and owners of agricultural enterprises should be aware that higher economic growth leads to more efficient management. Thus, during economic growth, it is vital to be more vigilant in identifying the latest technologies and their implementation directly for the development of agriculture in Kazakhstan. This process can be more dynamic in agricultural enterprises with no or minimal share of state ownership.

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