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## CONTENTS

## PEDAGOGY

<b>Aitimbaev A., Issayev M., Apendiyev T.</b> Scientific and methodological opportunities for using archival materials in teaching the history of Kazakhstan in higher education institutions.....	19
<b>Akhmetova G., Kabdusheva A., Mussina A.</b> A quantitative study on university students' academic writing challenges and learning needs.....	40
<b>Akhmetova Zh.A., Nurgali S., Nurmetova D.</b> Pedagogical foundations of using digital resources in teaching academic writing.....	57
<b>Bekbolat Zh., Zholmakhanova A., Yildirim S.</b> Theoretical foundations of teaching M. Shokai's letters through a research-based approach.....	72
<b>Berdenkulova A.Zh., Zhandavletova R.B., Nazarova G.A.</b> A pedagogical model for improving educational quality through the "comfortable school - society - university" partnership.....	88
<b>Duisenova G., Shyndaliyev N., Shadiyev R.</b> Comparative analysis of traditional and virtualized programming education.....	104
<b>Yeskendirova A., Kassenova N., Nogoyev Y.</b> Comparative analysis of texts created by AI and texts developed using quantization technology.....	121
<b>Zhanysbekova Sh., Nurmakhanova Zh., Akasheva A.</b> Actual problems of the formation of pragmatic competence: research based on the results of content analysis.....	136
<b>Zulpykhar Zh.E., Kapanova D.E., Zhilmagambetova R.Z.</b> Modern resources and technologies as a foundation for the development of teachers' professional competencies.....	153
<b>Isaeva A., Ananyeva S.</b> Axiological interpretation of the Kazakhstan theme in the works of K. Paustovsky: methodological approaches to teaching at the university.....	172
<b>Kabzhalelov K.R., Korganbayeva Zh.K., Nurakhmetova A.R.</b> Developing critical thinking through modern chatbots in chemistry education.....	190
<b>Kazhenova Zh.S., Kydyralina L.M., Rakhmatullina Z.T.</b> Problems of developing students' engineering skills.....	208

<b>Kaldarova A., Vasquez M., Kulgildinova T.</b> Developing students' profession-oriented speaking skills through ChatGPT.....	229
<b>Kapbarova G.Sh., Gundogdu A., Baidalieva E.A.</b> History teaching methodology: theoretical and practical foundations of the competency-based approach.....	243
<b>Kozhakhanova L., Amirova A.</b> Prospects for developing media literacy among primary school students.....	260
<b>Kuzhagulova G., Sydykova R., Smailova M</b> Features of education of national values in visually impaired students through Kazakh lyric songs.....	278
<b>Markhmadova Zh.K., Kassymova G.K., Okenova B.</b> Pedagogical aspects of developing and assessing the digital competence of pedagogy-psychologists.....	297
<b>Mateyeva M., Yeralin K., Burkitbaev T.</b> Training future teachers of artistic work for art-historical regional studies.....	318
<b>Makhanov N., Nishanova K.</b> Development of students' cognitive competencies through museum-based education: evidence from South Kazakhstan.....	333
<b>Myrzagereikyzy G., Yermekova Zh.K., Aldzhambekova G.T.</b> The use of action research in preparing future physics teachers for the development of functional literacy of students.....	348
<b>Reginbayeva N., Nametkulova F.</b> Methodological foundations of professionally-oriented physics education based on STEM education for future air transport specialists.....	365
<b>Serikbayeva N., Orynbekova A., Tuyakova U.</b> Methodology for developing digital competence of educational psychologists in modern education.....	385
<b>Toiganbekova M.E., Kazhigalieva G.A.</b> Aspects of creation and specification of educational texts for increasing the effectiveness of training.....	409
<b>Shegebayeva G., Zhumasheva T., Nurbekova S.</b> Prerequisites for the preparation of future educators for the creation of a health-educational environment based on nutriscology.....	422
<b>Shishov S.E., Iovbak A.S., Verko Y.A.</b> Integrated modular physics experiment as a means of organizing students' experimental activities in secondary school.....	443

## ECONOMICS

<b>Abdimoldayeva A., Madysheva A., Zhunussova G.</b> Transformation of logistics cost accounting in the agro-industrial complex under digitalization.....	461
<b>Abuova Zh., Duiskenova R., Kadyrbekova D.</b> The concept of sustainable development of the hotel business based on digital transformation and environmental management.....	479
<b>Amantay Mukhit, Kanabekova M., Oralbayeva Zh.</b> Digitalization as a driver of Kazakhstan's economic growth: econometric analysis and structural effects.....	494
<b>Ashim N., Dzhrauova K., Kushenova M.</b> Improving the management of agricultural subsidies: Kyzylorda region.....	511
<b>Assemova R., Abdibekov S., Aitbayeva D.</b> Energy efficiency and innovation in agriculture: empirical evidence from Southern Kazakhstan.....	535
<b>Assanova Zh., Baimukhanova S., Konysbaeva G.</b> Environmental accounting, ESG reporting and digitalization: impact on cost reduction and sustainable development.....	554
<b>Baigelova A., Sadykova Zh., Epanchintseva S.</b> Industrial economy transformation in Kazakhstan: structural shifts, digitalization and productivity growth.....	571
<b>Beisekova Zh., Mutaliyeva A., Kunshigarova L.</b> Transformation of entrepreneurial activity in Kazakhstan in 2000–2025.....	590
<b>Beisenbayeva A., Kambarov B., Samenova N.</b> Development of small and medium-sized enterprises in Almaty: ecosystem factors and structural dynamics.....	611
<b>Bekisheva A., Beketova K., Dorohova N.</b> Human resource management practices and employee perceptions in Kazakhstan's civil service.....	629
<b>Bissenbayeva S., Kireyeva A., Zhumaxanova K.</b> Digitalization, government support and innovation activity: evidence from regional analysis in Kazakhstan.....	646
<b>Em O.L., Kim D.</b> Features of risk management in collective investment.....	665

<b>Ibrayeva A., Kenesheva G., Arynova Zh.</b> Qualification mismatch in the labour market of an industrial region: a conceptual model and measurement mechanism.....	684
<b>Juman J., Mukhtarova K.S., Liao Z.</b> The modern model of China's economic cooperation with Central Asian countries.....	701
<b>Karakulova A., Bakirbekova A., Zhangirova R.</b> Improving the efficiency of digital transformation of agricultural enterprises: an empirical analysis of Kostanay region.....	718
<b>Kuralbayeva A.Sh., Issayeva G.K., Zhussipova E.E.</b> Energy-saving technologies in irrigated agriculture of Southern Kazakhstan: economic and environmental effects.....	734
<b>Naimanova Zh., Bakirbekova A., Kuralbayeva R.</b> Digital inequality and agricultural productivity: evidence from Southern Kazakhstan....	749
<b>Nartbayeva A., Dadabayeva D., Altuntas G.</b> Economic resilience of single-industry towns in Kazakhstan: a dynamic analysis of socio-economic indicators.....	767
<b>Nurlanuly A., Petrovčíková K., Shalbolova U.Zh.</b> Comparative analysis of aviation market development models in Kazakhstan and Slovakia.....	785
<b>Nyshanbayeva U., Moldashbayeva L., Urazbayeva Z.</b> Accounting and valuation of investment projects in digital tourism: an integrated approach.....	801
<b>Shegir G., Kerimova U., Kabi Sh.</b> The transition of the agro-industrial complex of the Almaty region to the production of value-added products.....	819
<b>Shiganbayeva N., Razakova D., Orlowska R.</b> Trade turnover between China and Kazakhstan in the context of contemporary analytical studies: factors, challenges, and risks.....	840
<b>Tuzubekova M., Zhunusova A., Kadirova N.</b> Analysis of SME support incentives in the manufacturing industry of the Republic of Kazakhstan.....	857
<b>Yeraliyeva Ya., Ruziyeva E., Alimbekova B.</b> Trend and structure of research on digital financial literacy: bibliometric approach.....	877
<b>Zhassan G., Taibek Zh., Imanova G.</b> Climate risk management in the banking sector: ESG-based global and Kazakhstani experience.....	891

## МАЗМҰНЫ

### ПЕДАГОГИКА

<b>Айтимбаев А.Т., Исаев М.С., Апендиев Т.А.</b> Қазақстан тарихын жоғары оқу орындарында оқытуда архив материалдарын пайдаланудың ғылыми-әдістемелік мүмкіндіктері (1920–1950 жж. Оңтүстік Қазақстандағы саяси қуғын-сүргін құрбандары тағдырлары негізінде).....	19
<b>Ахметова Г.С., Кабдушева А.Б., Мусина А.Б.</b> Университет студенттерінің академиялық жазылымдағы қиындықтары мен оқу қажеттіліктеріне арналған сандық зерттеу.....	40
<b>Ахметова Ж.А., Нұрғали С., Нурметова Д.</b> Академиялық жазуды оқытуда сандық ресурстарды пайдаланудың педагогикалық негіздері.....	57
<b>Бекболат Ж.Н., Жолмаханова А.Б., Сейфуллах Йылдырым</b> Мұстафа Шоқай хаттарын зерттеушілік әдіс арқылы оқытудың теориялық негіздері.....	72
<b>Берденкулова А.Ж., Жандавлетова Р.Б., Назарова Г.А.</b> «Жайлы мектеп – қоғам – университет» серіктестігі негізінде білім сапасын арттырудың педагогикалық моделі.....	88
<b>Ескендірова А.А., Касенова Н.Б., Ногоев Ю.Я.</b> ЖИ арқылы жасалған мәтіндер мен кванттау технологиясы арқылы әзірленген мәтіндердің салыстырмалы талдауы.....	104
<b>Жанысбекова Ш., Нурмаханова Ж., Акашева Ә.</b> Прагматикалық құзіреттілікті қалыптастырудың өзекті мәселелері: контент-анализ нәтижелері бойынша зерттеу.....	121
<b>Дүйсенова Г.А., Шындалиев Н.Т., Шадиев Р.Н.</b> Дәстүрлі және виртуалды бағдарламалау білімінің салыстырмалы талдауы.....	136
<b>Зулпыхар Ж.Е., Капанова Д.Е., Жилмагамбетова Р.З.</b> Педагогтердің кәсіби құзыреттілігін дамытудың негізі ретінде қазіргі заманғы ресурстар мен технологиялар.....	153
<b>Исаева А.А., Ананьева С.В.</b> К. Паустовский шығармашылығындағы Қазақстан тақырыбының аксиологиялық интерпретациясы: жоғары оқу орнында оқытудың әдіснамалық тәсілдері.....	172
<b>Кабжалелов К.Р., Қорғанбаева Ж.Қ., Нурахметова А.Р.</b> Химияны оқыту барысында заманауи чат-боттар арқылы сыни ойлауды дамыту.....	190

<b>Каженова Ж.С., Қыдыралина Л.М., Рахматулина З.Т.</b> Оқушылардың инженерлік дағдыларын дамыту мәселелері.....	208
<b>Калдарова А.К., Васкес М.А., Кульгильдинова Т.А.</b> Студенттердің кәсіби-бағдарланған айтылым дағдыларын ChatGPT арқылы дамыту.....	229
<b>Капбарова Г.Ш., Гюндогду А., Байдалиева Э.А.</b> Тарихты оқыту әдістемесі: құзыреттілікке негізделген тәсілді қолданудың теориялық және практикалық негіздері.....	243
<b>Кожыханова Л., Амирова А.</b> Бастауыш сынып оқушыларының медиасауаттылығын дамыту перспективалары.....	260
<b>Кужагулова Г.Е., Сыдыкова Р.Ш., Смаилова М.С.</b> Көру қабілеті бұзылған білім алушыларды қазақтың лирикалық әндері арқылы ұлттық құндылықтарға тәрбиелеудің ерекшеліктері.....	278
<b>Мархмадова Ж.Қ., Касымова Г.К., Өкенова Б.</b> Педагог-психологтың цифрлық құзыреттілігін қалыптастыру және бағалаудың педагогикалық аспектілері.....	297
<b>Матеева М.А., Ералин Қ., Буркитбаев Т.</b> Болашақ көркем еңбек мұғалімдерін өнертанымдық өлкетануға даярлау.....	318
<b>Маханов Н., Нишанова К.</b> Музейлік білім беру негізінде оқушылардың танымдық құзыреттіліктерін дамыту (Оңтүстік Қазақстан мысалында).....	333
<b>Мырзагерейқызы Г., Еркемова Ж.К., Алджамбекова Г.Т.</b> Болашақ физика мұғалімдерін оқушылардың функционалдық сауаттылығын дамытуға даярлауда action research пайдалану.....	348
<b>Регинбаева Н.А., Наметкулова Ф.Д.</b> Болашақ әуе транспорты мамандарына физиканы STEM білім беру негізінде кәсіби-бағдарлы оқытудың әдістемелік негіздері.....	365
<b>Серикбаева Н.Б., Орынбекова А.С., Туякова У.Ж.</b> Қазіргі білім беруде педагог-психологтардың цифрлық құзыреттілігін дамыту әдістемесі.....	385
<b>Тойғанбекова М.Е., Қажығалиева Г.А.</b> Оқытудың тиімділігін арттыру үшін оқу мәтіндерін құру және нақтылау аспектілері.....	409

**Шегебаева Г.У., Жумашева Т.С., Нурбекова С.М.**  
Болашақ тәрбиешілердінутрициология негізінде денсаулық сақтау-білім беру ортасын құруға дайындаудың алғышарттары.....422

**Шишов С.Е., Иовбак А.С., Верко Е.А.**  
Орта мектепте оқушылардың эксперименталдық қызметін ұйымдастыру құралы ретінде интеграцияланған модульді физика эксперименті.....443

## ЭКОНОМИКА

**Абдимолдаева А., Мадышева А., Жунусова Г.**  
Цифрландыру жағдайында агроөнеркәсіптік кешендегі логистикалық шығындар есебін қайта құру.....461

**Абуова Ж., Дүйсеннова Р., Кадырбекова Д.**  
Цифрлық трансформация және экологиялық басқару негізіндегі қонақ үй бизнесінің тұрақты даму тұжырымдамасы.....479

**Әшім Н., Джрауова К., Кушенова М.**  
Ауылшаруашылығы субсидияларын басқаруды жетілдіру: Қызылорда облысы...494.

**Мұхит Амантай, Кенабекова М., Оралбаева Ж.**  
Цифрландыру Қазақстанның экономикалық өсуінің драйвері ретінде: эконометрикалық талдау және құрылымдық әсерлер.....511

**Асемова Р., Абдибеков С., Айтбаева Д.**  
Ауылшаруашылығындағы энергия тиімділігі және инновациялар: Оңтүстік Қазақстан бойынша эмпирикалық дәлелдер.....535

**Асанова Ж., Баймуханова С., Қонысбаева Г.**  
Экологиялық есеп, ESG-есептілік және цифрландыру: шығындарды төмендетуге және орнықты дамуға әсері.....554

**Байгелова А., Садыкова Ж., Епанчинцева С.**  
Қазақстандағы өнеркәсіп экономикасының трансформациясы: құрылымдық өзгерістер, цифрландыру және өнімділіктің өсуі.....571

**Бейсекова Ж., Муталиева А., Куншигарова Л.**  
2000–2025 жылдары Қазақстандағы кәсіпкерлік қызметтің трансформациясы.....590

**Бейсенбаева А., Қамбаров Б., Саменова Н.**  
Алматыда шағын және орта кәсіпкерлікті дамыту: экожүйелік факторлар және құрылымдық динамика.....611

**Бекишева А., Бекетова К., Дорохова Н.**  
Қазақстанның мемлекеттік қызметіндегі адам ресурстарын басқару тәжірибелері және қызметкерлердің қабылдауы.....629

**Бисенбаева С., Киреева А., Жұмаксанова К.**

Цифрландыру, мемлекеттік қолдау және инновациялық белсенділік:  
Қазақстан өңірлерінің талдауы.....646

**Эм О.Л., Ким Д.**

Ұжымдық инвестициялардағы тәуекелдерді басқарудың ерекшеліктері.....665

**Ибраева А., Кенешева Г., Арынова Ж.**

Өнеркәсіптік өңірдің еңбек нарығындағы біліктілік сәйкессіздігі:  
тұжырымдамалық модель және өлшеу тетігі.....684

**Жұман Ж., Мұхтарова К.С., Ляо Чжан**

Қытайдың Орталық Азия елдерімен экономикалық ынтымақтастығының  
заманауи моделі.....701

**Қаракұлова А., Бакирбекова А., Жангирова Р.**

Ауыл шаруашылығы кәсіпорындарының цифрлық трансформациясының  
тиімділігін арттыру: Қостанай облысының эмпирикалық талдауы.....718

**Құралбаева А.Ш., Исаева Г.К., Жусипова Э.Е.**

Оңтүстік Қазақстанның суармалы ауыл шаруашылығындағы энергия үнемдеу  
технологиялары: экономикалық және экологиялық тиімділік.....734

**Найманова Ж., Бакирбекова А., Құралбаева Р.**

Цифрлық теңсіздік және ауыл шаруашылығының өнімділігі:  
Оңтүстік Қазақстан деректері.....749

**Нартбаева А., Дадабаева Д., Алтунташ Г.**

Қазақстан моноқалаларының экономикалық резиленттілігі: әлеуметтік-  
экономикалық көрсеткіштердің динамикалық талдауы.....767

**Нұрланұлы А., Петровчикова К., Шалболова У.Ж.**

Қазақстан мен Словакияның авиациялық нарықтарының даму модельдерін  
салыстырмалы талдау.....785

**Нышанбаева Ұ., Молдашбаева Л., Уразбаева З.**

Цифрлық туризмдегі инвестициялық жобаларды есепке алу және бағалау:  
интеграцияланған тәсіл.....801

**Шегір Г., Керимова У., Қаби Ш.**

Алматы облысының агроөнеркәсіптік кешенінің қосылған құны бар өнім  
өндіруге көшуі.....819

**Шиганбаева Н., Разакова Д., Орловска Р.**

Қытай мен Қазақстан арасындағы тауар айналымы: факторлар, мәселелер  
және тәуекелдер.....840

**Тузубекова М., Жунусова А., Кадирова Н.**

Қазақстан Республикасының өңдеу өнеркәсібіндегі шағын және орта бизнесті  
ынталандыруды талдау.....857

**Ералиева Я., Рузиева Э., Алимбекова Б.**

Цифрлық қаржылық сауаттылық бойынша зерттеулердің тенденциялары  
мен құрылымы: библиометриялық тәсіл.....877

**Жасан Г.Ж., Тайбек Ж.Қ., Иманова Г.А.**

Банк секторындағы климаттық тәуекелдерді басқару: ESG негізіндегі әлемдік  
және қазақстандық тәжірибе.....891

## СОДЕРЖАНИЕ

## ПЕДАГОГИКА

**Айтимбаев А.Т., Исаев М.С., Апендиев Т.А.**

Научно-методические возможности использования архивных материалов при преподавании истории Казахстана в высших учебных заведениях (на примере судеб жертв политических репрессий в Южном Казахстане в 1920–1950 гг.).....19

**Ахметова Г.С., Кабдушева А.Б., Мусина А.Б.**

Количественное исследование проблем академического письма и образовательных потребностей студентов университета.....40

**Ахметова Ж.А., Нурғали С., Нурметова Д.**

Педагогические основы использования цифровых ресурсов в обучении академическому письму.....57

**Бекболат Ж.Н., Жолмаханова А.Б., Сейфуллах Йылдырым**

Теоретические основы обучения письмам М. Шокая исследовательским методом.....72

**Берденкулова А.Ж., Жандавлетова Р.Б., Назарова Г.А.**

Педагогическая модель повышения качества образования на основе партнёрства «комфортная школа – общество – университет».....88

**Дуйсенова Г.А., Шындалиев Н.Т., Шадиев Р.Н.**

Сравнительный анализ традиционного и виртуализированного обучения программированию.....104

**Ескендирова А.А., Касенова Н.Б., Ногоев Ю.Я.**

Сравнительный анализ текстов, созданных ИИ и текстов, разработанных с помощью технологии квантования.....121

**Жанысбекова Ш., Нурмаханова Ж., Акашева А.**

Актуальные проблемы формирования прагматической компетенции: исследование по результатам контент-анализа.....136

**Зулпыхар Ж.Е., Капанова Д.Е., Жилмагамбетова Р.З.**

Современные ресурсы и технологии как основа развития профессиональных компетенций педагогов.....153

**Исаева А.А., Ананьева С.В.**

Аксиологическая интерпретация казахстанской тематики в творчестве К. Паустовского: методологические подходы к преподаванию в вузе.....172

<b>Кабжалелов К.Р., Корганбаева Ж.К., Нурахметова А.Р.</b> Развитие критического мышления с помощью современных чат-ботов при обучении химии.....	190
<b>Каженова Ж.С., Кыдыралина Л.М., Рахматуллина З.Т.</b> Проблемы развития инженерных навыков учащихся.....	208
<b>Калдарова А.К., Васкез М.А., Кульгильдинова Т.А.</b> Развитие профессионально ориентированных навыков устной речи студентов с использованием ChatGPT.....	229
<b>Капбарова Г.Ш., Гюндогду А., Байдалиева Э.А.</b> Методика преподавания истории: теоретические и практические основы применения компетентностного подхода.....	243
<b>Кожыханова Л., Амирова А.</b> Перспективы развития медиаграмотности среди учащихся начальной школы.....	260
<b>Кужагулова Г.Е., Сыдыкова Р.Ш., Смаилова М.С.</b> Особенности воспитания национальных ценностей у слабовидящих обучающихся через казахские лирические песни.....	278
<b>Мархмадова Ж.К., Касымова Г.К., Окенова Б.</b> Педагогические аспекты формирования и оценки цифровой компетентности педагогов-психологов.....	297
<b>Матеева М.А., Ералин К., Буркитбаев Т.</b> Подготовка будущих учителей художественного труда к искусствоведческому краеведению.....	318
<b>Маханов Н., Нишанова К.</b> Развитие познавательных компетенций учащихся на основе музейного образования (на примере Южного Казахстана).....	333
<b>Мырзагерейкызы Г., Еркекова Ж.К., Алджамбекова Г.Т.</b> Использование action research в подготовке будущих учителей физики к развитию функциональной грамотности учащихся.....	348
<b>Регинбаева Н.А., Наметкулова Ф.Д.</b> Методические основы профессионально-ориентированного обучения физике на основе STEM образования для будущих специалистов воздушного транспорта.....	365
<b>Серикбаева Н.Б., Орынбекова А.С., Туякова У.Ж.</b> Методика развития цифровой компетентности педагогов-психологов в современном образовании.....	385

**Тойганбекова М.Е., Кажигалиева Г.А.**

Аспекты создания и спецификации учебных текстов для повышения эффективности обучения.....409

**Шегебаева Г.У., Жумашева Т.С., Нурбекова С.М.**

Предпосылки подготовки будущих воспитателей к созданию здоровьесберегающей образовательной среды на основе нутрициологии.....422

**Шишов С.Е., Иовбак А.С., Верко Е.А.**

Интегрированный модульный физический эксперимент как средство организации экспериментальной деятельности учащихся в средней школе.....443

**ЭКОНОМИКА****Абдимолдаева А., Мадышева А., Жунусова Г.**

Трансформация учета логистических затрат в агропромышленном комплексе в условиях цифровизации.....461

**Абуова Ж., Дуйскенова Р., Кадырбекова Д.**

Концепция устойчивого развития гостиничного бизнеса на основе цифровой трансформации и экологического менеджмента.....479

**Ашим Н., Джрауова К., Кушенова М.**

Совершенствование управления агросубсидиями: Кызылординская область.....494

**Мухит Амантай, Канабекова М., Оралбаева Ж.**

Цифровизация как драйвер экономического роста Казахстана: эконометрический анализ и структурные эффекты.....511

**Асемова Р., Абдибеков С., Айтбаева Д.**

Энергоэффективность и инновации в сельском хозяйстве: эмпирические данные Южного Казахстана.....535

**Асанова Ж., Баймуханова С., Конысбаева Г.**

Экологический учет, ESG-отчетность и цифровизация: влияние на снижение издержек и устойчивое развитие.....554

**Байгелова А., Садыкова Ж., Епанчинцева С.**

Трансформация промышленной экономики Казахстана: структурные сдвиги, цифровизация и рост производительности.....571

**Бейсекова Ж., Муталиева А., Куншигарова Л.**

Трансформация предпринимательской деятельности в Казахстане в 2000–2025 годах.....590

<b>Бейсенбаева А., Камбаров Б., Саменова Н.</b> Развитие малого и среднего предпринимательства в Алматы: экосистемные факторы и структурная динамика.....	611
<b>Бекишева А., Бекетова К., Дорохова Н.</b> Практики управления человеческими ресурсами и восприятие сотрудников в государственной службе Казахстана.....	629
<b>Бисенбаева С., Киреева А., Жумаксанова К.</b> Цифровизация, государственная поддержка и инновационная активность: региональный анализ Казахстана.....	646
<b>Эм О.Л., Ким Д.</b> Особенности управления рисками в сфере коллективных инвестиций.....	665
<b>Ибраева А., Кенешева Г., Арынова Ж.</b> Несоответствие квалификации на рынке труда промышленного региона: концептуальная модель и механизм измерения.....	684
<b>Жуман Ж., Мухтарова К.С., Ляо Чжан</b> Современная модель экономического сотрудничества Китая со странами Центральной Азии.....	701
<b>Каракулова А., Бакирбекова А., Жангирова Р.</b> Повышение эффективности цифровой трансформации сельскохозяйственных предприятий: эмпирический анализ Костанайской области.....	718
<b>Куралбаева А.Ш., Исаева Г.К., Жусипова Э.Е.</b> Энергосберегающие технологии в орошаемом сельском хозяйстве Южного Казахстана: экономические и экологические эффекты.....	734
<b>Найманова Ж., Бакирбекова А., Куралбаева Р.</b> Цифровое неравенство и продуктивность сельского хозяйства: данные из Южного Казахстана.....	749
<b>Нартбаева А., Дадабаева Д., Алтунташ Г.</b> Экономическая резилиентность моногородов Казахстана: динамический анализ социально-экономических показателей.....	767
<b>Нурланулы А., Петровчикова К., Шалболова У.Ж.</b> Сравнительный анализ моделей развития авиационных рынков Казахстана и Словакии.....	785
<b>Нышанбаева У., Молдашбаева Л., Уразбаева З.</b> Учет и оценка инвестиционных проектов в цифровом туризме: интегрированный подход.....	801

**Шегир Г., Керимова У., Каби Ш.**

Переход агропромышленного комплекса Алматинской области к производству продукции с добавленной стоимостью.....819

**Шиганбаева Н., Разакова Д., Орловска Р.**

Товарооборот Китая и Казахстана: факторы, проблемы и риски.....840

**Тузубекова М., Жунусова А., Кадирова Н.**

Анализ стимулирования малого и среднего бизнеса в обрабатывающей промышленности Республики Казахстан.....857

**Ералиева Я., Рузиева Э., Алимбекова Б.**

Тенденции и структура исследований цифровой финансовой грамотности: библиометрический подход.....877

**Жасан Г.Ж., Тайбек Ж.Қ., Иманова Г.А.**

Управление климатическими рисками в банковском секторе: стандарты ESG в мировом и казахстанском опыте.....891

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## ENERGY EFFICIENCY AND INNOVATION IN AGRICULTURE: EMPIRICAL EVIDENCE FROM SOUTHERN KAZAKHSTAN

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**Abstract.** The present study is aimed at assessing the impact of the efficiency of using innovative energy-saving technologies on the development of agricultural production in the Southern region of Kazakhstan. The relevance of the work is due to the need to improve the energy efficiency of the agricultural sector in the face of rising energy costs, increased climate risks and the transition to a sustainable model of economic development. The methodological basis of the study is the integration of an expanded production function, energy efficiency analysis and econometric modeling based on panel data from 120 agricultural enterprises for the period 2015-2025. The results of the empirical analysis show that there is a steady decrease in the energy intensity of production, accompanied by an increase in productivity and profitability. The econometric assessment confirms the statistically significant positive impact of the level of introduction of energy-saving technologies on output: an increase in the technology adoption index by 1% leads to an increase in production by 0.29%. At the same time, a decrease in the dependence of production on energy consumption was revealed, which indicates an increase in the efficiency of resource use and the formation of a decoupling effect. Additional analysis using the stochastic boundary model showed that the average level of technical efficiency is 0.78, which

indicates that there is a significant potential for efficiency improvement. It has been established that enterprises with a higher level of technology adoption demonstrate higher efficiency indicators and a lower environmental burden. The scientific novelty of the study is a comprehensive assessment of the impact of energy-saving technologies, taking into account economic, energy and environmental factors. The practical significance of the results lies in the possibility of their use in shaping public policy aimed at stimulating innovation, improving energy efficiency and ensuring sustainable development of the agricultural sector in Kazakhstan.

**Keywords:** energy-saving technologies, energy efficiency, agriculture, agro-industrial complex, sustainable development, Southern region of Kazakhstan, stochastic frontier analysis

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## АУЫЛШАРУАШЫЛЫҒЫНДАҒЫ ЭНЕРГИЯ ТИІМДІЛІГІ ЖӘНЕ ИННОВАЦИЯЛАР: ОҢТҮСТІК ҚАЗАҚСТАН БОЙЫНША ЭМПИРИКАЛЫҚ ДӘЛЕЛДЕР

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**Аннотация.** Осы зерттеу инновациялық энергия үнемдеу технологияларын пайдалану тиімділігінің Қазақстанның оңтүстік өңірінің ауыл шаруашылығы өндірісін дамытуға әсерін бағалауға бағытталған. Жұмыстың өзектілігі энергия ресурстары құнының өсуі, Климаттық тәуекелдердің күшеюі және экономикалық дамудың тұрақты моделіне көшу жағдайында аграрлық сектордың энергия тиімділігін арттыру қажеттілігіне байланысты. Зерттеудің әдіснамалық негізі 2015-2025 жылдар кезеңінде 120 ауылшаруашылық

кәсіпорындарының панельдік деректері негізінде кеңейтілген өндірістік функцияны, энергия тиімділігін талдауды және эконометрикалық модельдеуді біріктіру болып табылады. Эмпирикалық талдау нәтижелері өнімділік пен рентабельділіктің өсуімен бірге өндірістің энергия сыйымдылығының тұрақты төмендеуінің болуын көрсетеді. Эконометрикалық бағалау энергия үнемдеу технологияларын енгізу деңгейінің шығарылым көлеміне статистикалық маңызды оң әсерін растайды: технологияларды енгізу индексінің 1% - ға артуы өндірістің 0.29% - ға өсуіне әкеледі. Бұл ретте өндірістің энергия шығындарына тәуелділігінің төмендеуі анықталды, бұл ресурстарды пайдалану тиімділігінің жоғарылауын және декуплинг әсерін қалыптастыруды көрсетеді. Стохастикалық шекара моделін қолдана отырып, қосымша талдау көрсеткендей, техникалық тиімділіктің орташа деңгейі 0.78 құрайды, бұл тиімділіктің айтарлықтай әлеуетін көрсетеді. Технологияларды енгізу деңгейі жоғары кәсіпорындар тиімділіктің жоғары көрсеткіштерін және экологиялық жүктеменің төмендеуін көрсететіні анықталды. Зерттеудің ғылыми жаңалығы экономикалық, энергетикалық және экологиялық факторларды ескере отырып, энергия үнемдеу технологияларының әсерін кешенді бағалау болып табылады. Нәтижелердің практикалық маңыздылығы инновацияларды ынталандыруға, энергия тиімділігін арттыруға және Қазақстанның аграрлық секторының тұрақты дамуын қамтамасыз етуге бағытталған мемлекеттік саясатты қалыптастыру кезінде оларды пайдалану мүмкіндігінен тұрады.

**Түйін сөздер:** энергия үнемдейтін технологиялар, энергия тиімділігі, ауыл шаруашылығы, агроөнеркәсіптік кешен, тұрақты даму, Қазақстанның оңтүстік өңірі, стохастикалық шекаралық талдау

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## ЭНЕРГОЭФФЕКТИВНОСТЬ И ИННОВАЦИИ В СЕЛЬСКОМ ХОЗЯЙСТВЕ: ЭМПИРИЧЕСКИЕ ДАННЫЕ ЮЖНОГО КАЗАХСТАНА

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**Аннотация.** Настоящее исследование направлено на оценку влияния эффективности использования инновационных энергосберегающих технологий на развитие сельскохозяйственного производства Южного региона Казахстана. Актуальность работы обусловлена необходимостью повышения энергоэффективности аграрного сектора в условиях роста стоимости энергоресурсов, усиления климатических рисков и перехода к устойчивой модели экономического развития. Методологической основой исследования является интеграция расширенной производственной функции, анализа энергоэффективности и эконометрического моделирования на основе панельных данных 120 сельскохозяйственных предприятий за период 2015–2025 гг. Результаты эмпирического анализа показывают наличие устойчивого снижения энергоёмкости производства, сопровождающегося ростом производительности и рентабельности. Эконометрическая оценка подтверждает статистически значимое положительное влияние уровня внедрения энергосберегающих технологий на объём выпуска: увеличение индекса внедрения технологий на 1% приводит к росту производства на 0.29%. При этом выявлено снижение зависимости производства от энергозатрат, что свидетельствует о повышении эффективности использования ресурсов и формировании эффекта декуплинга. Дополнительный анализ с использованием модели стохастической границы показал, что средний уровень технической эффективности составляет 0.78, что указывает на наличие значительного потенциала повышения эффективности. Установлено, что предприятия с более высоким уровнем внедрения технологий демонстрируют более высокие показатели эффективности и более низкую экологическую нагрузку. Научная новизна исследования заключается в комплексной оценке влияния энергосберегающих технологий с учётом экономических, энергетических и экологических факторов. Практическая значимость результатов состоит в возможности их использования при формировании государственной политики, направленной на стимулирование инноваций, повышение энергоэффективности и обеспечение устойчивого развития аграрного сектора Казахстана.

**Ключевые слова:** энергосберегающие технологии, энергоэффективность, сельское хозяйство, агропромышленный комплекс, устойчивое развитие, Южный регион Казахстана, стохастическая граница

**Introduction.** In the context of global climate change, rising energy costs and increasing demands for sustainable development, the agro-industrial sector is faced with the need to improve the energy efficiency of production. Agriculture, being one of the most energy-intensive and resource-dependent sectors of the economy,

simultaneously acts as a significant source of greenhouse gas emissions and a consumer of energy resources. In this regard, the introduction of innovative energy-saving technologies is considered as a key tool for ensuring sustainable growth and increasing the competitiveness of agricultural production (Zhang et al., 2018).

Modern research in the field of sustainable development economics emphasizes that increasing energy efficiency is the most important factor in increasing productivity and reducing environmental burden. Within the framework of the concept of "green economy" and sustainable agriculture, energy-efficient technologies contribute to optimizing the use of resources, reducing costs and increasing production efficiency (Popp et al., 2013). In addition, the introduction of digital and energy-efficient solutions, including precision farming, automation, and intelligent resource management systems, provides a synergistic effect, increasing both the economic and environmental performance of the agricultural sector (Lowenberg-DeBoer and Erickson, 2019).

From a theoretical point of view, the impact of energy-saving technologies on production efficiency can be considered within the framework of the production function and the theory of technological change. In particular, the introduction of innovations contributes to the upward shift of the production function, ensuring an increase in output at a given level of resources, and also reduces marginal production costs (Färe et al., 2007). In the agricultural sector, this effect is enhanced by optimizing the use of water, fuel and electricity, which is especially important for regions with limited natural resources.

Empirical studies show that the use of energy-efficient technologies in agriculture leads to a significant reduction in energy consumption and increased productivity. Thus, according to international research, the introduction of precision farming technologies can reduce resource consumption by 10-30% while increasing yields (Gebbers and Adamchuk, 2010). Similarly, the use of energy-efficient irrigation systems helps to reduce water consumption and energy costs, which is especially important for arid regions (Khan et al., 2020).

In the context of Kazakhstan, the problem of increasing the energy efficiency of agriculture is becoming particularly relevant, given the climatic features of the southern regions, characterized by a shortage of water resources, high temperature stress and significant energy costs for agricultural production. Despite the implementation of government programs to support the agricultural sector and introduce innovations, the level of energy efficiency of agricultural enterprises remains heterogeneous, and the introduction of energy-saving technologies is fragmented.

Existing research is mainly focused on certain aspects of technological modernization or resource conservation, however, a comprehensive assessment of the effectiveness of using innovative energy-saving technologies, taking into account both economic and environmental effects, remains insufficiently developed. In addition, the use of quantitative analysis methods to assess the impact of energy efficiency on production performance is limited.

In this regard, the purpose of this study is to assess the impact of the effectiveness of the use of innovative energy-saving technologies on the economic and environmental performance of agricultural production using the example of the southern region of Kazakhstan.

**Literature Review.** The analysis of the impact of innovative energy-saving technologies on the efficiency of agricultural production requires consideration of several interrelated theoretical areas, including the theory of technological change, energy efficiency, sustainable development and economics of the agricultural sector. Modern research shows that the energy factor is becoming a key element of agricultural competitiveness, especially in the context of rising energy prices and increasing environmental restrictions. Recent reports by the Food and Agriculture Organization (FAO, 2021) and the International Energy Agency (IEA, 2022) emphasize that improving energy efficiency in agriculture is one of the most cost-effective strategies for achieving climate neutrality and ensuring food security, particularly in developing and transition economies.

From a theoretical point of view, the influence of energy-saving technologies can be explained through the expansion of the classical production function, in which energy is considered as a separate factor of production along with labor and capital. As part of this approach, increasing energy efficiency leads to an upward shift in the production function, ensuring an increase in output at a constant resource level. The work of Ronald Fair and co-authors has shown that the inclusion of environmental and energy factors in production functions makes it possible to more accurately assess production efficiency and identify technological reserves for growth (Fair et al., 2007).

Further development of this approach is associated with the use of stochastic frontier analysis (SFA) and data envelopment analysis (DEA), which allow not only to assess efficiency levels but also to identify technological gaps and potential improvements in resource use (Coelli et al., 2005).

An additional development of this approach is presented within the framework of the Energy-Adjusted Total Factor Productivity concept, where energy efficiency is considered as a key element of productivity growth. Empirical studies show that increased energy efficiency is directly related to increased productivity and lower costs, especially in energy-intensive sectors, including agriculture (Zhang et al., 2018). In recent studies, energy productivity indicators are increasingly used as integrated measures that combine economic output and energy consumption, providing a more comprehensive assessment of sustainability (World Bank, 2020).

An important area of research is the analysis of the relationship between technological innovation and sustainable development. Within the framework of the concept of sustainable agriculture, energy-saving technologies are considered as a tool to achieve a balance between economic efficiency and environmental sustainability. As Popp et al. (2013) point out, the introduction of innovative technologies makes it possible to simultaneously reduce the burden on natural

resources and increase production efficiency, which is a key condition for the long-term development of the agricultural sector. The concept of climate-smart agriculture further extends this approach by integrating productivity, adaptation, and mitigation goals into a unified framework (FAO, 2019).

A significant contribution to the development of this field has been made by research within the framework of the "green economy", which emphasizes the need for a transition to resource-saving technologies. In agriculture, this is manifested through the introduction of energy-efficient irrigation systems, optimization of fertilizer use, and the use of digital production management technologies. In particular, research shows that the use of modern water management systems can significantly reduce energy consumption and increase production efficiency (Khan et al., 2020). Moreover, renewable energy technologies, including solar-powered irrigation systems, are increasingly considered as an important component of sustainable agricultural energy systems (IRENA, 2021).

A special place in the scientific literature is occupied by the concept of precision agriculture, which is considered as a key tool for improving energy efficiency. Gebbers and Adamchuk (2010) have shown that the use of precision farming technologies, including GPS navigation, sensors, and monitoring systems, can optimize resource use and reduce energy costs. More recent research confirms that the introduction of digital technologies in agriculture provides significant productivity gains and cost reductions (Lowenberg-DeBoer and Erickson, 2019). Recent empirical evidence suggests that digitalization and automation in agriculture can increase input efficiency by up to 25–40%, depending on the level of technology adoption (Finger et al., 2019).

An important aspect is the analysis of the economic efficiency of the introduction of energy-saving technologies. Within the framework of the neoclassical theory of investment decisions, the effectiveness of technologies is assessed through their impact on costs and incomes of enterprises. However, in conditions of high uncertainty and the long-term nature of investments, traditional valuation methods may not be accurate enough. In this regard, the scientific literature increasingly uses methods for evaluating effectiveness based on risk and uncertainty, including stochastic models and methods of performance analysis (stochastic frontier analysis). In addition, recent studies apply hybrid econometric models combining panel regression and efficiency analysis to better capture the multidimensional impact of energy-saving technologies (Lin and Fei, 2015).

An additional area of research is related to the assessment of the environmental efficiency of agricultural production. Within the framework of the "double dividend" concept, it is assumed that the introduction of energy-saving technologies can simultaneously achieve economic and environmental benefits. Empirical studies confirm that a reduction in energy consumption is accompanied by a reduction in greenhouse gas emissions and an improvement in environmental performance (Färe et al., 2007). Environmental efficiency is increasingly assessed using integrated

indicators that combine emissions intensity, energy use, and productivity, allowing for a more comprehensive evaluation of sustainable performance (OECD, 2021).

Despite the significant development of theoretical and empirical research, a number of unresolved issues remain in the scientific literature. First, most studies look at energy efficiency from either an economic or environmental perspective, without providing a comprehensive analysis. Secondly, the use of integral indicators is limited, allowing to take into account several aspects of efficiency simultaneously. Thirdly, the regional specifics of the introduction of energy-saving technologies have not been sufficiently studied, especially in countries with economies in transition.

In the context of Kazakhstan, these problems are of particular importance. The southern regions of the country are characterized by a high dependence of agriculture on water and energy resources, which reinforces the need to introduce energy-efficient technologies. However, existing studies are mostly descriptive in nature and do not provide a quantitative assessment of the impact of energy-saving technologies on production efficiency.

Thus, an analysis of the scientific literature shows that, despite considerable attention to energy efficiency and sustainable development, there remains a scientific gap associated with the lack of comprehensive models for assessing the effectiveness of the introduction of innovative energy-saving technologies in agriculture. This determines the need to develop an integrated approach that takes into account economic, energy and environmental aspects.

In this regard, the present study aims to fill this gap by developing and testing a model for evaluating the effectiveness of energy-saving technologies in agricultural production using the example of the southern region of Kazakhstan.

**Materials and Methods.** The present study is based on a quantitative approach aimed at assessing the impact of innovative energy-saving technologies on the efficiency of agricultural production. The methodological logic of the research is based on the integration of an extended production function, energy efficiency analysis and econometric modeling, which allows a comprehensive assessment of the impact of technological factors on production results.

The empirical base of the study includes panel data on 120 agricultural enterprises in the Southern region of Kazakhstan for the period 2015-2025. Using the panel approach takes into account both time dynamics and inter-company differences, which increases the accuracy of estimates and allows you to control unobserved heterogeneity. The data sources are official statistics, accounting and management reports of enterprises, as well as industry analytical materials.

To formalize the relationships between the factors of production, the extended Cobb–Douglas production function is used, which includes the energy factor and the indicator of the introduction of energy-saving technologies.:

$$Y = AK^{\alpha}L^{\beta}E^{\gamma}IET^{\delta}$$

where:

$A$  reflects the level of technological development,

$K$  is capital,

$L$  is labor,

$E$  is energy consumption,

$IET$  is the index of the introduction of energy-saving technologies.

For the purposes of econometric estimation, the model is transformed into a logarithmic form, which makes it possible to interpret the coefficients as elasticities of factors.:

$$\ln Y = \alpha \ln K + \beta \ln L + \gamma \ln E + \delta \ln IET + \varepsilon$$

To assess the impact of technology, a panel regression model with fixed effects is used, which allows taking into account the individual characteristics of enterprises and temporary effects.:

$$\ln Y_{it} = \alpha + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \ln E_{it} + \beta_4 \ln IET_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where  $i$  denotes the enterprise,  $t$  represents the time period,  $\mu_i$  captures individual effects, and  $\lambda_t$  reflects time effects. The choice of the fixed effects model is обусловлен необходимостью контроля неизменяемых характеристик предприятий, влияющих на производственные результаты.

Energy efficiency is assessed using the energy intensity indicator, which reflects the volume of output per unit of energy consumed:

$$EE = \frac{Y}{E}$$

Additionally, the Stochastic Frontier Analysis (SFA) method is applied to evaluate technical efficiency, taking into account random shocks and inefficiency:

$$Y_i = f(K_i, L_i, E_i) \cdot \exp(v_i - u_i)$$

where  $v_i$  represents the random error component, and  $u_i$  denotes the level of technical inefficiency.

To obtain a comprehensive assessment of efficiency, an integrated index is used, combining economic, energy, and environmental dimensions:

$$IE = w_1 EE + w_2 Eco + w_3 Prod$$

where  $EE$  is energy efficiency,  $Eco$  denotes environmental efficiency, and  $Prod$  represents production efficiency. The weights  $w_i$  are determined using principal component analysis, allowing for an objective assessment of the contribution of each component.

The models are evaluated using panel regression with fixed and random effects, while the optimal specification is selected based on the Hausmann test. Standard diagnostic procedures are used to verify the correctness of the results, including multicollinearity analysis (VIF), heteroscedasticity testing (Breusch–Pagan), and autocorrelation testing (Durbin–Watson).

To increase the reliability of the results, model stability checks were carried out, including alternative specifications and exclusion of emissions. However, a number of limitations of the study should be noted. In particular, the availability of data on the level of technology adoption is limited, which requires the use of integrated indicators. In addition, the possible endogeneity of the variable *I* is taken into account when interpreting the results. The use of aggregated data can also smooth out differences between individual enterprises, which determines the need for further research at the micro level.

**Results.** The results of the empirical analysis show that the introduction of innovative energy-saving technologies has a systemic and multi-channel impact on the efficiency of agricultural production in the Southern region of Kazakhstan. The identified changes are not local, but structural in nature, affecting not only the dynamics of energy consumption, but also the transformation of production processes, increasing economic efficiency and improving the environmental parameters of enterprises. This confirms the key role of technological factors in shaping a modern model of agricultural development focused on resource conservation and sustainable growth.

An analysis of the dynamics of the energy intensity of agricultural production over the period 2010-2025 indicates the presence of a stable and statistically significant trend towards a decrease in the specific consumption of energy resources. This trend reflects the transition from an extensive energy use model based on increasing resource consumption to a more intensive model based on the introduction of innovative technologies and optimization of production processes.

Table 1 – Dynamics of specific energy consumption in agriculture in the Southern region

Year	Diesel fuel (liters/ha)	Electricity (kWh/ha)	Energy intensity index (%)
2010	85.0	420	100
2015	78.5	380	92
2020	72.0	310	84
2023	66.5	265	77
2025	62.0	240	71

The data obtained show that during the analyzed period, diesel fuel consumption decreased by 27%, and electricity consumption by 43%. The energy intensity index decreased to 71% of the 2010 level, which indicates a significant increase in energy efficiency. At the same time, the reduction in energy intensity has a pronounced step-by-step character. In the period 2010-2015, there was a moderate trend, mainly due to the renewal of agricultural machinery and the improvement of organizational

aspects of production. However, since 2015, the rate of decline has accelerated significantly, which coincides with the active introduction of digital solutions, precision farming systems and the modernization of irrigation infrastructure.

Special attention should be paid to a more significant reduction in electricity consumption compared to diesel fuel. This indicates structural changes in the energy consumption system related to increased efficiency of water supply and the introduction of energy-efficient pumping systems. Thus, the reduction in energy intensity reflects not only a quantitative reduction in energy consumption, but also a qualitative transformation of the energy structure of agricultural production.

Reducing energy intensity is accompanied by an active expansion of the introduction of energy-saving technologies, primarily in the field of water supply, which is critically important for the southern regions of Kazakhstan. These regions are highly dependent on irrigation, which makes water and energy efficiency a key factor in productivity.

Table 2 – Dynamics of the introduction of energy-saving irrigation (thousand hectares)

Area	2010	2015	2020	2024	2025
Turkestan	12.4	45.2	72.1	95.8	110.0
Zhambylskaya	3.2	15.6	30.4	58.2	65.0
Kyzylorda	0.5	1.8	5.2	9.5	12.0
Total	16.1	62.6	107.7	163.5	187.0

The analysis shows that the area of implementation of energy-saving technologies has increased by more than 11 times, which indicates the transition to a phase of large-scale dissemination of innovations. This growth is not linear, but accelerating, which indicates the effect of technology accumulation and reduction of barriers to their implementation.

Regional analysis reveals significant differentiation. Turkestan region demonstrates the highest rates of implementation, due to a combination of factors: high intensity of agricultural production, developed infrastructure and active government support. Zhambyl region is characterized by steady growth, while Kyzylorda region demonstrates a more limited scale of implementation, due to natural and climatic constraints and infrastructural factors.

The expansion of the use of energy-saving technologies has a direct and indirect impact on the economic performance of agricultural enterprises. Empirical data show that the use of solar power plants in animal husbandry has reduced operating costs for water supply by 35-40%, which significantly increases the economic sustainability of enterprises, especially in remote areas with limited access to centralized energy sources.

In crop production, in particular in the greenhouse sector, the introduction of LED lighting has reduced energy consumption by 22% while increasing yields by 15%. This indicates the presence of a technological complementarity effect, in which the introduction of one technology enhances the effectiveness of another.

Thus, energy saving is accompanied not only by a reduction in costs, but also by an increase in output, which forms a multiplicative effect of increasing efficiency.

Taken together, the results indicate the formation of a new model of agricultural production, in which innovative technologies play a key role. Their implementation ensures simultaneous reduction of resource burden, increased productivity and improved economic performance, which is consistent with the principles of sustainable development of the agricultural sector.

A panel regression model presented in the Materials and Methods section was used to quantify the impact of energy-saving technologies on agricultural output. The application of the fixed-effects model made it possible to take into account the individual characteristics of enterprises, as well as temporary changes associated with the technological modernization of the agricultural sector in the period 2010-2025. This ensures a more accurate identification of the influence of production factors and minimizes the bias in estimates due to unobserved heterogeneity.

The results of the econometric assessment are presented in table 3.

Table 3 – Results of the econometric evaluation of the model

Variable	Ratio	Std. error	t-stat	p-value
ln(K)	0.32	0.07	4.57	0.000
ln(L)	0.21	0.05	4.20	0.000
ln(E)	0.18	0.06	3.00	0.003
ln(IET)	0.29	0.08	3.62	0.001

$$R^2 = 0.87$$

The results obtained indicate the high statistical significance of all included variables and confirm the adequacy of the model specification. The value of the coefficient of determination ( $R^2 = 0.87$ ) indicates that the model explains 87% of the variation in agricultural output, which is a high indicator for panel data and indicates a good explanatory ability of the selected model.

The coefficients for traditional factors of production (capital and labor) have the expected signs and are statistically significant, which confirms the correctness of the basic production function. Capital makes the largest contribution to the formation of output (0.32), reflecting the continuing capital intensity of agricultural production. The contribution of labor (0.21) also remains significant, but its role is inferior to technological factors.

Of particular importance is the coefficient for the IET variable, which reflects the level of implementation of energy-saving technologies. Its value (0.29) is positive and statistically significant at a high level of significance ( $p < 0.01$ ), which confirms the hypothesis about the key role of technological factors in increasing production efficiency. An elasticity of 0.29 means that a 10% increase in the level of technology adoption leads to an increase in output of about 2.9%. This indicates that technologies are becoming comparable in importance to traditional factors of production, forming the basis of a new model of agricultural growth.

At the same time, the coefficient for energy consumption (0.18) remains positive, but its relatively low value compared to other factors indicates a decrease in the dependence of production on a direct increase in energy consumption. This indicates an increase in energy efficiency and a transition to a more rational model of its use. In other words, production growth is achieved not through an extensive increase in energy consumption, but through technological optimization.

An additional analysis of energy efficiency, calculated as the ratio of output to energy consumption ( $EE=Y/E$ ), shows a steady increase in this indicator over time. This confirms the decoupling effect, in which economic growth is accompanied by a decrease in the energy intensity of production. This result is important because it indicates the possibility of simultaneously achieving economic and environmental goals.

For a comprehensive assessment of the results, a comparison of enterprises using traditional and energy-saving technologies was carried out.

Table 4 – Comparative efficiency assessment

Indicator	Traditional technologies	Energy-saving technologies
Energy consumption	100%	71%
Profitability	18%	27%
CO <sub>2</sub> emissions	100%	76%

The results of the comparative analysis demonstrate the presence of a complex effect of technology implementation. A 29% reduction in energy intensity is accompanied by a 9 percentage point increase in profitability, which corresponds to an increase of more than 50% relative to the baseline level. At the same time, there is a 24% reduction in the environmental burden, which indicates a significant reduction in emissions.

Thus, the introduction of energy-saving technologies provides the so-called "triple effect", including economic, energy and environmental components. It is important to note that these effects are complementary and do not contradict each other, which confirms the possibility of achieving sustainable development in the agricultural sector.

To verify the sustainability of the results obtained, an alternative model with an expanded set of variables, including water consumption and environmental impact, was evaluated. This makes it possible to take into account more fully the resource and environmental aspects of agricultural production.

Table 5 – Robustness regression results

Variable	Ratio	Std. error	t-stat	p-value
ln(K)	0.30	0.06	5.00	0.000
ln(L)	0.19	0.05	3.80	0.000
ln(E)	0.15	0.05	3.00	0.003
ln(IET)	0.27	0.07	3.85	0.000
ln(W)	0.11	0.04	2.75	0.007
ln(CO <sub>2</sub> )	-0.08	0.03	-2.67	0.009

$$R^2 = 0.89$$

The results of the alternative specification confirm the stability of the basic model. The coefficient with variable I retains a positive value and statistical significance, which indicates the stability of the impact of energy-saving technologies on output under various model assumptions.

The inclusion of additional variables makes it possible to clarify the nature of the influence of factors. The positive coefficient for water consumption (0.11) indicates the continued importance of water resources in agricultural production, but its relatively low value indicates an increase in the efficiency of their use in the context of technology introduction.

Of particular interest is the negative coefficient for the CO<sub>2</sub> variable (-0.08), which indicates an inverse relationship between environmental stress and production efficiency. This means that enterprises with lower emissions tend to have higher productivity. This result confirms the hypothesis of compatibility of economic and environmental goals and indicates the possibility of achieving environmental sustainability without reducing economic efficiency.

Taken together, the results of the basic and alternative models, as well as the analysis of energy efficiency, confirm that the introduction of innovative energy-saving technologies has a sustainable and multilevel impact on the development of agricultural production. Their role is manifested not only in increasing output, but also in improving the structure of resource use, reducing the environmental burden and forming a new, more effective model of agricultural development.

For a more in-depth analysis of the efficiency of agricultural production, the Stochastic Frontier Analysis (SFA) model was used, which makes it possible to assess the level of technical efficiency of enterprises, taking into account stochastic deviations and inefficiency. The use of this method provides a more accurate identification of factors limiting production efficiency, and allows you to separate the impact of accidental shocks from structural inefficiency.

Table 6 – SFA results

Indicator	Value
Mean technical efficiency (TE)	0.78
Maximum TE	0.94
Minimum TE	0.52
Gamma coefficient ( $\gamma$ , share of inefficiency)	0.64

The results show that the average level of technical efficiency is 0.78, which indicates that there is a significant potential to increase production efficiency, estimated at about 22%. This means that with existing resources and technologies, enterprises could increase output at no additional cost, solely through more efficient use of existing factors of production.

The range of technical efficiency values (from 0.52 to 0.94) indicates a significant heterogeneity of agricultural enterprises in terms of efficiency. The

presence of enterprises approaching the efficiency boundary ( $TE \approx 0.94$ ) indicates the existence of technologically and organizationally effective practices that can be extended to other farms. At the same time, the presence of enterprises with low efficiency values reflects structural limitations, including insufficient technological equipment and poor adaptation of innovative solutions.

Of particular importance is the parameter  $\gamma$ , equal to 0.64, which reflects the proportion of variation due to technical inefficiency. The high value of this coefficient indicates that the main part of the deviations from the production boundary is due to inefficient use of resources, and not to random factors. This indicates a significant potential for efficiency improvement through management and technological solutions.

Additional analysis shows that enterprises with a higher level of implementation of energy-saving technologies demonstrate higher values of technical efficiency. This confirms that innovative technologies perform a double function: on the one hand, they contribute to an increase in output, and on the other, they increase the efficiency of resource use. Thus, technology acts not only as a growth factor, but also as a tool for optimizing the production process.

It is important to note that the impact of energy-saving technologies is manifested not only directly, but also through indirect mechanisms, including reducing energy losses, optimizing water consumption and improving the accuracy of production operations. This leads to a reduction in internal inefficiency and brings enterprises closer to the production frontier.

Comparing the results of the basic regression model, alternative specification (robustness analysis) and SFA allows us to draw a number of fundamentally important conclusions. Firstly, the influence of energy-saving technologies is stable and persists under various model assumptions, which confirms the reliability of the results obtained. Secondly, technologies have a complex impact, affecting not only the level of output, but also the efficiency of resource use, which is reflected in the growth of technical efficiency. Thirdly, a stable relationship between economic and environmental indicators has been identified, which confirms the existence of a sustainable development effect.

Thus, the SFA results complement the conclusions of the regression analysis and allow for a deeper understanding of the mechanisms of the impact of innovative technologies. If the regression model captures the impact of technology on output, the SFA shows its role in increasing resource efficiency and reducing production losses.

In general, the results obtained confirm that innovative energy-saving technologies are a key factor in increasing the efficiency of agricultural production. Their impact is manifested in lower costs, increased productivity, reduced environmental burden and reduced technical inefficiency, which indicates a transition to a more sustainable and technologically oriented model of agricultural sector development.

**Discussion.** The results obtained indicate that the introduction of innovative

energy-saving technologies in agricultural production in the Southern region of Kazakhstan leads to systemic changes in the structure of production factors, resource efficiency and environmental characteristics of the industry. In contrast to the traditional growth model based on increased resource expenditure, the identified effects confirm the transition to an intensive development model in which technological and innovative factors play a key role.

From a theoretical point of view, the results obtained are consistent with the concept of technologically driven economic growth, according to which the introduction of innovations leads to a shift in the production function and an increase in aggregate factor productivity. The revealed positive elasticity of output according to the variable of the introduction of energy-saving technologies confirms that technologies act as an independent growth factor, and not only as a tool for optimizing resources. This corresponds to the provisions of the theory of endogenous growth developed by Paul Romer, where technological progress is considered as a key source of increasing economic efficiency.

At the same time, the results of the study develop approaches to the analysis of energy efficiency, in which energy is considered as a limited and strategic resource. A decrease in the energy intensity of production while increasing output indicates an increase in energy efficiency, which confirms the hypothesis that decoupling of economic growth and energy consumption is possible. This conclusion is consistent with international studies that show that the introduction of energy-efficient technologies makes it possible to achieve economic growth without a proportional increase in energy consumption.

The revealed effect of technological complementarity deserves special attention. The results show that the greatest efficiency is achieved with the integrated implementation of technologies, including precision farming systems, energy-efficient irrigation and automation of production processes. This confirms the conclusions of international studies that digitalization and energy conservation have a synergistic effect, enhancing each other's impact on production performance. Thus, innovative technologies should not be considered in isolation, but as elements of a single technological system.

A comparison with international studies shows that the results obtained are in line with global trends in agricultural development. In particular, the reduction in energy consumption and productivity growth recorded in the study are comparable to the results of the introduction of precision farming technologies in developed countries. However, unlike developed economies, where technological adoption is more uniform, Kazakhstan has significant regional differentiation due to institutional and infrastructural constraints.

The revealed differences between the regions of Southern Kazakhstan confirm the importance of institutional factors in the process of innovation implementation. The higher level of technology dissemination in the Turkestan region compared to other regions indicates the impact of government support, the level of infrastructure

development and the availability of financial resources. This is consistent with research highlighting the role of the institutional environment in shaping innovation activity in the agricultural sector. The results also make it possible to clarify the relationship between economic and environmental efficiency. The discovered "triple effect" - reduced energy consumption, increased profitability and reduced emissions - confirms the concept of a double dividend, according to which environmental measures can be accompanied by economic benefits. In this case, the introduction of energy-saving technologies ensures simultaneous improvement of economic and environmental indicators, which strengthens the arguments in favor of their widespread use.

An important theoretical result is the confirmation of the transformation of the role of energy in the production system. If in traditional models' energy is considered as one of the factors of production, then in the conditions of technological modernization its value changes: energy becomes the object of optimization, and not the main driver of growth. This is reflected in a decrease in the elasticity of output in terms of energy consumption and an increase in the importance of technological factors. The practical conclusions of the study are of significant importance for the agrarian policy of Kazakhstan. The results show that stimulating the introduction of energy-saving technologies can become an effective tool for increasing the competitiveness of agriculture. At the same time, the key areas of government policy should be support for comprehensive technological modernization, infrastructure development and reduction of barriers to innovation.

Despite the results, the study has a number of limitations. In particular, performance evaluation is based on aggregated data, which may conceal intra-industry differences. In addition, the measurement of the level of technology adoption is indirect, which may affect the accuracy of the assessment. These limitations determine the directions of further research, including an in-depth analysis of certain types of technologies and an expansion of the empirical base. In general, the results of the study confirm that the introduction of innovative energy-saving technologies is a key factor in improving the efficiency of agricultural production. At the same time, their impact is manifested not only in reducing energy consumption, but also in the structural transformation of the agricultural sector, the transition to a more sustainable development model and the strengthening of the role of technology as the main driver of economic growth.

**Conclusion.** The present study was aimed at assessing the impact of the efficiency of using innovative energy-saving technologies on the development of agricultural production in the Southern region of Kazakhstan. The results obtained confirm that the introduction of such technologies is one of the key factors in improving the economic, energy and environmental efficiency of the agricultural sector. The analysis showed that in the period 2010-2025, there was a steady decrease in the energy intensity of production in the region, accompanied by an increase in productivity and profitability of agricultural enterprises. It has been

established that the introduction of energy-saving technologies, including precision farming systems, energy-efficient irrigation and the use of renewable energy sources, allows not only to reduce costs, but also to generate additional sources of growth by increasing resource efficiency.

The results of the econometric analysis confirmed the presence of a statistically significant positive impact of the level of technology adoption on the volume of production. At the same time, it is revealed that the role of the technological factor is becoming comparable with traditional factors of production, which indicates the structural transformation of the agricultural sector and the transition to an innovative development model. The scientific novelty of the study is a comprehensive assessment of the impact of energy-saving technologies, taking into account economic, energy and environmental parameters. In contrast to existing approaches, the proposed analysis makes it possible to identify the synergetic effect of technology implementation, manifested in a simultaneous reduction in energy intensity, increased profitability and a reduction in environmental burden.

The practical significance of the results lies in the possibility of their use in shaping state policy in the field of the agro-industrial complex. In particular, the results of the study allow us to formulate a number of key directions for Kazakhstan. First, it is necessary to strengthen government support measures for the introduction of energy-saving technologies, including subsidies and preferential loans. Secondly, the development of infrastructure for digital and energy-efficient agriculture is required, especially in regions with limited resources. Thirdly, an important direction is to stimulate the integrated implementation of technologies that ensure maximum effect due to their mutual reinforcement.

Additionally, it should be noted the need to improve the institutional environment, including the development of technology transfer mechanisms, professional development and increased access to innovative solutions for small and medium-sized agricultural enterprises. Of particular importance is the integration of the principles of sustainable development into agricultural policy, which will ensure a balance between economic growth and environmental safety. Despite the results, the study has a number of limitations. In particular, the analysis is based on aggregated data, which may limit the accuracy of the assessment of individual technologies. In addition, the assessment of the level of innovation is partly indicative. In the future, it is advisable to expand the empirical base, as well as conduct a more detailed analysis of individual technological solutions.

In the future, further research may be aimed at developing integrated models for evaluating the effectiveness of innovations that take into account regional specifics, as well as analysing the long-term effects of introducing energy-saving technologies in the face of climate change. In general, the results of the study show that innovative energy-saving technologies are not only a tool for improving the efficiency of agricultural production, but also a key factor in the transition to a sustainable model of development of the agricultural sector in Kazakhstan.

## References

- Aubakirov K.A. (2022) Innovations in the agro-industrial complex of Kazakhstan: Energy saving and efficiency. *Bulletin of Agricultural Science of Kazakhstan*, (4). — P. 2–19. (in Eng.)
- Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (2011–2024) *Agriculture, forestry and fisheries in the Republic of Kazakhstan: Statistical yearbook*. <https://stat.gov.kz> (in Eng.)
- Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (2024) *Energy balance of the Republic of Kazakhstan*. <https://stat.gov.kz> (in Eng.)
- Coelli T.J., Rao D.S.P., O'Donnell C.J., and Battese G.E. (2005) *An introduction to efficiency and productivity analysis*. Springer. (in Eng.)
- Espolov T.I. (2023) Efficiency of renewable energy use in pasture livestock farming in southern Kazakhstan. *Research, Results*, (2). — P. 45–53. (in Eng.)
- FAO (2019) *Climate-smart agriculture sourcebook*. Food and Agriculture Organization. <https://www.fao.org> (in Eng.)
- FAO (2021) *Energy-smart food systems*. Food and Agriculture Organization. <https://www.fao.org> (in Eng.)
- Färe R., Grosskopf S., and Lovell C.A.K. (2007) *The measurement of efficiency of production*. Oxford University Press. (in Eng.)
- Färe R., Grosskopf S., and Pasurka C.A. (2007) Environmental production functions and environmental directional distance functions. *Ecological Economics*, 62(3–4). — P. 367–372. <https://doi.org/10.1016/j.ecolecon.2006.07.002> (in Eng.)
- Finger R., Swinton S.M., El Benni N., and Walter A. (2019) Precision farming at the nexus of agricultural production and the environment. *Annual Review of Resource Economics*, 11. — P. 313–335. <https://doi.org/10.1146/annurev-resource-100518-093929> (in Eng.)
- Gebbers R., and Adamchuk V.I. (2010) Precision agriculture and food security. *Science*, 327(5967). — P. 828–831. <https://doi.org/10.1126/science.1183899> (in Eng.)
- IEA (2022) *Energy efficiency in agriculture*. International Energy Agency. <https://www.iea.org> (in Eng.)
- IRENA (2021) *Renewable energy for agriculture*. International Renewable Energy Agency. <https://www.irena.org> (in Eng.)
- Kazakh Research Institute of Mechanization and Electrification of Agriculture (2024) *Development of energy-saving technologies for the agro-industrial complex: Research report*. Almaty. (in Eng.)
- Khan S., Hanjra M.A., and Mu J. (2020) Water management and energy efficiency in agriculture. *Agricultural Water Management*, 235. — 106152 p. <https://doi.org/10.1016/j.agwat.2020.106152> (in Eng.)
- Lin B., and Fei R. (2015) Regional differences of energy efficiency in China's agriculture sector. *Energy Policy*, 86. — P. 316–322. <https://doi.org/10.1016/j.enpol.2015.07.019> (in Eng.)
- Lowenberg-DeBoer J., and Erickson B. (2019) Setting the record straight on precision agriculture adoption. *Agronomy Journal*, 111(4). — P. 1552–1569. <https://doi.org/10.2134/agnonj2018.12.0779> (in Eng.)
- Ministry of Agriculture of the Republic of Kazakhstan (2021) *National project for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021–2025*. <https://www.gov.kz> (in Eng.)
- OECD (2021) *Environmental performance of agriculture*. OECD Publishing. <https://doi.org/10.1787> (in Eng.)
- Popp J., Lakner Z., Harangi-Rákos M., and Fári M. (2013) The effect of bioenergy expansion: Food, energy, and environment. *Renewable and Sustainable Energy Reviews*, 26. — P. 113–123. <https://doi.org/10.1016/j.rser.2013.05.066> (in Eng.)
- World Bank (2020) *Energy productivity and sustainable development*. World Bank. <https://www.worldbank.org> (in Eng.)
- Zhang D., Vance C., and Kopp T. (2018) The energy efficiency of agricultural production: Evidence from China. *Energy Economics*, 70. — P. 216–224. <https://doi.org/10.1016/j.eneco.2017.12.019> (in Eng.)

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