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ECONOMIC MECHANISM FOR AGRICULTURAL E-COMMERCE DEVELOPMENT IN KAZAKHSTAN

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Original Article

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ABSTRACT
Agricultural e-commerce can improve market access, price transparency, and commercial opportunities for rural producers, but its development requires more than basic internet connectivity. This study assesses regional readiness for agricultural e-commerce in Kazakhstan and proposes a policy mechanism based on the DalaMart platform. The empirical analysis uses an unbalanced panel of 95 observations covering 17 regions from 2018 to 2024. A fixed-effects model examines the relationship between rural internet penetration and digital literacy, fixed internet subscriptions, rural telephone use, road quality, and a national time trend. A composite digital-agricultural readiness index is applied only to compare regional conditions and should not be interpreted as a direct indicator of online sales. The results show considerable territorial inequality. The average readiness index is 0.714 in leading regions, compared with 0.424 in lagging regions. Digital literacy is positively associated with rural internet penetration ($\beta = 0.214$; $p < 0.05$), while the national time trend is also positive and highly significant ($\beta = 2.774$; $p < 0.001$). Infrastructure variables are not statistically significant within regions during the observed period. This finding is interpreted cautiously because regional fixed effects absorb persistent differences, while infrastructure indicators change only gradually. DalaMart is presented as a policy design rather than an empirically validated impact model. The proposed mechanism combines connectivity, practical producer training, verified marketplace transactions, logistics, digital payments, product traceability, and data-driven services. The study concludes that agricultural e-commerce policies should evaluate completed transactions, delivery performance, producer margins, and repeat demand rather than relying only on platform registrations or connectivity indicators.

Keywords: *agricultural e-commerce, DalaMart, digital literacy, regional readiness, rural markets, platform economy, logistics, Kazakhstan*

1. INTRODUCTION

Digital platforms are transforming how agricultural products are marketed, ordered, paid for and delivered. For producers, e-commerce can lower buyer-search costs, improve access to market information, and create more direct links with retailers, processors, and consumers. For buyers, digital platforms can increase transparency regarding product

origin, price, quality, and delivery conditions (Aumeboonsuke & Caplanova, 2026). These benefits are especially relevant in countries with geographically dispersed production and supply chains involving multiple intermediaries.

Kazakhstan provides an important setting for examining agricultural e-commerce because its strong agricultural potential is combined with long distances, low population density, and unequal rural infrastructure. Regional conditions vary considerably, from commercial grain-producing areas and livestock regions to peri-urban horticultural zones and remote settlements with limited logistics services. Consequently, the same digital platform is unlikely to produce uniform outcomes. Regions with reliable connectivity, stronger digital skills, and developed commercial networks may progress quickly toward formal online transactions, while less prepared regions may remain dependent on informal communication and ordering.

A key distinction in this study is between digital readiness and actual e-commerce adoption (Shojaei et al., 2026). Internet access is necessary, but it does not automatically produce searchable product catalogues, digital payments, coordinated delivery, traceability, or repeat purchases. Agricultural e-commerce should therefore be viewed as an institutional system in which product information, orders, payments, logistics, and dispute procedures are standardized and verifiable. Its development requires infrastructure, organizational capacity, and effective market rules.

The theoretical framework draws on transaction-cost economics, information-asymmetry theory, and diffusion theory. Platforms can reduce search, negotiation, and monitoring costs (Williamson, 1985), while verified identities and reliable product information can reduce information asymmetry (Akerlof, 1970). Diffusion theory further highlights the importance of perceived usefulness, complexity, and observable benefits (Rogers, 2003). Recent studies also emphasize digital literacy, trust, logistics, and consumer confidence as essential conditions for rural e-commerce development (He et al., 2024; Hendricks & Mwapwele, 2024; Liu et al., 2022; Sun & Yu, 2025).

The study has two objectives. First, it evaluates regional readiness for agricultural e-commerce in Kazakhstan using a composite index and a fixed-effects panel model. Second, it translates the empirical findings into a policy mechanism centred on DalaMart, proposed as a pilot platform integrating transactions, logistics, and data-based services. The analysis does not estimate actual e-commerce turnover or the causal impact of DalaMart. Instead, its main contribution is the regional assessment of readiness and the development of a differentiated implementation strategy.

2. THEORETICAL FRAMEWORK

Agricultural trade involves substantial costs related to buyer search, negotiation, packaging, transport, payment, and complaint handling. These costs are especially high for small, geographically dispersed, and weakly standardized producers. A specialized digital marketplace can reduce them by providing reusable product profiles, transparent rules, and standardized transaction procedures.

Unlike generic messaging applications, agricultural e-marketplaces can offer searchable supply, verified identities, payment protection, transaction histories, and coordinated commercial services. Their value depends not only on enabling contact but also on building trust, supporting fulfilment, and measuring buyer satisfaction (Garcia-Gallego et al., 2025; Jahan et al., 2025; Mayorga-Abril et al., 2026).

Digital readiness combines infrastructure and human capability. Connectivity enables access, while digital literacy determines whether producers can create product listings, compare offers, process payments, manage orders, and resolve complaints. Practical training

is therefore more important than general computer literacy because successful participation requires the ability to complete the full transaction cycle (Nguyen et al., 2025).

Territorial conditions also shape adoption outcomes. Because agricultural products are physical, often perishable, and costly to transport, road quality, storage, aggregation capacity, and delivery density determine whether online demand can be fulfilled. Digital commerce and rural logistics must therefore develop together, which explains why the same platform may perform differently across regions (Liu et al., 2022).

International evidence supports this interpretation. Studies from China emphasize public policy, farmer awareness, and benefit-sharing mechanisms, while research from Spain, Poland, and Bangladesh highlights the importance of trust, product information, quality perception, and delivery experience (Wei & Ruan, 2022; Barska & Wojciechowska-Solis, 2020; Garcia-Gallego et al., 2025; Jahan et al., 2025). Comparative research on China and the European Union similarly shows that digital tools create value when integrated with production, logistics, and service systems (Qin et al., 2022).

Research from Kazakhstan also points to the importance of governance, institutional coordination, data flows, and market-support infrastructure (Akilzhanova et al., 2025; Yessengeldin et al., 2026b). DalaMart should therefore be viewed not as an isolated application but as part of a wider regulatory and service-delivery system.

The proposed economic mechanism includes five connected functions: access, capability, transaction, fulfilment, and scaling. DalaMart would serve as a pilot platform linking these functions through marketplace rules, logistics, payments, and analytics. Public support should remain conditional on transparent fees, interoperability, data portability, competition, and independently measured outcomes, ensuring that the platform supports producers without creating a protected monopoly.

3.MATERIALS AND METHODS

3.1. DATA AND VARIABLES

The empirical analysis covers 17 regions of Kazakhstan from 2018 to 2024. Although the theoretical maximum is 119 region-year observations, the final sample includes 95 observations after removing cases with missing values. Missing data mainly result from incomplete historical records for newly established regions and gaps in official statistics. No interpolation was used because estimated values could distort within-region variation in a short panel. The resulting dataset is therefore unbalanced.

Rural internet penetration is the dependent variable, measured as the share of the rural population aged 16-74 with internet access. It is used as an indicator of digital readiness rather than as a measure of actual agricultural e-commerce activity, such as sales, transactions, or platform revenues. This distinction allows the study to assess enabling conditions but limits conclusions about market performance.

The main explanatory variable is digital literacy, measured as the proportion of the population with basic digital skills. Control variables include the logarithm of fixed internet subscribers, the logarithm of rural telephone users, the road quality index, and a linear time trend. Data were obtained from the Bureau of National Statistics of Kazakhstan and other official sectoral sources. The short panel is appropriate for identifying within-region associations, although it is less effective for estimating the influence of infrastructure variables that change slowly over time.

3.2. COMPOSITE INDEX CONSTRUCTION

A composite digital-agricultural readiness index is used for territorial comparison. Five indicators are normalised to the interval from zero to one: rural internet penetration, dig-

ital literacy, road quality, enterprise digitalisation intensity and smart-farm prevalence. The index is calculated as the equal-weighted mean of these normalised components:

$$Readiness_{it} = (Internet_{it}^{N} + DigitalLiteracy_{it}^{N} + RoadQuality_{it}^{N} + EnterpriseDigitalisation_{it}^{N} + SmartFarm_{it}^{N}) / 5 \quad (1)$$

Equal weighting is used to ensure transparency and avoid prioritizing any readiness dimension without strong empirical justification. The index is not included as a causal variable in the fixed-effects model but is used only to group regions for implementation planning. Regions scoring above 0.65 are classified as leaders, those between 0.50 and 0.65 as middle-tier, and those below 0.50 as lagging. These policy-oriented thresholds distinguish advanced, transitional, and foundation-building contexts rather than absolute levels of agricultural performance.

The robustness of the classification was assessed using two alternative weighting schemes: one emphasizing digital capability through internet penetration and digital literacy, and another emphasizing infrastructure and logistics through road quality and enterprise digitalization. Although regional scores vary under these alternatives, the main conclusion remains unchanged: readiness differs substantially across territories and requires differentiated policy responses. Equal weighting is retained because it is transparent, reproducible, and less dependent on subjective assumptions.

3.3. ECONOMETRIC SPECIFICATION

A regional fixed-effects model is estimated to remove unobserved time-invariant characteristics such as geography, historical settlement patterns and persistent agricultural specialisation. The specification is:

$$Y_{it} = \alpha_i + \beta_1 DL_{it} + \beta_2 FI_{it} + \beta_3 RT_{it} + \beta_4 RQ_{it} + \beta_5 T_t + \varepsilon_{it} \quad (2)$$

In the model, (Y) denotes rural internet penetration; (DL) digital literacy; (FI) fixed internet subscriptions; (RT) rural telephone use; (RQ) road quality; and (T) the time trend. Regional fixed effects are represented by (α_i), while (ε_{it}) is the error term. Estimation uses the within estimator with robust standard errors. Variance inflation factors are below five, suggesting that multicollinearity is not a serious concern.

The model captures associations within regions and does not establish causal effects on agricultural e-commerce sales or the effectiveness of DalaMart.

Evidence from the survey of 120 farms conducted by Yessengeldin et al. (2026a) is used only as an external plausibility check. Two descriptive indicators are referenced: the share of farms using electronic sales channels and the share exhibiting high digital maturity. These data are not included in the regression and are not treated as a separate empirical dataset, allowing the study to maintain its focus on regional readiness.

4.RESULTS AND DISCUSSION

4.1. REGIONAL READINESS

The regional index shows a clear readiness gap. Five leading regions - Akmola, North Kazakhstan, Pavlodar, Kostanay and Zhetysu - have a mean score of 0.714. Five middle-tier regions have a mean of 0.574, while seven lagging regions average 0.424. The difference between leader and lagging means is approximately 0.290, which is large relative to the index scale. The results indicate that national programmes operate within substantially different territorial environments.

Table 1. Regional digital-agricultural readiness groups

Group	Number of regions	Mean index	Index range	Representative regions
Leader	5	0.714	0.67-0.79	Akmola; North Kazakhstan; Pavlodar; Kostanay; Zhetysu
Middle-tier	5	0.574	0.51-0.62	East Kazakhstan; Almaty; Karaganda; Zhambyl; Turkestan
Lagging	7	0.424	0.35-0.49	Abay; Aktobe; West Kazakhstan; Kyzylorda; Atyrau; Mangystau; Ulytau

Source: Author's calculations based on Bureau of National Statistics and official agricultural digitalisation data

4.2. FIXED-EFFECTS ESTIMATES

The fixed-effects results are presented in Table 2. The model explains a high share of within-region variation in rural internet penetration (within R-squared = 0.857). Digital literacy has a positive and statistically significant coefficient. A one-percentage-point increase in digital literacy is associated with a 0.214-percentage-point increase in rural internet penetration, holding other included factors constant. The national time trend is also positive and highly significant, indicating broad technological diffusion across the country.

Table 2. Fixed-effects model of rural internet penetration

Variable	Coefficient	Robust standard error	t-statistic	Significance
Digital literacy	0.214	0.089	2.40	$p < 0.05$
Fixed internet subscribers, ln	0.108	0.124	0.87	Not significant
Rural telephone users, ln	0.071	0.091	0.78	Not significant
Road quality index	0.063	0.078	0.81	Not significant
Time trend	2.774	0.183	15.16	$p < 0.001$

Notes: N = 95 region-year observations; 17 regional fixed effects; within R-squared = 0.857; overall R-squared = 0.912

Source: Author's calculations

4.3. INTERPRETATION, ROBUSTNESS AND INTERNATIONAL COMPARISON

The lack of statistical significance for fixed internet subscriptions, rural telephone use, and road quality should not be taken to mean that infrastructure is unimportant. In a fixed-effects model, persistent regional differences are absorbed by the regional effects, while slowly changing infrastructure indicators provide limited within-region variation over a short period. Moreover, the road quality index does not capture important logistical factors such as last-mile delivery, cold-chain capacity, collection points, and route reliability. The results therefore suggest that digital literacy and broader technological diffusion are more visible short-term drivers of rural internet access, while physical infrastructure remains essential for fulfilment and regional inclusion.

The positive association between digital literacy and rural internet penetration has clear policy implications. Training should focus on practical transaction skills, including creating verified profiles and product listings, setting prices and delivery terms, using digital payments, and completing orders. General computer courses alone are unlikely to support effective e-commerce participation. This interpretation is consistent with studies showing that rural e-commerce depends on skills, trust, and logistics as well as platform access (Hendricks & Mwapwele, 2024; He et al., 2024; Liu et al., 2022).

The findings also align with international evidence. Studies from China emphasize the

combined role of policy support, logistics, and farmer participation, while European research highlights trust, product information, and viable business models for small producers (Wei & Ruan, 2022; Qin et al., 2022; Garcia-Gallego et al., 2025). Evidence from Poland and Bangladesh further shows that consumer confidence and delivery quality influence online market outcomes (Barska & Wojciechowska-Solis, 2020; Jahan et al., 2025). This study extends these insights by linking them to regional readiness differences in Kazakhstan and proposing a staged rather than uniform implementation approach.

Farm-level evidence provides a limited external benchmark. Yessengeldin et al. (2026a) found that 44.2% of surveyed farms used electronic sales channels, while only 11.7% had achieved high digital maturity. Although these values are not re-estimated here, they support the distinction between access, initial adoption, and fully developed e-commerce use. The main policy challenge is therefore to move producers from basic online communication toward verified transactions and reliable fulfilment.

5. DALAMART ECONOMIC MECHANISM

5.1. SCOPE OF THE POLICY PROPOSAL

DalaMart is recommended as a pilot mechanism, not presented as an already validated policy intervention. The fixed-effects model supports the need for differentiated regional targeting, while the DalaMart proposal translates this finding into an implementation design. The empirical results do not prove that DalaMart will increase producer income, reduce logistics costs or expand e-commerce sales. Those outcomes require a separate impact evaluation using direct transaction, logistics and producer-income data.

The platform should support both business-to-business and business-to-consumer transactions, but its public-policy value depends on openness. DalaMart should operate as a competitive pilot rather than a protected monopoly. Public support should be conditional on transparent fees, data portability, interoperable interfaces, non-discriminatory seller rules and independent monitoring. This distinction between empirical findings and policy recommendation reduces the risk of overstating the study's conclusions.

5.2. PLATFORM ARCHITECTURE

DalaMart is recommended as a mobile-first pilot marketplace integrating verified registration, standard catalogues, B2B and B2C ordering, digital payments, transparent fees, delivery options and dispute procedures. Later modules can add certification, traceability, analytics, forecasting and links to finance.

Table 3. DalaMart implementation mechanism

Layer	Main constraint	DalaMart and supporting policy	Performance indicator
1. Access	Uneven connectivity and service coverage	Mobile-first interface; assisted rural access points; regional onboarding partners	Active service area; connection reliability
2. Capability	Low practical digital-selling skills	Task-based training; catalogue templates; cooperative digital specialists	Verified profiles; complete product cards
3. Transaction	Informal orders and weak trust	Verified sellers; standard terms; payments; ratings; dispute process	Verified orders; payment completion; repeat buyers
4. Fulfilment	High logistics cost and perishability	Aggregation; delivery partners; cold-chain options; traceability	Delivery time; cancellation rate; spoilage rate
5. Scaling	Limited finance and market intelligence	Transaction analytics; demand forecasts; finance based on verified history	Sales growth; market radius; access to finance

Source: Author's proposal. DalaMart is a recommended pilot and has not been impact-evaluated in this study

5.3. DIFFERENTIATED REGIONAL ROLLOUT

Leader regions should serve as demonstration and scaling sites. Given their stronger readiness, pilots can focus on advanced B2B contracts, integrated payments, export traceability, and data-based demand planning. Performance should be assessed through producer margins, repeat purchases, delivery reliability, and the share of verified transactions. Public support should concentrate on interoperability, independent evaluation, and temporary assistance for shared infrastructure where market failures persist.

Middle-tier regions require a combined platform and logistics package. Although they have sufficient readiness to participate, they often need stronger coordination among producers, buyers, and delivery providers. Useful measures include group onboarding, standardized catalogue templates, regional aggregation partners, and anchor buyers capable of generating initial transaction volume.

Lagging regions need a foundation-building approach. Assisted access points, cooperative digital specialists, and local aggregation hubs can help overcome skills and delivery barriers. Any subsidies should be temporary and linked to verified registration, completed orders, and repeat use. The immediate priority in these regions is to convert basic digital access into reliable transactions and fulfilment routines.

5.4. FINANCING, GOVERNANCE AND MONITORING

A three-stage incentive scheme is proposed. The first stage supports producer onboarding and verified product information. The second partially covers initial transaction and logistics costs to address low order density. The third co-finances expansion only when platform data demonstrate sustained demand and reliable fulfilment. This approach rewards actual use rather than equipment purchases and reduces the risk of supporting inactive accounts.

Governance should ensure transparent fees, understandable ranking rules, data portability, and human review of automated decisions. Consumer protection should cover accurate product descriptions, delivery obligations, refunds, and perishable goods. Producers should have access to transaction histories and clear procedures for suspension, complaints, and ranking changes. Such safeguards reflect the need for coordinated institutional support in agricultural digitalisation (Akilzhanova et al., 2025; Yessengeldin et al., 2026b).

Monitoring should distinguish readiness, adoption, formalisation, and market outcomes. Key indicators include active verified sellers, completed orders, digital payments, delivery times, cancellations, spoilage, repeat purchases, producer margins, and market reach. Registration numbers alone are insufficient because they do not demonstrate actual sales or reliable logistics.

5.5. IMPLEMENTATION RISKS AND EVALUATION LIMITS

The first risk is the platform coordination problem. Producers may avoid preparing catalogues when buyer demand is weak, while buyers may stay away when supply and delivery are unreliable. Pilots should therefore focus on selected products and territories where sufficient transaction density can be created. Cooperative aggregation, anchor buyers, and temporary logistics support can help overcome this initial network barrier.

A second risk concerns market power and data concentration. A dominant platform may increase fees, favour related services, or restrict access to transaction data. Public support should therefore require data portability, non-discriminatory seller rules, transparent rankings, and regular competition review. Clear consent, purpose limitation, and data-retention rules are also necessary because agricultural data may reveal commercially sensitive information (Wolfert et al., 2017).

A third risk is inadequate fulfilment capacity. Perishable goods require suitable packag-

ing, storage, cold chains, and reliable delivery. Regional implementation should therefore begin with a logistics assessment and realistic service areas. In remote regions, shared collection points and scheduled delivery may be more practical than individual on-demand shipping (Deichmann et al., 2016).

The study has four main limitations. Rural internet penetration is only a readiness proxy, the panel is short and incomplete for newly created regions, the composite index uses equal weights, and DalaMart has not yet been evaluated empirically. The index should therefore be treated as a screening tool rather than a definitive regional ranking.

Future research should use direct platform data on sales, delivery distances, product categories, cancellations, repeat purchases, and producer margins. Pilot evaluation should compare similar producer groups introduced at different times and measure outcomes before and after onboarding. It should also separate the effects of platform access from those of training, logistics, and payment integration before wider national support is considered.

6. CONCLUSION

This study assessed agricultural e-commerce in Kazakhstan through regional readiness rather than direct transaction performance. The results reveal substantial territorial inequality, with leading regions averaging 0.714 on the composite readiness index compared with 0.424 among lagging regions. Digital literacy was positively associated with rural internet penetration, while the significant time trend reflected broader nationwide digital diffusion. Although infrastructure variables were not statistically significant within regions, they remain essential for territorial accessibility, logistics, and reliable order fulfilment.

The main policy implication is that agricultural e-commerce should not be treated simply as a matter of connectivity or platform registration. Regions require different combinations of digital access, producer capabilities, transaction support, logistics infrastructure, and performance monitoring. DalaMart is proposed as an interoperable pilot platform linking these functions, but its effectiveness should be tested through phased implementation and direct transaction-level evidence before national expansion. Success should be evaluated through completed orders, delivery reliability, producer margins, and repeat demand rather than the number of registered users alone.

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