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Unlocking Intersectoral Integration in Kazakhstan's Agro-Industrial Complex: Technological Innovations, Knowledge Transfer, and Value Chain Governance as Predictors

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Abstract: The agro-industrial complex plays a vital role in driving economic growth and sustainable development. This study investigates the direct and indirect impact of technological innovations, knowledge transfer, and value chain governance on intersectoral integration through the mediatory role of innovation diffusion and the moderating role of the regulatory environment. This study adopts a time-lagged quantitative survey research design, utilizing a multistage random sampling technique to collect data from employees within the agro-industrial complex in Kazakhstan. The findings reveal that technological innovations, knowledge transfer, and value chain governance positively influence intersectoral integration within the agro-industrial complex. Furthermore, innovation diffusion mediates the relationship between these variables, indicating that the diffusion of innovative practices, technologies, and ideas plays a crucial role in facilitating intersectoral integration. This study also demonstrates that the regulatory environment moderates the relationship between innovation diffusion and intersectoral integration, highlighting the importance of supportive regulatory frameworks in facilitating collaboration and innovation diffusion. The results contribute to the theoretical understanding of intersectoral integration and provide practical implications for policymakers, industry stakeholders, and managers.

Keywords: technological innovations; knowledge transfer; value chain governance; intersectoral integration; innovation diffusion; regulatory environment

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1. Introduction

The agro-industrial complex plays a pivotal role in the economic development of nations, as it contributes significantly to the country's GDP and employment (Olshanska et al. 2022). However, unlocking the full potential of this sector requires effective intersectoral integration (Nurmanbetova et al. 2022). By fostering collaboration among various stakeholders, such as government agencies, farmers, technology providers, and value chain actors, intersectoral integration can lead to improved productivity, sustainable growth, and enhanced competitiveness (Huseynov et al. 2023). This research paper aims to explore the predictors of intersectoral integration, focusing on technological innovations, knowledge transfer, and value chain governance. Technological innovations have been recognized as a key drivers of productivity and competitiveness in the agricultural sector worldwide (Popkova and Sergi 2023). Moreover, technological advancements offer

immense potential to transform traditional farming practices and improve efficiency all over the globe (Shivay et al. 2022). By adopting modern farming technologies, such as precision agriculture, remote sensing, and smart irrigation systems, farmers can optimize resource utilization, enhance crop yields, and reduce environmental impact (Bwambale et al. 2022).

At the same time, knowledge transfer is vital for sustainable development and innovation in any industry. In the context of the agro-industrial complex, knowledge transfer involves disseminating and applying best practices, scientific research, and technical expertise among various stakeholders (Wieliczko and Floriańczyk 2022). Effective knowledge transfer mechanisms enable farmers, policymakers, and value chain actors to stay updated with the latest trends, methodologies, and techniques (Blazquez-Soriano and Ramos-Sandoval 2022). Simultaneously, value chain governance, by promoting collaboration and coordination among diverse sectors, enhances the efficiency and effectiveness of the value chain. (Martens and Zscheischler 2022). Effective governance mechanisms facilitate information sharing, resource allocation, and decision-making processes across sectors (Smidt and Jokonya 2022). This integration leads to improved supply chain management, innovation, and overall performance. It enables stakeholders to identify and leverage synergies, optimize resource utilization, and address challenges collectively (Montalbano and Nenci 2022). Intersectoral integration, supported by robust value chain governance, creates opportunities for sustainable growth, competitiveness, and resilience in today's interconnected and complex business landscape.

Additionally, there is a lack of comprehensive understanding of the underlying mechanisms and processes through which technological innovations, knowledge transfer, and value chain governance facilitate intersectoral integration. The literature reveals that innovation diffusion facilitates the spread and adoption of new technologies, ideas, and practices across sectors, promoting collaboration and integration (Yuen et al. 2021). Innovation diffusion acts as a bridge, enabling the transfer of knowledge and best practices and driving changes in value chain governance mechanisms (Xia et al. 2022), ultimately leading to intersectoral integration. Hence, by studying the mediating role of innovation diffusion, we can gain deeper insights into how these factors interact, identify barriers or facilitators, and develop strategies to foster effective intersectoral collaboration and sustainable development. Moreover, the regulatory environment encompasses policies, laws, and regulations that govern industries and sectors (van Hove and Gillund 2023). It can facilitate the diffusion of innovation and its impact on intersectoral integration. The moderating role of the regulatory environment can help researchers to understand how regulatory frameworks and incentives shape the adoption and spread of innovative practices across sectors. This knowledge is essential for policymakers and stakeholders in creating an enabling environment that promotes seamless intersectoral integration and maximizes the benefits of innovation diffusion.

Furthermore, the existing literature on intersectoral integration in the agro-industrial complex primarily focuses on developed economies (Egamberdiev et al. 2020). While these studies provide valuable insights, there is a significant gap in understanding the dynamics of intersectoral integration in emerging economies, particularly in the context of the Kazakhstani agro-industrial complex. Exploring intersectoral integration in the Kazakhstani agro-industrial complex is crucial because it plays a vital role in the country's economy, contributing to employment, export revenues, and food security (Anokhina et al. 2019). Moreover, the complex nature of the agro-industrial sector requires collaboration among various stakeholders, including farmers, processors, distributors, policymakers, and research institutions (Lemechshenko et al. 2022). At the same time, Kazakhstan's agro-industrial complex faces specific challenges and opportunities, such as technological advancements, market integration, sustainability, and rural development (Lukpanova et al. 2022). Hence, understanding the dynamics of intersectoral integration in Kazakhstan's agro-industrial complex can provide insights into effective strategies, policies, and institutional frameworks that promote collaboration, knowledge sharing, and innovation. It can also

identify barriers and opportunities for value chain governance, technology transfer, and sustainable development within the sector. In order to address the academic and contextual gaps, the research objectives of this study are as follows:

- To examine the impact of technological innovations, knowledge transfer, and value chain governance on innovation diffusion and intersectoral integration within Kazakhstan's agro-industrial complex.
- To investigate the mediatory role of innovation diffusion in the relationship of technological innovations, knowledge transfer, and value chain governance with intersectoral integration.
- To explore the moderating effect of the regulatory environment on the relationship between innovation diffusion and intersectoral integration.
- To provide theoretical and practical insights into the interplay of these variables and their implications for promoting collaboration, innovation, and sustainable development within the agro-industrial complex.
- To offer recommendations for policymakers, industry stakeholders, and managers to enhance intersectoral integration and foster a conducive environment for technological innovations, knowledge transfer, and value chain governance in the agro-industrial sector.

1.1. Theoretical Foundation and Hypothesis Development

This research paper draws upon the diffusion of innovations theory as its theoretical foundation to examine the relationship between technological innovations, knowledge transfer, value chain governance, and intersectoral integration in Kazakhstan's agro-industrial complex (Kuo et al. 2022). The diffusion of innovations theory provides a comprehensive framework for understanding how new ideas, technologies, and practices spread and are adopted within a social system (Yuen et al. 2021). This theory posits that the adoption and diffusion of innovations are influenced by several key factors, including the characteristics of the innovation itself, the communication channels used to disseminate information, the attributes of the individuals or organizations adopting the innovation, and the social system in which the diffusion process takes place (Xia et al. 2022). The theory emphasizes the importance of perceived relative advantages, compatibility, complexity, trialability, and observability of the innovations in influencing their adoption and subsequent integration across different sectors (Menzli et al. 2022). By applying this theory, we can explore how the characteristics of technological innovations, such as their compatibility with existing practices, the perceived advantages they offer, and their complexity, influence their adoption and integration within the agro-industrial complex.

The theory also highlights the role of communication channels, such as interpersonal networks, mass media, and formal institutions, in disseminating knowledge about innovations and facilitating their adoption and integration (He and Lee 2020). Furthermore, the diffusion of innovations theory provides insights into the role of knowledge transfer as a facilitator of innovation diffusion and intersectoral integration. According to the theory, interpersonal communication and social networks play a crucial role in disseminating and adopting innovations (Kuo et al. 2022). By leveraging existing communication channels and networks, knowledge transfer can occur more effectively, enabling the exchange of information, expertise, and best practices across different sectors of the agro-industrial complex (Shukla et al. 2023). The theory also highlights the importance of opinion leaders and change agents in influencing the adoption of innovations (Menzli et al. 2022). Therefore, by utilizing the diffusion of innovations theory, this study can explore the mechanisms through which knowledge transfer contributes to intersectoral integration and the diffusion of technological innovations within the agro-industrial complex.

1.2. Technological Innovations, Knowledge Transfer, and Value Chain Governance and Intersectoral Integration

Technological innovations enable farmers to gather real-time data, make informed decisions, and implement precise farming techniques, ultimately aligning their operations with the evolving demands of downstream value chain actors (Li et al. 2022). Moreover, the adoption of modern technologies facilitates the integration of information and communication systems, enabling seamless coordination and collaboration among different sectors. For example, digital platforms and mobile applications can connect farmers with input suppliers, traders, and processors, fostering efficient value chain linkages (Khan et al. 2022). Therefore, technological innovations positively influence intersectoral integration by enhancing productivity, resource management, and market connectivity. On the other hand, effective knowledge transfer mechanisms enable stakeholders to share best practices, scientific research, and technical expertise, creating a learning ecosystem that drives innovation and collaboration (Pe'er et al. 2022). Through knowledge transfer, farmers gain access to the latest advancements in agricultural practices, enabling them to adopt sustainable techniques, improve crop quality, and meet market requirements (Cruz et al. 2022).

Furthermore, value chain governance, encompassing the coordination and management of activities along the value chain, is another critical factor influencing intersectoral integration (Kumari et al. 2023). Effective governance mechanisms ensure a smooth flow of goods, services, and information across sectors, minimizing transaction costs and maximizing value creation (Klingenberg et al. 2022). Transparent and efficient governance structures enable different sectors to collaborate, synchronize their activities, and jointly address challenges. For instance, establishing robust quality standards, certification systems, and traceability mechanisms promotes trust and enhances coordination between farmers, processors, and retailers (Cohen et al. 2022). Hence, it is postulated that:

H1. *(a) Technological innovations, (b) knowledge transfer, and (c) value chain governance positively influence intersectoral integration within Kazakhstan's agro-industrial complex.*

1.3. Technological Innovations, Knowledge Transfer, Value Chain Governance, and Innovation Diffusion

By introducing new and advanced technologies, such as precision agriculture, IoT devices, and data analytics, technological innovations create a pathway for the adoption and diffusion of novel practices (Liu et al. 2020). These innovations offer farmers the opportunity to enhance productivity, optimize resource utilization, and reduce environmental impact (Shivay et al. 2022). As farmers witness the benefits and advantages of these technologies, they are more likely to adopt and diffuse them within their operations (Hallerman et al. 2022). Simultaneously, by disseminating information, expertise, and best practices, knowledge transfer mechanisms enable stakeholders to learn from each other, embrace new ideas, and adopt innovative approaches (Shukla et al. 2023). Effective knowledge transfer can occur through various channels, such as training programs, educational institutions, industry networks, and collaborations (Hattori et al. 2022). Hence, by creating a supportive learning environment, knowledge transfer facilitates the diffusion of technological innovations by reducing uncertainties, addressing barriers, and promoting the adoption of new practices (Ureña Espaillat et al. 2022).

Additionally, effective governance mechanisms foster collaboration and coordination among different sectors, enabling the smooth flow of information, goods, and services (Hallerman et al. 2022). Innovation diffusion becomes more seamless and efficient when value chain actors are aligned and integrated. Moreover, value chain governance can address market access, quality standards, and certification challenges, which are crucial for innovation diffusion (Klingenberg et al. 2022). By ensuring transparent and efficient value chain governance, policymakers and industry practitioners can create an enabling environment that supports the diffusion of innovations throughout the agro-industrial complex. Hence, it is postulated that:

H2. *(a) Technological innovations, (b) knowledge transfer, and (c) value chain governance positively influence innovation diffusion within Kazakhstan's agro-industrial complex.*

1.4. Innovation Diffusion and Intersectoral Integration

Innovation diffusion facilitates intersectoral integration by fostering a common understanding and alignment of goals among different sectors. As innovative practices and technologies are disseminated and adopted, stakeholders become more aware of collaboration and coordination's potential benefits and advantages (El-Kassar et al. 2022). The diffusion of innovations creates a shared knowledge base, enabling stakeholders to recognize the interdependencies and interconnections among sectors (He and Lee 2020). Likewise, research shows that farmers' adoption of precision agriculture techniques can create opportunities for collaboration with input suppliers, technology providers, and downstream value chain actors (Vinci et al. 2023). This alignment of goals and recognition of mutual benefits lay the foundation for intersectoral integration, as stakeholders perceive the value of working together to achieve shared objectives (Tien et al. 2022).

Furthermore, innovation diffusion enhances the competitiveness and resilience of the agro-industrial complex. By adopting innovative practices, sectors can enhance their productivity, reduce environmental impact, and improve resource management (Stuiver et al. 2004). For instance, the diffusion of sustainable farming techniques can contribute to ecological sustainability while meeting market demands environmentally friendly products (Xia et al. 2022). This enhanced competitiveness and sustainability position sectors within the agro-industrial complex for long-term success and growth. Hence, it is postulated that:

H3. *Innovation diffusion positively influences intersectoral integration within Kazakhstan's agro-industrial complex.*

1.5. Mediatory Role of Innovation Diffusion

In addition to the direct impacts of technological innovations, knowledge transfer, and value chain governance on intersectoral collaboration and synergy, we project that innovation diffusion acts as a mechanism through which the benefits of all three predictor variables are transmitted and integrated across the agro-industrial sector, fostering intersectoral collaboration and synergy. These innovations' successful adoption and integration depend on their diffusion throughout the agro-industrial complex. Innovation diffusion serves as the bridge that enables the transfer of knowledge and awareness about technological innovations from early adopters to the broader community of farmers, processors, input suppliers, and other stakeholders (Strong et al. 2022). It facilitates understanding these technologies' potential advantages, adaptability, and compatibility with existing practices, ultimately driving their integration into different sectors (Birhanu et al. 2022).

Additionally, the diffusion process creates a ripple effect, where some actors' successful adoption and implementation of technological innovations motivate and encourage others to follow suit, thereby enhancing intersectoral integration (Subrahmanyeswari and Chander 2022). Moreover, knowledge exchange fosters a shared language, facilitates joint problem-solving, and encourages the adoption and diffusion of innovations across sectors (Singh and Kaundal 2022). Innovation diffusion, in turn, strengthens intersectoral integration by ensuring that the knowledge and expertise gained through knowledge transfer are effectively applied and integrated into the practices and strategies of different sectors (Barrios et al. 2023). At the same time, value chain governance establishes mechanisms to identify and address bottlenecks, streamline processes, and ensure the efficient integration of technological innovations and knowledge transfer initiatives (Montalbano and Nenci 2022). Thus, innovation diffusion, facilitated by value chain governance, reinforces the interconnections and interdependencies between sectors, ultimately leading to a higher degree of intersectoral integration. Hence, it is postulated that:

H4. *Innovation diffusion mediates the relationship between (a) technological innovations, (b) knowledge transfer, and (c) value chain governance, with intersectoral integration within Kazakhstan's agro-industrial complex.*

1.6. Moderating Role of Type Regulatory Environment

Supportive regulatory frameworks that promote innovation, encourage collaboration, and provide incentives for the adoption of new practices can enhance the diffusion process (Cahyani et al. 2022). For instance, policies that facilitate access to financing for innovation projects, offer tax incentives, or provide subsidies for technology adoption can stimulate innovation diffusion and encourage intersectoral collaboration (Ahmed et al. 2022). Such regulations create an environment conducive to adopting and integrating innovations, enabling stakeholders to overcome financial, legal, or technical barriers (Borsatto and Bazani 2021). A supportive regulatory environment can accelerate the diffusion process and contribute to increased intersectoral integration by reducing the risks and uncertainties associated with innovation adoption (Verburg et al. 2022). The moderating role of the regulatory environment is crucial in shaping the impact of innovation diffusion on intersectoral integration. A favorable regulatory environment can amplify the positive effects of innovation diffusion on integration by providing the necessary support, incentives, and frameworks for collaboration (Mariani et al. 2022). It can foster a culture of innovation, encourage stakeholders to adopt and integrate new practices, and facilitate the alignment of regulations and standards across sectors. Research also shows that, by reducing barriers and providing a level playing field, a supportive regulatory environment enables stakeholders to harness the full potential of innovation diffusion (Hu et al. 2023), leading to enhanced intersectoral integration. Hence, it is postulated that:

H5. *The regulatory environment moderates the relationship between innovation diffusion and intersectoral integration within Kazakhstan's agro-industrial complex.*

1.7. Theoretical Framework

This study's theoretical framework is represented in Figure 1, which illustrates the interplay between technological innovations, knowledge transfer, value chain governance, innovation diffusion, and intersectoral integration. Drawing on the diffusion of innovations theory and existing literature, the framework visually represents the relationships and dependencies among these key variables, highlighting the moderating role of the regulatory environment in shaping the association between innovation diffusion and intersectoral integration.

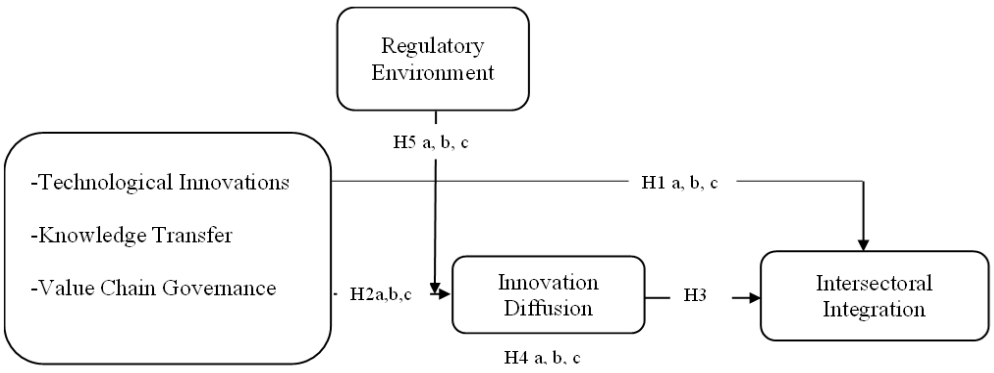

Figure 1. Theoretical Framework.

2. Research Methodology

A multistage random quantitative survey research method was employed in this study (Mansoor et al. 2022b). In the first stage of data collection, the researchers identified a list of organizations operating within the Kazakhstan agro-industrial complex. A random

selection of organizations was made, ensuring representation from various sectors and regions (Noor et al. 2022). In the second stage, a random sampling of employees was conducted within each selected organization. The number of participants selected from each organization was proportional to its size to ensure an equal representation of employees. To contact the potential respondents, the researchers used a combination of methods, including email, telephone calls, and personal visits. They explained the purpose of this study, assured confidentiality, and requested participation. Out of the initial contact attempts, a certain number of respondents agreed to participate. The response rate was calculated by dividing the number of respondents who agreed to participate by the total number of individuals contacted. Data collection occurred at two time points using a time-lagged approach. At Time 1, data collection took place from 1 August 2022 to 30 October 2022. After a four-week gap to minimize the potential bias of immediate recall, Time 2 data collection was conducted from 1 December 2022 to 28 February 2023. The researchers distributed the survey questionnaires to the participants during these periods and provided clear instructions on completing and returning them. Upon the completion of both data collection periods, the researchers received a data set of 542 filled questionnaires from the participants who completed the survey at both Time 1 and Time 2. The number of questionnaires filled and included in the analysis was calculated by cross-referencing the participant IDs and matching the responses from both time points. The multistage random sampling technique, along with the time-lagged data collection method, allowed the researchers to gather information from a diverse group of employees within the Kazakhstan agro-industrial complex. The data collected at two different time points provided valuable insights into the temporal dynamics of the variables of interest, enhancing the validity and reliability of the findings of this study.

2.1. Demographic Characteristics of the Respondents

In terms of gender, the respondents consisted of 54% male and 46% female employees. The age distribution of the participants revealed that 18% were between 18 and 25 years old, 32% were between 26 and 35 years old, 28% were between 36 and 45 years old, and 22% were 46 years old and above. Regarding educational attainment, 12% of the respondents held a high school diploma or equivalent, 35% had a bachelor's degree, 38% possessed a master's degree, and 15% had a doctoral degree or higher. The participants' job positions within the agro-industrial complex were also examined. The findings showed that 25% of the respondents held managerial positions, 42% were in technical or specialized roles, 20% were administrative staff, and 13% were in other job categories. The distribution of participants across sectors was as follows: 30% from agriculture and farming, 25% from food processing and manufacturing, 18% from logistics and distribution, 12% from research and development, and 15% from other sectors. The demographic characteristics of the respondents provided a comprehensive understanding of the sample composition in terms of gender, age, educational background, job positions, and sector representation. These characteristics contributed to the diversity and representativeness of the study sample, ensuring a broader perspective on the association between study variables.

2.2. Measures of this Study

This study employed established measurement scales to assess the variables of this study. To assess the level of technological innovations, the researchers employed a scale by Jahanmir and Lages (2016). This scale consists of 10 items that capture various dimensions of technological innovations, including adopting new technologies, investment in research and development, and implementing innovative practices. The knowledge transfer scale by Chang and Chuang (2011) was utilized to measure the extent of knowledge transfer among stakeholders. This scale comprises 12 items that assess knowledge sharing, knowledge absorption, and knowledge utilization across sectors. The value chain governance scale, developed by Christian et al. (2011), was employed to evaluate the effectiveness of value chain governance mechanisms. This scale consists of 8 items that capture aspects such as

coordination, trust, and collaboration within the value chain. The innovation diffusion scale adapted from Kappelman (1995) was used to measure the diffusion of technological innovations across sectors. This scale includes 9 items that assess the rate of adoption, perceived relative advantage, and compatibility of innovations. Finally the, the level of intersectoral integration was assessed using the intersectoral integration scale developed by Yalley and Sekhon (2014). This scale consists of 7 items that capture the extent of collaboration, coordination, and information sharing between different sectors.

2.3. Descriptive Statistics

The descriptive statistics (Table 1) presents the summary statistics of the study variables.

Table 1. Descriptive statistics of study variables.

Variables	Mean	STD	Skewness	Kurtosis	Max.	Min.
Technological Innovations	4.58	0.89	−0.27	1.45	6.23	2.14
Knowledge Transfer	3.92	1.12	−0.51	1.12	5.87	1.23
Value Chain Governance	4.15	0.96	0.12	0.88	5.67	2.34
Innovation Diffusion	3.75	0.98	0.06	0.95	5.43	1.56
Intersectoral Integration	3.98	0.87	−0.13	1.32	5.87	2.11
Regulatory Environment	3.45	1.02	−0.34	1.08	5.21	1.76

Note: All values are based on a scale of 1 to 7, where higher values indicate higher levels of the respective variables.

The mean values indicate the average level of each variable across the sample. For example, the mean of technological innovations is 4.58, suggesting a moderate level of technological innovations in the agro-industrial complex. Similarly, the mean of knowledge transfer is 3.92, indicating a moderate level of knowledge transfer among stakeholders. The standard deviation represents the variability or dispersion of responses around the mean. A higher standard deviation suggests greater diversity in the responses. For instance, the standard deviation of value chain governance is 0.96, indicating moderate variability in the perceptions of value chain governance among respondents. Skewness measures the asymmetry of the distribution of responses. Negative skewness values indicate a left-skewed distribution, while positive skewness values indicate a right-skewed distribution. For instance, the skewness of technological innovations is −0.27, indicating a slightly left-skewed distribution. Kurtosis measures the peakedness or flatness of the distribution. Positive kurtosis values indicate a leptokurtic distribution (more peaked), while negative kurtosis values indicate a platykurtic distribution (flatter). For example, the kurtosis of knowledge transfer is 1.12, indicating a slightly leptokurtic distribution. The maximum and minimum values represent the highest and lowest scores observed for each variable. For example, the maximum value for innovation diffusion is 5.43, indicating the highest level of diffusion of innovations across sectors.

2.4. Correlation Analysis

The correlation (Table 2) presents the bivariate correlations between the study variables.

Table 2. Correlation matrix of study variables.

Variables	1.	2.	3.	4.	5.	6.
1. Technological Innovations	1.00	0.64 *	0.72 *	0.54 *	0.58 *	0.46 *
2. Knowledge Transfer		1.00	0.55 *	0.47 *	0.63 *	0.39 *
3. Value Chain Governance			1.00	0.62 *	0.55 *	0.51 *
4. Innovation Diffusion				1.00	0.58 *	0.48 *
5. Intersectoral Integration					1.00	0.57 *
6. Regulatory Environment						1.00

Note: * Correlation is significant at the 0.05 level (2-tailed).

Technological innovations showed a significant positive correlation with knowledge transfer (r = 0.64, $p < 0.05$), value chain governance (r = 0.72, $p < 0.05$), innovation diffusion (r = 0.54, $p < 0.05$), intersectoral integration (r = 0.58, $p < 0.05$), and a moderate positive correlation with the regulatory environment (r = 0.46, $p < 0.05$). These results indicate that higher levels of technological innovations are associated with increased knowledge transfer, stronger value chain governance, greater innovation diffusion, improved intersectoral integration, and a more supportive regulatory environment within the agro-industrial complex. Knowledge transfer exhibited a significant positive correlation with value chain governance (r = 0.55, $p < 0.05$), innovation diffusion (r = 0.47, $p < 0.05$), intersectoral integration (r = 0.63, $p < 0.05$), and a moderate positive correlation with the regulatory environment (r = 0.39, $p < 0.05$). These findings suggest that higher levels of knowledge transfer are associated with better value chain governance, increased innovation diffusion, enhanced intersectoral integration, and a more favorable regulatory environment.

Value chain governance showed a significant positive correlation with innovation diffusion (r = 0.62, $p < 0.05$), intersectoral integration (r = 0.55, $p < 0.05$), and a moderate positive correlation with the regulatory environment (r = 0.51, $p < 0.05$). These results indicate that stronger value chain governance is associated with higher levels of innovation diffusion, improved intersectoral integration, and a more supportive regulatory environment. Innovation diffusion exhibited a significant positive correlation with intersectoral integration (r = 0.58, $p < 0.05$) and a moderate positive correlation with the regulatory environment (r = 0.48, $p < 0.05$). These findings suggest that higher levels of innovation diffusion are associated with increased intersectoral integration and a more favorable regulatory environment. Intersectoral integration demonstrated a significant positive correlation with the regulatory environment (r = 0.57, $p < 0.05$), indicating that improved intersectoral integration is associated with a more supportive regulatory environment.

2.5. Reliability Analysis

The reliability analysis displays Cronbach's alpha coefficients for each study variable, indicating the internal consistency or reliability of the measurement scales used (Hair and Sarstedt 2021). Cronbach's alpha values range from 0 to 1, with higher values indicating greater internal consistency. The reliability analysis results indicate that the scales used in this study exhibit satisfactory levels of internal consistency. The technological innovations scale, consisting of 10 items, demonstrates a Cronbach's alpha coefficient of 0.82, suggesting good reliability. The knowledge transfer scale, comprising 12 items, demonstrates a Cronbach's alpha coefficient of 0.87, indicating high internal consistency. This suggests that the items within the scale consistently measure the construct of knowledge transfer. The value chain governance scale, consisting of 8 items, shows a Cronbach's alpha coefficient of 0.76, indicating acceptable reliability. This suggests that the scale captures the intended aspects of value chain governance in a consistent manner. The innovation diffusion scale, comprising 9 items, demonstrates a Cronbach's alpha coefficient of 0.79, suggesting good internal consistency. This indicates that the items within the scale consistently measure the diffusion of technological innovations. The intersectoral integration scale, consisting of 7 items, exhibits a Cronbach's alpha coefficient of 0.85, indicating high internal consistency. This suggests that the scale consistently measures the level of intersectoral integration among the respondents. The regulatory environment scale, comprising 6 items, demonstrates a Cronbach's alpha coefficient of 0.72, suggesting acceptable internal consistency. This indicates that the scale reliably measures the perceptions of the regulatory environment. Overall, the reliability analysis confirms that the measurement scales used in this study are reliable and consistent in capturing the intended constructs of technological innovations, knowledge transfer, value chain governance, innovation diffusion, intersectoral integration, and the regulatory environment.

2.6. Model Fit Indices

The model fit indices assess the goodness-of-fit of the proposed theoretical model. It provides insights into how well the proposed theoretical model fits the observed data (Sarstedt et al. 2017). The Chi-Square test of model fit yielded a significant value of 201.76 with 98 degrees of freedom ($p < 0.001$). While the Chi-Square test is significant, it is important to consider other fit indices to determine the overall model fit. The Root Mean Square Error of Approximation (RMSEA) value of 0.065 indicates a good fit for the model, since it is below the recommended threshold of 0.08. The Comparative Fit Index (CFI) value of 0.946 suggests an acceptable fit, as it exceeds the threshold of 0.90. Similarly, the Tucker-Lewis Index (TLI) value of 0.930 indicates an acceptable fit. The Standardized Root Mean Square Residual (SRMR) value of 0.042 suggests a good fit, as it is below the recommended threshold of 0.08. Overall, the model fit indices indicate a satisfactory fit of the proposed theoretical model to the observed data. These results suggest that the proposed model provides a reasonable fit to the data, indicating that the collected data support the relationships among the study variables (technological innovations, knowledge transfer, value chain governance, innovation diffusion, intersectoral integration, and the regulatory environment).

2.7. VIF and Tolerance

The variance inflation factor (VIF) and tolerance values are measures of multicollinearity, assessing the degree of correlation between independent variables. Table 3 displays the VIF and tolerance values for each study variable. The VIF values range from 1 to above 3, with values greater than 3 indicating high multicollinearity. Conversely, tolerance values range from 0 to 1, with values closer to 1 indicating lower multicollinearity (Mansoor et al. 2022a). The results show that all variables in this study have VIF values below the threshold of 3, ranging from 1.68 to 2.01. This indicates a low level of multicollinearity among the study variables. Similarly, the tolerance values range from 0.50 to 0.60, which are sufficiently high, indicating that multicollinearity is not a concern in the model. These results suggest that the study variables are not highly correlated with each other, ensuring the reliability of the regression coefficients and minimizing the potential for biased estimations. Therefore, based on the VIF and tolerance values, it can be concluded that there is no significant multicollinearity issue among the study variables, providing confidence in the accurate estimation and interpretation of the regression model.

Table 3. Regression analysis results.

Hyp.	Predictor Variable	β Values	*p*-Value	t-Statistics
H1a	Technological Innovations → Intersectoral Integration	0.328	<0.001	<0.001
H1b	Knowledge Transfer → Intersectoral Integration	0.278	<0.001	<0.001
H1c	Value Chain Governance → Intersectoral Integration	0.215	<0.001	<0.001
H2a	Technological Innovations → Innovation Diffusion	0.382	<0.001	<0.001
H2b	Knowledge Transfer → Innovation Diffusion	0.297	<0.001	<0.001
H2c	Value Chain Governance → Innovation Diffusion	0.186	<0.001	<0.001
H3	Innovation Diffusion → Intersectoral Integration	0.546	<0.001	<0.001

2.8. Regression Analysis

2.8.1. Direct Hypothesis

The regression analysis was conducted to examine the direct impacts of the independent variables on the dependent variable and mediator. Table 4 depicts the detailed results for all direct hypothesized links.

Table 4. Variance inflation factor (VIF) and tolerance values.

Variables	VIF	Tolerance
Technological Innovations	2.01	0.50
Knowledge Transfer	1.85	0.54
Value Chain Governance	1.72	0.58
Innovation Diffusion	1.93	0.52
Intersectoral Integration	1.68	0.60
Regulatory Environment	1.78	0.56

Technological innovations demonstrated a significant positive impact on intersectoral integration ($\beta = 0.328$, $p < 0.001$), indicating that an increase in technological innovations leads to higher levels of intersectoral integration. Similarly, knowledge transfer significantly positively affected intersectoral integration ($\beta = 0.278$, $p < 0.001$), suggesting that knowledge transfer contributes to greater intersectoral integration. Additionally, value chain governance significantly positively impacted intersectoral integration ($\beta = 0.215$, $p < 0.001$), implying that effective value chain governance enhances intersectoral integration. Moving to the direct impacts on the mediator, the results revealed that technological innovations had a significant positive effect on innovation diffusion ($\beta = 0.382$, $p < 0.001$), indicating that technological innovations contribute to the diffusion of innovations. Similarly, knowledge transfer showed a significant positive impact on innovation diffusion ($\beta = 0.297$, $p < 0.001$), suggesting that knowledge transfer facilitates the diffusion of innovations. Furthermore, value chain governance significantly positively affected innovation diffusion ($\beta = 0.186$, $p < 0.001$), indicating that effective value chain governance promotes the diffusion of innovations. Additionally, innovation diffusion had a significant positive impact on intersectoral integration ($\beta = 0.546$, $p < 0.001$), suggesting that increased innovation diffusion leads to higher levels of intersectoral integration.

2.8.2. Mediation Analysis

The Sobel test was conducted to assess the significance of the indirect effects of the independent variables on the dependent variable through the mediator (innovation diffusion).

For the indirect effect of technological innovations on the DV, the standardized coefficient was 0.102, yielding a z-score of 3.72 ($p < 0.001$), indicating a significant indirect effect (see Table 5). Similarly, the indirect effect of knowledge transfer on the DV had a standardized coefficient of 0.079, resulting in a z-score of 2.91 ($p = 0.004$), indicating a significant indirect effect. However, the indirect effect of value chain governance on the dv had a standardized coefficient of 0.051, resulting in a z-score of 1.82 ($p = 0.069$), which did not reach statistical significance at the conventional alpha level. These Sobel test results provide evidence for the indirect effects of technological innovations and knowledge transfer on the dv through the mediator, innovation diffusion. However, the indirect effect of value chain governance on the dv did not reach statistical significance.

Table 5. Sobel test results for indirect effects.

Indirect Effect	β-Values	Z-Score	*p*-Value
Technological Innovations → Innovation Diffusion → Intersectoral Integration	0.102	3.72	<0.001
Knowledge Transfer → Innovation Diffusion → Intersectoral Integration	0.079	2.91	0.004
Value Chain Governance → Innovation Diffusion → Intersectoral Integration	0.051	1.82	0.069

2.8.3. Moderation Analysis

The moderation analysis was conducted to examine the role of the regulatory environment as a moderator in the relationship between innovation diffusion and intersectoral integration (see Table 6). The results of the moderation analysis indicated that the regulatory environment significantly moderated the relationship between innovation diffusion and intersectoral integration ($\beta = 0.157$, $p < 0.001$). This finding suggests that the impact of innovation diffusion on intersectoral integration is contingent upon the regulatory environment. Specifically, the positive relationship between innovation diffusion and intersectoral integration becomes stronger when the regulatory environment is more favorable. The findings underscore the need for policymakers and organizations to create a conducive regulatory environment to maximize the positive impact of technological innovations on intersectoral integration in the agro-industrial complex.

Table 6. Moderation results.

Hypothesis	β-Values	*p*-Value
H5: Regulatory Environment*Innovation Diffusion → Intersectoral Integration	0.157	<0.001

3. Discussion and Conclusions

The results indicated that technological innovations positively influenced intersectoral integration, suggesting that adopting and implementing advanced technologies play a crucial role in promoting collaboration and integration among different sectors. This finding aligns with previous research emphasizing the importance of technological advancements in fostering intersectoral cooperation (Liu et al. 2020; Shivay et al. 2022). Moreover, knowledge transfer was found to have a significant positive impact on intersectoral integration. This implies that exchanging and disseminating knowledge and expertise among different sectors contribute to enhanced coordination and synergy (Barrios et al. 2023). Organizations that actively engage in knowledge-sharing practices are better positioned to overcome sectoral boundaries and foster collaboration, leading to improved intersectoral integration. Furthermore, this study revealed that effective value chain governance positively influenced intersectoral integration. Robust governance mechanisms ensure smooth coordination and cooperation among various actors involved in the value chain, enabling seamless integration across sectors (Kumari et al. 2023). This finding underscores the significance of establishing effective governance structures and processes to promote intersectoral collaboration and integration.

The results of this study also shed light on the impact of technological innovations, knowledge transfer, and value chain governance on innovation diffusion within the agro-industrial complex. The findings revealed that technological innovations significantly influenced the diffusion of innovation, indicating that the adoption and implementation of advanced technologies are key drivers in facilitating the spread of innovation across sectors. This aligns with prior research highlighting the pivotal role of technological advancements in driving innovation diffusion (Vrontis et al. 2022; Xu et al. 2023). Furthermore, knowledge transfer was found to have a significant positive impact on innovation diffusion. This suggests knowledge transfer positively influences intersectoral integration by creating a

shared knowledge base, enabling stakeholders to align their goals, and fostering cooperative relationships. Additionally, value chain governance was found to positively influence innovation diffusion. Robust governance structures and processes enable the identification, evaluation, and implementation of innovative ideas, contributing to the widespread adoption of new practices (Sorge et al. 2022). Hence, value chain governance fosters a conducive environment for intersectoral integration by aligning incentives, resolving conflicts, and promoting fair trade practices.

The findings also revealed a significant positive relationship between innovation diffusion and intersectoral integration, suggesting that the spread and adoption of innovative practices across sectors contribute to enhanced collaboration and integration among different industry players. This study's results align with previous research emphasizing the importance of innovation diffusion in breaking down sectoral boundaries and fostering collaboration (Menzli et al. 2022; Xia et al. 2022). By diffusing innovative ideas, technologies, and practices, organizations can overcome barriers and promote cross-sector partnerships, leading to improved intersectoral integration. The findings also suggest that innovation diffusion acts as a mechanism through which the positive impacts of technological advancements, knowledge sharing, and effective governance practices are transferred to intersectoral integration. Innovation diffusion serves as a bridge, facilitating the adoption and spread of innovative ideas, technologies, and practices across different sectors, thereby promoting collaboration and integration. Additionally, the mediatory role of innovation diffusion underscores the importance of actively promoting and facilitating the diffusion process. Organizations and policymakers should focus on creating an environment that encourages the adoption and implementation of innovations, establishing channels for knowledge exchange, and supporting initiatives that enable the dissemination of innovative practices.

The results revealed that the type of regulatory environment significantly influenced the strength and nature of the relationship between innovation diffusion and intersectoral integration. Specifically, the analysis demonstrated that a more favorable regulatory environment strengthened the positive relationship between innovation diffusion and intersectoral integration. This implies that, when the regulatory environment is supportive and conducive to innovation and collaboration, the impact of innovation diffusion on intersectoral integration becomes more pronounced (Teng 2022). These findings emphasize the importance of regulatory frameworks and policies in facilitating intersectoral collaboration and integration. Policymakers should focus on creating an enabling environment that promotes innovation, removes barriers, and encourages cross-sector partnerships (Hartanto et al. 2021; Hu et al. 2023). By implementing supportive regulations and providing incentives for collaboration and knowledge sharing, policymakers can foster an ecosystem where innovation diffusion can thrive, ultimately leading to enhanced intersectoral integration within the agro-industrial complex.

3.1. Theoretical Implications

Theoretically, this study contributes to the existing body of knowledge in several ways. Firstly, the findings support and extend the existing diffusion of innovation theory, linking it to intersectoral integration within the agro-industrial complex. The significant impacts of technological innovations, knowledge transfer, and value chain governance on intersectoral integration align with the theory emphasizing collaboration and synergy among different sectors. This study provides empirical evidence that these factors play a crucial role in promoting intersectoral integration and can serve as a basis for further theoretical development in the field. Secondly, this study highlights the mediatory role of innovation diffusion in the relationship between technological innovations, knowledge transfer, value chain governance, and intersectoral integration. This finding extends the understanding of how innovation spreads across sectors and influences collaboration and integration. This study contributes to the literature by emphasizing the importance of

actively promoting and facilitating innovation diffusion as a mechanism for enhancing intersectoral integration.

Thirdly, this study identifies the moderating role of the regulatory environment in the relationship between innovation diffusion and intersectoral integration. This finding adds to the knowledge regarding the contextual factors that influence the effectiveness of innovation diffusion in driving collaboration and integration. This study highlights the significance of creating a supportive regulatory environment to maximize the positive impacts of innovation diffusion. The theoretical implications of this study suggest that a comprehensive understanding of intersectoral integration requires considering multiple factors, including technological innovations, knowledge transfer, value chain governance, innovation diffusion, and the regulatory environment. The findings contribute to developing and refining theoretical frameworks that explain the dynamics of intersectoral collaboration and integration in the agro-industrial complex. Future research can build upon these theoretical implications by exploring other contextual factors, examining different industry settings, and investigating the long-term effects of intersectoral integration on organizational performance and industry growth. By expanding the theoretical foundation, researchers can provide a more comprehensive understanding of the complex relationships and dynamics involved in intersectoral integration, ultimately guiding policymakers and industry stakeholders in fostering collaboration and sustainable development within the agro-industrial complex.

3.2. Practical Implications

The practical implications of this study provide valuable insights for policymakers, cindustry stakeholders, and managers within the agro-industrial complex. The findings offer actionable recommendations to enhance intersectoral integration, innovation diffusion, and overall industry development. Firstly, this study highlights the importance of fostering technological innovations within the agro-industrial complex. Policymakers should create a supportive ecosystem that encourages research and development, promotes investment in innovative technologies, and incentivizes organizations to adopt and implement advanced technological solutions. Industry stakeholders can leverage technological innovations to improve productivity, quality, and sustainability while facilitating the diffusion of these innovations across sectors. Secondly, knowledge transfer initiatives should be prioritized to promote collaboration and innovation diffusion. Organizations can establish knowledge-sharing platforms, collaborative networks, and partnerships to exchange ideas, expertise, and best practices among different sectors. Policymakers can support such initiatives by providing funding and resources for knowledge transfer programs, training opportunities, and educational initiatives to enhance industry professionals' skills and knowledge.

Thirdly, effective value chain governance mechanisms are crucial for promoting intersectoral integration. Organizations should establish strong governance structures, communication channels, and collaboration frameworks that facilitate coordination and cooperation among value chain actors. Policymakers can contribute by developing regulations and policies that encourage collaboration, promote fair trade practices, and ensure a level playing field for all stakeholders within the agro-industrial complex. Furthermore, this study emphasizes the need for a supportive regulatory environment that encourages innovation, removes barriers, and promotes collaboration. Policymakers should review and revise existing regulations to create an enabling environment for innovation diffusion and intersectoral integration. This may involve streamlining bureaucratic processes, providing financial incentives, and fostering a culture of innovation and entrepreneurship. Practical implications also include the development of innovation diffusion strategies that leverage the mediatory role of innovation diffusion.

Organizations can implement targeted initiatives to promote the adoption and diffusion of innovative practices, technologies, and ideas across sectors. Collaboration platforms, innovation hubs, and knowledge-sharing events can facilitate the spread of innovation and enhance intersectoral integration. By implementing these practical recommendations, poli-

cymakers, industry stakeholders, and managers can foster a collaborative and innovative ecosystem within the agro-industrial complex. This, in turn, can lead to improved productivity, competitiveness, and sustainable growth while addressing industry challenges and creating new opportunities for all stakeholders involved.

4. Limitations and Future Directions

One limitation of this study is the potential lack of generalizability of the findings. This study focused on the agro-industrial complex in a specific geographic region and used a specific sample of respondents. Therefore, the results may not fully represent other industries or regions. Future studies should aim to replicate the research in different contexts to validate the findings and enhance generalizability. Another limitation is the reliance on self-reported data, which may be subject to bias. Participants might provide socially desirable responses or inaccurately recall information, leading to potential measurement errors. Future studies could employ alternative methods, such as observation or objective measures, to overcome self-reporting bias and provide more accurate data. This study utilized a time-lagged data collection method, which introduced a time gap between the measurement of variables. While this approach allows for examining temporal relationships, it may also introduce potential biases due to changes in the external environment or participants' circumstances over time. Future research could consider longitudinal designs to capture real-time changes and minimize the impact of time-related biases. Another limitation is the potential for self-selection bias in the recruitment of participants. Employees who voluntarily participated in this study may have different characteristics or motivations compared to those who chose not to participate. This could introduce bias and affect the external validity of the findings. Future research could employ random sampling techniques to mitigate self-selection bias and ensure a more representative sample.

5. Conclusions

This study sheds light on the critical factors influencing intersectoral integration and innovation diffusion within the agro-industrial complex. The findings highlight the pivotal role of technological innovations, knowledge transfer, and value chain governance in fostering collaboration and synergy among different sectors. Innovation diffusion acts as a mechanism through which the positive impacts of these factors are transferred to intersectoral integration. This study emphasizes the importance of actively promoting and facilitating innovation diffusion to enhance collaboration and integration. Furthermore, the regulatory environment was identified as a key contextual factor, with a more favorable environment strengthening the relationship between innovation diffusion and intersectoral integration. Policymakers should create an enabling environment that encourages innovation, collaboration, and knowledge sharing to foster a conducive ecosystem for intersectoral integration. Hence, it is suggested that a comprehensive understanding of intersectoral integration requires considering multiple factors, guiding the development of theoretical frameworks for sustainable industry growth. Additionally, this study offers actionable recommendations for policymakers and industry stakeholders to foster a collaborative and innovative ecosystem. By implementing these insights, the agro-industrial complex can achieve enhanced productivity, competitiveness, and sustainable growth, addressing industry challenges and creating new opportunities for all stakeholders.

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References

Ahmed, Zahoor, Mahmood Ahmad, Husam Rjoub, Olga A. Kalugina, and Nazim Hussain. 2022. Economic growth, renewable energy consumption, and ecological footprint: Exploring the role of environmental regulations and democracy in sustainable development. *Sustainable Development* 30: 595–605. [CrossRef]

Anokhina, Marina Y., Elmira B. Daribayeva, and Gulnar K. Joldasbayeva. 2019. Clustering as a Mechanism of Kazakhstan Agro-industrial Complex Economic Growth. *Journal of Advanced Research in Law and Economics* 10: 1101–9. [CrossRef]

Barrios, Andres, Laurel Steinfield, Samuelson Appau, Roland Gau, and Charlene A. Dadzie. 2023. How Does Knowledge Translation Involving (Non) Humans Influence the Adoption of Climate Change Solutions? The Case of Nature-Dependent Prosumers. *Journal of the Association for Consumer Research* 8: 243–45. [CrossRef]

Birhanu, Mulugeta Y., Jasmine E. Bruno, Tesfahun Alemayehu, Wondmeneh Esatu, Kumlachew Geremew, Tsion Yemane, Fasil Getachew Kebede, and Tadelle Dessie. 2022. Beyond diffusion to sustained adoption of innovation: A case of smallholder poultry development in sub-Saharan Africa. *International Journal of Agricultural Sustainability* 20: 1028–46. [CrossRef]

Blazquez-Soriano, Amparo, and Rosmery Ramos-Sandoval. 2022. Information transfer as a tool to improve the resilience of farmers against the effects of climate change: The case of the Peruvian National Agrarian Innovation System. *Agricultural Systems* 200: 103431. [CrossRef]

Borsatto, Jaluza Maria Lima Silva, and Camila Lima Bazani. 2021. Green innovation and environmental regulations: A systematic review of international academic works. *Environmental Science and Pollution Research* 28: 63751–68. [CrossRef]

Bwambale, Erion, Felix K. Abagale, and Geophrey K. Anornu. 2022. Smart irrigation monitoring and control strategies for improving water use efficiency in precision agriculture: A review. *Agricultural Water Management* 260: 107324. [CrossRef]

Cahyani, F. A., P. Wulandari, and N. A. Putri. 2022. Food waste management regulation in Indonesia to achieve sustainable development goals. In *IOP Conference Series: Earth and Environmental Science*. Bristol: IOP Publishing.

Chang, Hsin Hsin, and Shuang-Shii Chuang. 2011. Social capital and individual motivations on knowledge sharing: Participant involvement as a moderator. *Information & Management* 48: 9–18.

Christian, Michelle, Karina Fernandez-Stark, G. Ahmed, and G. Gereffi. 2011. The tourism global value chain: Economic upgrading and workforce development. In *Skills for Upgrading, Workforce Development and Global Value Chains in Developing Countries*. Edited by Gary Gereffi, Karina Fernandez-Stark and Phil Psilos. Durham: Duke University, pp. 276–80.

Cohen, Amy J., Mark Vicol, and Ganesh Pol. 2022. Living under value chains: The new distributive contract and arguments about unequal bargaining power. *Journal of Agrarian Change* 22: 179–96. [CrossRef]

Cruz, J. L., L. M. Albisu, J. P. Zamorano, and S. Sayadi. 2022. Agricultural interactive knowledge models: Researchers' perceptions about farmers' knowledges and information sources in Spain. *The Journal of Agricultural Education and Extension* 28: 325–40. [CrossRef]

Egamberdiev, Farmonqul, Nozim Muminov, Tatyana Kim, and Bekmurod Elmonov. 2020. Priority Directions of the State Regional Policy: Development of the Agricultural Sector in Order to Reduce Poverty. *International Journal of Advanced Science and Technology* 29: 4806–27.

El-Kassar, Abdul-Nasser, Grace K Dagher, Sophie Lythreatis, and Mohamad Azakir. 2022. Antecedents and consequences of knowledge hiding: The roles of HR practices, organizational support for creativity, creativity, innovative work behavior, and task performance. *Journal of Business Research* 140: 1–10. [CrossRef]

Hair, Joseph F., and Marko Sarstedt. 2021. Explanation plus prediction—The logical focus of project management research. *Project Management Journal* 52: 319–22. [CrossRef]

Hallerman, Eric M., Justin P. Bredlau, Luiz Sergio A. Camargo, Maria Lucia Zaidan Dagli, Margaret Karembu, Godfrey Ngure, Rhodora Romero-Aldemita, Pedro Jesús Rocha-Salavarrieta, Mark Tizard, and Mark Walton. 2022. Towards progressive regulatory approaches for agricultural applications of animal biotechnology. *Transgenic Research* 31: 167–99. [CrossRef] [PubMed]

Hartanto, Dadang, Juhriyansyah Dalle, A. Akrim, and Hastin Umi Anisah. 2021. Perceived effectiveness of e-governance as an underlying mechanism between good governance and public trust: A case of Indonesia. *Digital Policy, Regulation and Governance* 23: 598–616. [CrossRef]

Hattori, Takashi, Hoseok Nam, and Andrew Chapman. 2022. Multilateral energy technology cooperation: Improving collaboration effectiveness through evidence from International Energy Agency Technology Collaboration Programmes. *Energy Strategy Reviews* 43: 100920. [CrossRef]

He, Meihan, and Jongsu Lee. 2020. Social culture and innovation diffusion: A theoretically founded agent-based model. *Journal of Evolutionary Economics* 30: 1109–49. [CrossRef]

Hu, Siying, Shangkun Lu, and Huiqiu Zhou. 2023. Public Investment, Environmental Regulation, and the Sustainable Development of Agriculture in China Based on the Decomposition of Green Total Factor Productivity. *Sustainability* 15: 1123. [CrossRef]

Huseynov, Rashad, Naila Aliyeva, Valery Bezpalov, and Denis Syromyatnikov. 2023. Cluster analysis as a tool for improving the performance of agricultural enterprises in the agro-industrial sector. *Environment, Development and Sustainability*, 1–14. [CrossRef]

Jahanmir, Sara F., and Luis Filipe Lages. 2016. The late-adopter scale: A measure of late adopters of technological innovations. *Journal of Business Research* 69: 1701–6. [CrossRef]
Kappelman, Leon A. 1995. Measuring user involvement: A diffusion of innovation perspective. *ACM SIGMIS Database: The DATABASE for Advances in Information Systems* 26: 65–86. [CrossRef]
Khan, Nawab, Ram L. Ray, Hazem S. Kassem, and Shemei Zhang. 2022. Mobile Internet Technology Adoption for Sustainable Agriculture: Evidence from Wheat Farmers. *Applied Sciences* 12: 4902. [CrossRef]
Klingenberg, Cristina Orsolin, José Antônio Valle Antunes Júnior, and Gordon Müller-Seitz. 2022. Impacts of digitalization on value creation and capture: Evidence from the agricultural value chain. *Agricultural Systems* 201: 103468. [CrossRef]
Kumari, Sneha, V. G. Venkatesh, Eric Deakins, Venkatesh Mani, and Sachin Kamble. 2023. Agriculture value chain sustainability during COVID-19: An emerging economy perspective. *The International Journal of Logistics Management* 34: 280–303. [CrossRef]
Kuo, Jennifer H., Catherine McManus, and James A. Lee. 2022. Analyzing the adoption of radiofrequency ablation of thyroid nodules using the diffusion of innovations theory: Understanding where we are in the United States? *Ultrasonography* 41: 25. [CrossRef]
Lemechshenko, Olessya, Gulmira Nakipova, and Galymzhan Akhmet. 2022. Improving the program-targeted management methodology and its practical application for the sustained and environment development of agro-industrial complex. *Journal of Environmental Management and Tourism* 13: 769–81. [CrossRef]
Li, Baozhi, Ni Zhuo, Chen Ji, and Qibiao Zhu. 2022. Influence of Smartphone-Based Digital Extension Service on Farmers' Sustainable Agricultural Technology Adoption in China. *International Journal of Environmental Research and Public Health* 19: 9639. [CrossRef] [PubMed]
Liu, Ye, Xiaoyuan Ma, Lei Shu, Gerhard Petrus Hancke, and Adnan M. Abu-Mahfouz. 2020. From Industry 4.0 to Agriculture 4.0: Current status, enabling technologies, and research challenges. *IEEE Transactions on Industrial Informatics* 17: 4322–34. [CrossRef]
Lukpanova, Zhanar, Almagul Jumabekova, Abzal Mukushev, Gulnar Mataibayeva, Maulet Kadrinov, and Zamzagul Baimagambetova. 2022. Environmental concerns associated with the development of the agro-industrial complex and analysis of its financing. *Journal of Environmental Management & Tourism* 13: 1396–406.
Mansoor, Mahnaz, Abid Saeed, Budi Rustandi Kartawinata, and Muhammad Kamran Naqi Khan. 2022a. Derivers of green buying behavior for organic skincare products through an interplay of green brand evaluation and green advertisement. *Journal of Global Fashion Marketing* 13: 328–43. [CrossRef]
Mansoor, Mahnaz, Tahir Mumtaz Awan, and Osman Sadiq Paracha. 2022b. Sustainable buying behaviour: An interplay of consumers' engagement in sustainable consumption and social norms. *International Social Science Journal* 72: 1053–70. [CrossRef]
Mariani, Laura, Benedetta Trivellato, Mattia Martini, and Elisabetta Marafioti. 2022. Achieving sustainable development goals through collaborative innovation: Evidence from four European initiatives. *Journal of Business Ethics* 180: 1075–95. [CrossRef] [PubMed]
Martens, Katrin, and Jana Zscheischler. 2022. The digital transformation of the agricultural value chain: Discourses on opportunities, challenges and controversial perspectives on governance approaches. *Sustainability* 14: 3905. [CrossRef]
Menzli, Leila Jamel, Lassaad K. Smirani, Jihane A. Boulahia, and Myriam Hadjouni. 2022. Investigation of open educational resources adoption in higher education using Rogers' diffusion of innovation theory. *Heliyon* 8: e09885. [CrossRef]
Montalbano, Pierluigi, and Silvia Nenci. 2022. Does global value chain participation and positioning in the agriculture and food sectors affect economic performance? A global assessment. *Food Policy* 108: 102235. [CrossRef]
Noor, Uzma, Mahnaz Mansoor, and Amjad Shamim. 2022. Customers create customers!–Assessing the role of perceived personalization, online advertising engagement and online users' modes in generating positive e-WOM. *Asia-Pacific Journal of Business Administration, ahead-of-print*. [CrossRef]
Nurmanbetova, Arailym, Yerzhan Zhussupov, Galiya Akimbekova, Yelena Gridneva, Gulnar Kaliakparova, and Yury Khan. 2022. Priority Areas for Increasing the Competitiveness of the Agro-Industrial Complex and Environmental Sustainability. *Journal of Environmental Management & Tourism* 13: 39–50.
Olshanska, Oleksandra, Svitlana Bebko, and Olena Budiakova. 2022. Solving the food crisis in the context of developing the bioeconomy of the agro-industrial complex of Ukraine. *Economics, Finance and Management Review* 4: 18–32. [CrossRef]
Pe'er, Guy, John A. Finn, Mario Díaz, Maren Birkenstock, Sebastian Lakner, Norbert Röder, Yanka Kazakova, Tanja Šumrada, Peter Bezák, and Elena D. Concepción. 2022. How can the European Common Agricultural Policy help halt biodiversity loss? Recommendations by over 300 experts. *Conservation Letters* 15: e12901. [CrossRef]
Popkova, Elena G., and Bruno S. Sergi. 2023. Advanced Climate-Smart Technology as the Basis for the Activities of Green Entrepreneurship in the Digital Economy Markets. In *Smart Green Innovations in Industry 4.0 for Climate Change Risk Management*. Cham: Springer, pp. 123–33.
Sarstedt, Marko, Christian M. Ringle, and Joseph F. Hair. 2017. Partial least squares structural equation modeling. In *Handbook of Market Research*. Cham: Springer, vol. 26, pp. 587–632. [CrossRef]
Shivay, Yashbir Singh, Radha Prasanna, Sunil Mandi, Amrita Kanchan, Kaur Simranjit, Somanath Nayak, Kirttiranjan Baral, Madan Pal Sirohi, and Lata Nain. 2022. Cyanobacterial Inoculation Enhances Nutrient Use Efficiency and Grain Quality of Basmati Rice in the System of Rice Intensification. *ACS Agricultural Science & Technology* 2: 742–53.
Shukla, Suwarna, Rohit Kapoor, Narain Gupta, and Deepak Arunachalam. 2023. Knowledge transfer, buyer-supplier relationship and supplier performance in agricultural supply chain: An agency theory perspective. *Journal of Knowledge Management* 27: 738–61. [CrossRef]

Singh, Sukhjinder, and Babita Kaundal. 2022. Academia-industry linkages: Theoretical and empirical review article. *World Journal of Advanced Research and Reviews* 15: 104–15. [CrossRef]
Smidt, Hermanus Jacobus, and Osden Jokonya. 2022. Factors affecting digital technology adoption by small-scale farmers in agriculture value chains (AVCs) in South Africa. *Information Technology for Development* 28: 558–84. [CrossRef]
Sorge, Stefan, Carsten Mann, Christian Schleyer, Lasse Loft, Martin Spacek, Mónica Hernández-Morcillo, and Tatiana Kluvankova. 2022. Understanding dynamics of forest ecosystem services governance: A socio-ecological-technical-analytical framework. *Ecosystem Services* 55: 101427. [CrossRef]
Strong, Robert, John Thomas Wynn, James R. Lindner, and Karissa Palmer. 2022. Evaluating Brazilian agriculturalists' IoT smart agriculture adoption barriers: Understanding stakeholder salience prior to launching an innovation. *Sensors* 22: 6833. [CrossRef] [PubMed]
Stuiver, Marian, Cees Leeuwis, and Jan Douwe van der Ploeg. 2004. The power of experience: Farmers' knowledge and sustainable innovations in agriculture. In *Seeds of Transition: Essays on Novelty Production, Niches Ans Regimes in Agriculture*. Assen: Van Gorcum, pp. 93–118.
Subrahmanyeswari, B., and Mahesh Chander. 2022. Diffusion of Agricultural Innovations: The Case of Organic Farming in Uttarakhand State of India. *Indian Journal of Extension Education* 58: 181–85. [CrossRef]
Teng, Lin Sophie. 2022. Explicit strategy-based instruction in L2 writing contexts: A perspective of self-regulated learning and formative assessment. *Assessing Writing* 53: 100645. [CrossRef]
Tien, Dung Nguyen, Hung Gia Hoang, and Le Thi Hoa Sen. 2022. Understanding farmers' behavior regarding organic rice production in Vietnam. *Organic Agriculture* 12: 63–73. [CrossRef]
Ureña Espaillat, Hayrold José, Antonio Juan Briones Penalver, and Juan Andrés Bernal Conesa. 2022. Influencing responsible green innovation in Dominican agribusiness performance. *Corporate Social Responsibility and Environmental Management* 29: 675–85. [CrossRef]
van Hove, Lilian, and Frøydis Gillund. 2023. Is it only the regulatory status? Broadening the debate on cisgenic plants. In *Cisgenic Crops: Safety, Legal and Social Issues*. Cham: Springer, pp. 269–88.
Verburg, René W., Emma Verberne, and Simona O. Negro. 2022. Accelerating the transition towards sustainable agriculture: The case of organic dairy farming in the Netherlands. *Agricultural Systems* 198: 103368. [CrossRef]
Vinci, Alessandra, Raffaella Brigante, Chiara Traini, and Daniela Farinelli. 2023. Geometrical Characterization of Hazelnut Trees in an Intensive Orchard by an Unmanned Aerial Vehicle (UAV) for Precision Agriculture Applications. *Remote Sensing* 15: 541. [CrossRef]
Vrontis, Demetris, Michael Christofi, Vijay Pereira, Shlomo Tarba, Anna Makrides, and Eleni Trichina. 2022. Artificial intelligence, robotics, advanced technologies and human resource management: A systematic review. *The International Journal of Human Resource Management* 33: 1237–66. [CrossRef]
Wieliczko, Barbara, and Zbigniew Floriańczyk. 2022. Priorities for Research on Sustainable Agriculture: The Case of Poland. *Energies* 15: 257. [CrossRef]
Xia, Zhengwei, Dongming Wu, and Langlang Zhang. 2022. Economic, functional, and social factors influencing electric vehicles' adoption: An empirical study based on the diffusion of innovation theory. *Sustainability* 14: 6283. [CrossRef]
Xu, Aiting, Yuhan Zhu, and Wenpu Wang. 2023. Micro green technology innovation effects of green finance pilot policy—From the perspectives of action points and green value. *Journal of Business Research* 159: 113724. [CrossRef]
Yalley, Andrews Agya, and Harjit Singh Sekhon. 2014. Service production process: Implications for service productivity. *International Journal of Productivity and Performance Management* 63: 1012–30. [CrossRef]
Yuen, Kum Fai, Lanhui Cai, Guanqiu Qi, and Xueqin Wang. 2021. Factors influencing autonomous vehicle adoption: An application of the technology acceptance model and innovation diffusion theory. *Technology Analysis & Strategic Management* 33: 505–19.