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THE IMPACT OF INSTITUTIONAL ENVIRONMENT QUALITY ON THE DEVELOPMENT OF E-COMMERCE IN KAZAKHSTAN

A.B. Zhanbozova[1]*, K.B. Zhumanazarov[2], A.A. Tapalova[3], R. Abuova[4]

[1]Institute of Economics CS MSHE RK, Almaty, Kazakhstan
[2]S.Seifullin Kazakh Agrotechnical Research university, Astana, Kazakhstan
[3]Institute of Economics, Information Technology, and Professional education, Uralsk, Kazakhstan
[4]Almaty Humanitarian and Economic University, Almaty, Kazakhstan

**Corresponding author e-mail: aksaulew@mail.ru*

Abstract. *This study develops a mathematical model to assess the relationship and mutual influence between institutional quality and the development of e-commerce. Institutional quality is measured using indicators such as the E-Government Development Index (EGDI), the Networked Readiness Index (NRI), selected sub-indices from the Index of Economic Freedom, and global governance metrics. The analysis employs Spearman and Kendall correlation coefficients, as well as multiple regression techniques. The results show that 43.4% of the variation in e-commerce development is explained by the NRI, and 37.8% by the Investment Freedom indicator. Furthermore, Control of Corruption (62.8%) and Rule of Law (28.3%) together account for 91.1% of the variation in Investment Freedom. Additionally, 97.4% of the total variation in the NRI is attributable to Investment Freedom (62.7%) and EGDI (34.7%). These findings contribute to a deeper understanding of how institutional quality shapes e-commerce development across countries. The study provides a data-driven framework for policymakers seeking to foster digital trade. By enhancing key institutional factors – such as investment freedom, governance quality, and digital infrastructure – governments, particularly in developing economies, can create an enabling environment for sustainable e-commerce growth. The research underscores the need for targeted institutional reforms to reduce barriers and support the digital economy.*

Keywords: *e-commerce, institutional environment, international indices, Spearman correlation coefficients, Kendall correlation coefficients, regression models.*

Main provisions. Identifying the key institutional factors that directly or indirectly influence the development of e-commerce enables governments to determine the most effective strategies for strengthening these institutions and supporting private investment in the sector. Analyzing the relationship between international institutional quality indices and the share of e-commerce in retail trade provides a foundation for constructing a mathematical model that captures these interdependencies. This study develops a multi-level regression model that illustrates the complex linkages between institutional variables and the growth of e-commerce in Kazakhstan. The analysis shows that 91.1% of the variation in Investment Freedom is explained by the Rule of Law and Control of Corruption, while 97.4% of the

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variation in the Network Readiness Index is jointly driven by Investment Freedom and E-Government Development. The share of e-commerce in retail trade is primarily determined by Network Readiness (43.4%) and Investment Freedom (37.8%). Partial determination coefficients were calculated to quantify the marginal contribution of each institutional factor to the total explained variance. These findings underscore the foundational role of institutional quality as a systemic driver of digital trade transformation in emerging economies.

Introduction. In the current era, as governments strive to create conditions for the development of digital infrastructure and e-commerce, identifying the directions of such efforts is of paramount importance. In this context, indices that assess the quality of the institutional environment and its components, as compiled by international organizations, hold significant interest. The research focuses on identifying specific institutional assessment indices that have a statistical relationship with the development of e-commerce.

The scientific contribution of this study is threefold. First, it introduces a novel multi-level mathematical model that captures the intricate interdependencies between core institutional variables and the development of e-commerce in Kazakhstan. Second, the study demonstrates – unlike prior research – the mediating role of investment freedom as a transmission channel linking governance-related factors (rule of law and control of corruption) with digital infrastructure indicators (network readiness and e-government development). Third, the methodological rigor of the analysis is enhanced through the use of partial determination coefficients, which allow for a more precise assessment of each variable's marginal contribution to the explained variance. Together, these results offer a refined conceptual framework for understanding how institutional quality shapes digital trade readiness in emerging economies and provide a basis for more targeted policy interventions.

Literature review. Previous studies have accounted for cross-country variation in the adoption and development of e-commerce by emphasizing factors such as internet penetration, the quality of distribution infrastructure, the prevalence of cashless payment systems, and the digital literacy of the population. In addition, proponents of New Institutional Theory argue that the activity and scalability of e-commerce are closely linked to the institutional environment in which it operates [1]. According to this theoretical framework, organizations function within a system of formal and informal institutions. Informal institutions include behavioral norms shaped through long-standing social interactions, while formal ones consist of codified laws and regulations that collectively constrain and guide the behavior of market participants [2]. Thus, an institutional perspective on e-commerce necessitates an exploration of how these structures influence digital market development and governance.

The institutional environment relevant to e-commerce includes not only legislative frameworks but also broader governance conditions, such as the rule of law, enforcement capacity, data privacy, consumer protection, and the prevention of cybercrime. Notably, several studies suggest that the legal environment plays a more pronounced role in the later stages of e-commerce expansion than during its initial uptake [3].

Stable and transparent institutions are widely recognized as key enablers of digital commerce. Gibbs and Kraemer identified regulatory barriers, institutional inertia, and lack of government support as major impediments to e-commerce adoption – alongside deficiencies in technology and financing [4]. E-commerce ecosystems tend to flourish when governments proactively foster trust, invest in digital infrastructure, and create clear regulatory environments [5]. Empirical findings confirm that strong legal protections for online

transactions and consumer rights are positively associated with increased digital market activity [6, 7].

Trade-related institutions – including customs administration and taxation regimes – also exert significant influence. Complicated tax systems or administrative delays at borders can undermine the competitiveness of cross-border e-commerce. The rapid globalization of e-commerce has therefore intensified the need for more adaptive and responsive institutional frameworks.

Conversely, poorly functioning institutions can act as serious barriers. Studies focusing on countries with high levels of corruption highlight how bureaucratic inefficiencies and rent-seeking behavior constrain business digitalization and erode public trust in electronic markets [8]. These institutional failures, particularly in developing economies, contribute to uneven e-commerce growth and deepen the digital divide.

Indeed, underdeveloped formal and informal institutions are now regarded as core reasons for the persistent disparities in e-commerce adoption across countries [9, 10]. It is increasingly clear that the establishment and expansion of digital markets depend not only on technology and infrastructure, but on the integrity, coherence, and performance of institutional systems. Accordingly, there is a pressing need to analyze the institutional drivers of e-commerce more holistically, including their interactions and compounding effects.

Despite these insights, much of the existing literature remains fragmented. Institutional variables are frequently examined in isolation, without consideration for how they interrelate or reinforce one another. Furthermore, the intersection between institutional quality and digital transformation remains insufficiently explored – particularly in the context of developing countries. Hendricks and Mwapwele [11] note that e-commerce uptake is often constrained not only by infrastructural deficits, but also by fragmented governance, inconsistent regulatory regimes, and low levels of institutional trust. Similarly, Díaz-Arancibia et al. [12] emphasize that the digital transition of SMEs in developing economies is hindered by weak alignment between technological policy and institutional reform.

In response to these challenges, some scholars now advocate for integrating institutional theory with the digital transformation paradigm. Mathafena and Msimango-Galawe [13] demonstrate that in South Africa, digitalization efforts are often obstructed by legacy bureaucratic structures and outdated administrative processes. UNCTAD [14] has also urged policymakers to develop integrated frameworks and performance metrics that simultaneously capture institutional readiness and digital capability. Recent public sector research further underscores the importance of institutional alignment in achieving equitable and effective delivery of digital services [15].

Building on these foundations, the present study advances a novel, multi-level regression model that moves beyond isolated variables and captures the indirect, mediating effects of legal governance, investment conditions, and digital infrastructure on the growth of e-commerce. This model allows for a more comprehensive and empirically grounded understanding of how institutional ecosystems support or constrain digital market development – especially in the context of emerging economies.

Materials and methods. The methodology is based on the use of correlation analysis (to assess the strength of relationships between international institutional indices and the diffusion of e-commerce) and regression analysis (to evaluate the influence of institutional indicators on e-commerce and their interdependencies).

To ensure objectivity, both Spearman and Kendall correlation coefficients were employed. These coefficients are particularly appropriate when the relationships between variables are monotonic but not necessarily linear.

The coefficients range from -1 to 1. A value close to 1 indicates a strong positive monotonic relationship – i.e., as one variable increases, the ranks of the other also increase. Conversely, a value near -1 denotes a strong negative monotonic relationship, while values close to 0 suggest no monotonic association. Although both coefficients measure monotonic relationships, they do so differently: Spearman's coefficient reflects the degree of monotonic dependence [16], whereas Kendall's coefficient evaluates the concordance of ranked data [17]. The strength of correlation was assessed using Chaddock's scale:

- $0.1 < rxy < 0.3$: weak;
- $0.3 < rxy < 0.5$: moderate;
- $0.5 < rxy < 0.7$: noticeable;
- $0.7 < rxy < 0.9$: high;
- $0.9 < rxy < 1$: very high [18].

To determine statistical significance, p-values were calculated for each coefficient, with a significance level of $\alpha = 0.05$. The interpretation was as follows:

- $p < 0.01$: very strong evidence against the null hypothesis.
- $p < 0.05$: strong evidence against the null hypothesis.
- $0.05 <= p < 0.1$: weak evidence against the null hypothesis.
- $p >= 0.1$: insufficient evidence to reject the null hypothesis [19].

The «share of e-commerce in retail trade» was used as a relative indicator of e-commerce penetration.

The Networked Readiness Index (NRI) was used to evaluate the ICT infrastructure supporting e-commerce. It measures infrastructure, accessibility, skills, usage, and the overall ICT-related business and innovation environment. NRI was selected as an endogenous variable due to the availability of sufficient data for correlation analysis.

The E-Government Development Index (EGDI) was also included as an endogenous variable, given its potential influence on e-commerce development. Specifically:

- a high egdi score reflects better telecommunications infrastructure, supporting stable internet access critical for online transactions;
- transparent and secure e-services foster user trust in e-commerce platforms;
- simplified administrative procedures – such as online business registration – lower market entry barriers.

However, neither the NRI nor EGDI fully captures institutional dimensions critical to e-commerce, such as legal protections, regulatory quality, or access to finance. While the World Bank's Doing Business Index would have been a suitable source for such indicators, its publication was discontinued in 2020 due to methodological review.

As a substitute, the Index of Economic Freedom was used. This index partially reflects government policies affecting entrepreneurship and economic activity. Economic freedom is defined here as «the absence of government coercion or constraint on the production, distribution, or consumption of goods and services, beyond what is necessary for the protection and maintenance of liberty itself».

Published by the Heritage Foundation, the index comprises 12 components, of which 7 were selected for this study: Tax Burden, Business Freedom, Monetary Freedom, Trade Freedom, Investment Freedom, and Financial Freedom.

To assess the rule of law and the enforceability of legal norms, the Rule of Law indicator from the World Bank's Worldwide Governance Indicators (WGI) was included. It

measures the extent to which individuals and firms have confidence in, and abide by, the rules of society.

The Control of Corruption indicator was also included, as corruption undermines the institutional environment for business, including e-commerce. Low corruption levels are associated with higher trust, better consumer protection, increased technological adoption, and enhanced market efficiency.

The dataset covers Kazakhstan and includes annual observations for the endogenous variables from 2007 to 2022.

Results and discussion. The correlation analysis (Table 1) revealed no statistically significant relationship between the share of e-commerce and indicators such as Business Freedom, Monetary Freedom, Trade Freedom, and Financial Freedom. While these factors are relevant in broader macroeconomic contexts, they do not appear to have a direct influence on the development of e-commerce in Kazakhstan.

Table 1 – Results of Correlation Analysis

Indicator	Spearman Coefficient	p-value S	Kendall Coefficient	p-value K
Tax Burden	**0.673**	**0.003**	**0.547**	**0.003**
Business Freedom	0.441	0.076	0.328	0.069
Monetary Freedom	-0.300	0.242	-0.224	0.215
Trade Freedom	-0.486	0.048	-0.434	0.016
Investment Freedom	**0.938**	**0.000**	**0.841**	**0.000**
Financial Freedom	-0.663	0.004	-0.562	0.008
E-Government Development Index	**0.801**	**0.000**	**0.746**	**0.000**
Network Readiness Index	**0.971**	**0.000**	**0.896**	**0.000**
Rule of Law	**0.906**	**0.000**	**0.797**	**0.000**
Control of Corruption	**0.918**	**0.000**	**0.776**	**0.000**
Note: calculations by the authors. *Statistically significant correlations are highlighted in bold.				

In contrast, a statistically significant direct dependence at $p < 0.01$ was identified between the share of e-commerce and several institutional indicators, including Investment Freedom, the E-Government Development Index (EGDI), the Network Readiness Index (NRI), Rule of Law, and Control of Corruption. These findings emphasize the central role of institutional quality, digital infrastructure, and governance in enabling the expansion of digital trade.

The remaining institutional indicators that exhibit a statistically significant direct relationship with the share of e-commerce in Kazakhstan at $p < 0.01$ are presented in descending order of relevance in Figure 1.

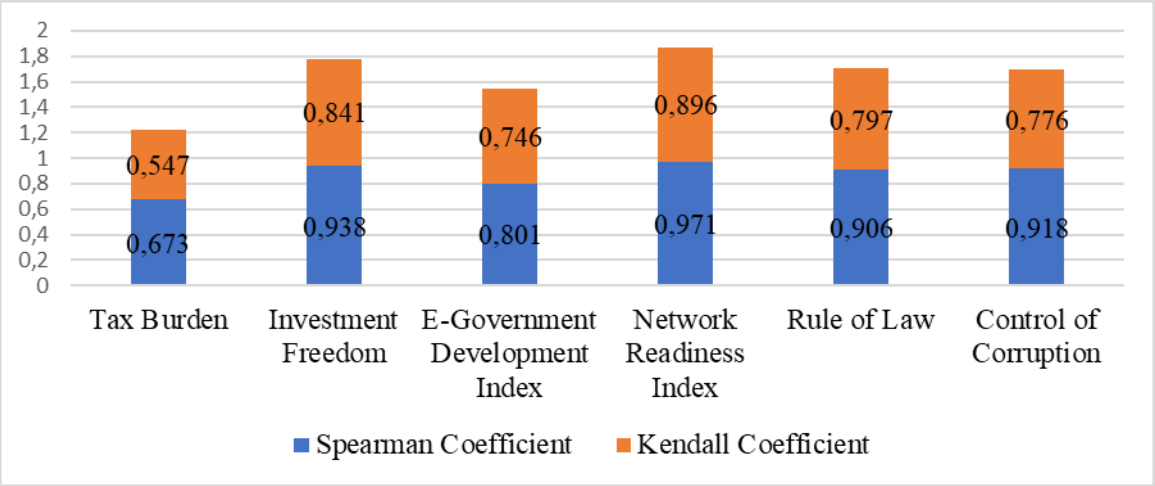

Figure 1 – Indices and components with strong correlation to the share of e-commerce in retail trade

Note: compiled based on data from table 1.

As shown in Figure 1, most of the institutional environment indices, with the exception of *Tax Burden*, demonstrate a statistically significant strong or very strong direct dependence on the share of e-commerce. The *Network Readiness Index* displayed the strongest such association, capturing dimensions such as:

– access to reliable internet services, mobile connectivity, and digital technologies;
– the extent of ict use across enterprises, government bodies, and households;
– levels of digital literacy and the availability of ict-related educational programs;
– institutional support for innovation and startups, along with a favorable tech business climate;
– government regulation and incentives that promote ict development;
– broader ict-driven impacts on productivity and employment.

A statistically significant direct dependence was also identified between the share of e-commerce and the *Investment Freedom indicator*. The growth of the e-commerce sector has coincided with policy reforms aimed at fostering investment – such as simplifying business registration, reducing administrative burden, and offering tax incentives. Investment freedom, in turn, facilitates the expansion of digital and logistical infrastructure and improves access to capital and technology for entrepreneurs. In Kazakhstan, favorable investment conditions have enabled the entry of global marketplaces, intensifying domestic competition and accelerating the adoption of technologies such as real-time online payments.

Additionally, a statistically significant direct dependence was revealed between the share of e-commerce and the *Control of Corruption indicator.* A similar pattern was observed for the Rule of Law, reflecting Kazakhstan's centralized governance approach and its emphasis on regulatory compliance and institutional stability.

The analysis further demonstrates that improvements in the E-Government Development Index are statistically significantly associated with the growth of e-commerce in Kazakhstan. This relationship is supported by several mechanisms:

–robust e-government infrastructure enhances digital accessibility for citizens and businesses;

–secure and user-friendly e-payment systems strengthen consumer trust in online transactions;

–digitalization of public administration lowers entry barriers and supports the development of digital entrepreneurship.

Together, these institutional components contribute to a conducive environment for the advancement of e-commerce. Moreover, the level of e-government development signals the government's commitment to digital transformation and public sector innovation.

In summary, the analysis identifies five core institutional dimensions that statistically significantly influence e-commerce development in Kazakhstan: network readiness, investment freedom, control of corruption, rule of law, and e-government development. To quantify the influence of these factors, pairwise correlation coefficients were calculated using MS Excel. The results are provided in Table 2.

Table 2 – Matrix of Pairwise Correlation Coefficients Between Variables

	Rule of Law	EGDI	Investment Freedom	NRI	Control of Corruption
Rule of Law	1				
EGDI	0,686615	1			
Investment Freedom	0,774891	0,881358	1		
NRI	0,735535	0,971441	0,939658	1	
Control of Corruption	0,592265	0,863676	0,907785	0,85836	1

The identified correlations do not allow for the construction of an adequate model; therefore, several regression models were developed based on the complex interrelationships among the components of the institutional environment. The following hypotheses were formulated:

1) Rule of law (x_1) and Control of Corruption (x_2) influence the Investment Freedom index ($У_1$).
2) Investment Freedom (y_1) and EGDI (x_3) influence the NRI ($У_2$).
3) NRI ($У_2$) influences the share of e-commerce in retail trade (y).
4) investment freedom ($У_1$) influences the share of e-commerce in retail trade (У).

Based on these hypotheses, the corresponding regression models were developed:

$$1) \quad У_1 = -9{,}60064 + 1{,}127941X_1 + 0{,}473233X_2 \quad (1)$$
$$2) \quad У_2 = 0{,}9576 + 0{,}02175У_1 + 3{,}7078X_3 \quad (2)$$
$$3) \quad У_3 = -18{,}243 + 4{,}48615У_2 \quad (3)$$
$$4) \quad У_4 = -7{,}73517 + 0{,}246655У_1 \quad (4)$$

The regression statistics, evaluation of the regression equations, and results of the statistical significance tests for the above-mentioned equations are summarized in Table 3.

Table 3 – Key statistical parameters for the models $У_1$, $У_2$, $У_3$ and $У_4$

Indicator	Value (for $У_1$)	Value (for $У_2$)	Value (for $У_3$)	Value (for $У_4$)
Multiple R (correlation coefficient)	0,954341	0,9873	0,65763	0,61489
R-squared (coefficient of linear determination)	0,910767	0,974912	0,43248	0,37809
Adjusted R-squared	0,892921	0,969894	0,38089	0,32155
Standard Error	2,821756	0,087982	2,72171	2,84916
Observations	13	13	13	13
F-statistic (Fisher coefficient)	51,03323	194,2972	8,38271	6,68745
Significance F	5,66E-06	9,94E-09	0,01457	0,02532
Note: compiled by the authors				

To construct a mathematical model capturing the interrelationships and mutual influences between components of the institutional environment and the share of e-commerce in retail trade, a comparative evaluation of the impact of endogenous variables on the dependent variable was conducted for each of the regression equations presented above. Partial determination coefficients were calculated to quantify these effects.

These coefficients make it possible to assess the individual contribution of each variable to the total explained variance of the dependent variable in a multivariate regression model. Each coefficient was computed as the difference between the R-squared value of the full model and that of the model excluding the variable in question.

The results are presented in Table 4.

Table 4 – Final table of partial determination coefficients

Equations	Determination Coefficient (R^2)	d^2_1	d^2_2
$У_1$=-9,60064+1,127941x_1+0,473233x_2 (1)	0,910767	0,283	0,628
У_2=0.9576+0.02175$У_1$+3.7078x_3 (2)	0,974	0,347	0,627
У=-18,243+4,48615$У_2$ (3)	0,432484		
У=-7,73517+0,246655$У_1$ (4)	0,37809		
Note: calculated by the authors			

The results obtained make it possible to present a model that illustrates the interrelationships and mutual influences between the institutional environment and e-commerce, as shown in Figure 2.

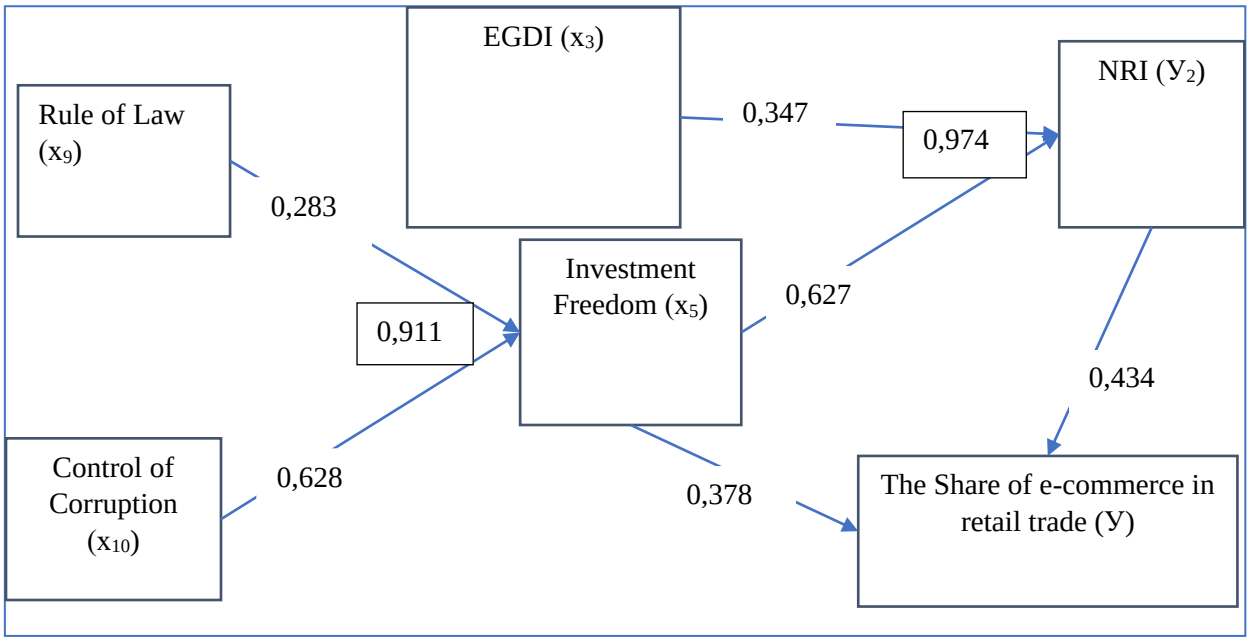

Figure 2 – Model of the interrelationships and mutual influences between components of the institutional environment and e-commerce in Kazakhstan

Note: compiled by the authors

According to the constructed mathematical model, 91.1% of the total variability in Investment Freedom is explained by two institutional factors: Control of Corruption (62.8%) and Rule of Law (28.3%). Furthermore, 97.4% of the variation in the Network Readiness Index is attributed to the combined influence of Investment Freedom (62.7%) and the E-Government Development Index (34.7%). In addition, 43.4% of the variability in the share of e-commerce in retail trade is explained by changes in Network Readiness, while Investment Freedom accounts for a further 37.8%.

Conclusion. This study yields the following key conclusions:

1. A strong to very strong statistically significant correlation was identified between the share of e-commerce and several components of the institutional environment in Kazakhstan, including *Rule of Law, E-Government Development Index (EGDI), Investment Freedom, Network Readiness Index (NRI),* and *Control of Corruption.* In addition, robust correlations were observed among several institutional factors themselves, particularly between Investment Freedom and: *Rule of Law, Control of Corruption, NRI, and EGDI.*

2. The constructed mathematical model captures the following statistically grounded relationships and mutual influences:

– EGDI and investment Freedom together explain 97.4% of the variation in network readiness;

– Rule of law and Control of Corruption jointly account for 91.1% of the variation in investment Freedom;

– The share of e-commerce in Kazakhstan's retail trade is explained by network readiness (43.4%) and investment Freedom (37.8%).

These findings highlight network readiness and investment freedom as the primary institutional predictors of e-commerce development in Kazakhstan. Improvements in network

readiness are positively influenced by both a liberal investment climate and the advancement of e-government initiatives (e.g., development of internet infrastructure, expansion of digital payment systems, and promotion of digital literacy among citizens and businesses).

Given the significant role of Investment Freedom in the model, enhancing this indicator requires targeted efforts to strengthen the Rule of Law and Control of Corruption, which are its key institutional drivers.

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ҚАЗАҚСТАНДАҒЫ ИНСТИТУЦИОНАЛДЫҚ ОРТА САПАСЫНЫҢ ЭЛЕКТРОНДЫҚ КОММЕРЦИЯ ДАМУЫНА ЫҚПАЛЫ

А.Б. Жанбозова[1]*, Қ.Б. Жұманазаров[2], Ә.А. Тапалова[3], Р. Әбуова[4]

[1]ҚРҒЖБМ ҒК Экономика институты, Алматы, Қазақстан
[2]С. Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Астана, Қазақстан
[3]Экономика, ақпараттық технологиялар және кәсіби білім беру институты, Орал, Қазақстан
[4]Алматы гуманитарлық-экономикалық университеті, Алматы, Қазақстан

Түйін. *Зерттеуде институционалдық орта сапасы мен электрондық коммерцияның даму деңгейі арасындағы күрделі өзара байланыстарды айқын көрсететін математикалық модель ұсынылған. Бұл модель заң үстемдігі деңгейі, сыбайлас жемқорлықты бақылау, инвестициялық еркіндік сияқты институттардың сапасын және олардың өзара ықпалын сипаттайды. Модель регрессия теңдеулеріне негізделген, олардың әрқайсысы институционалдық ортаның негізгі көрсеткіштері мен электрондық коммерция арасындағы өзара байланыстарды бағалауға бағытталған. Әрбір теңдеу үшін жеке детерминация коэффициенттері есептелген, олар желілік дайындық немесе электрондық үкіметті дамыту сияқты жеке айнымалылардың тәуелді айнымалының жалпы түсіндірілетін дисперсиясына қосқан үлесін сандық бағалауға мүмкіндік береді. Бұл тәсіл цифрлық инфрақұрылымды дамыту, инвестициялық еркіндік деңгейі және институттарға деген сенім сияқты электрондық коммерцияның таралуына ең көп әсер ететін негізгі факторларды анықтауға, сондай-ақ институционалдық факторлардың осы процестегі маңыздылығын атап көрсетуге мүмкіндік береді.*

Түйінді сөздер: *электрондық коммерция, институционалдық орта, халықаралық индекстер, Спирменнің корреляциялық талдау, регрессиялық модельдеу.*

ВЛИЯНИЕ КАЧЕСТВА ИНСТИТУЦИОНАЛЬНОЙ СРЕДЫ НА РАЗВИТИЕ ЭЛЕКТРОННОЙ КОММЕРЦИИ В КАЗАХСТАНЕ

А.Б. Жанбозова[1]*, К.Б. Жуманазаров[2], А.А. Тапалова[3], Р.К.Абуова[4]

[1]Институт экономики КН МНВО РК, Алматы, Казахстан
[2]Казахский агротехнический исследовательский университет им. С. Сейфуллина, Астана, Казахстан
[3]Институт экономики, информационных технологий и профессионального образования, Уральск, Казахстан
[4]Алматинский гуманитарно-экономический университет, Алматы, Казахстан

Резюме. *В статье предложена математическая модель, отражающая сложные взаимосвязи между качеством институтов – такими, как уровень верховенства права, контроль коррупции, свобода инвестиций – и уровнем развития электронной коммерции. Учтено также взаимное влияние между самими институциональными показателями. Модель построена на основе системы регрессионных уравнений, каждое из которых направлено на оценку зависимости между ключевыми характеристиками институциональной среды и показателями электронной коммерции. Расчёт коэффициентов частной детерминации позволил количественно определить вклад отдельных переменных (например, уровня сетевой готовности и развития электронного правительства) в объяснённую дисперсию зависимой переменной в многомерной регрессии. Такой подход позволил выявить наиболее значимые факторы – развитие цифровой инфраструктуры, уровень инвестиционной свободы и степень доверия к институтам – оказывающие определяющее влияние на распространение электронной коммерции. Тем самым подчёркивается роль институциональных условий как ключевого фактора в процессе цифровизации торговли.*

Ключевые слова: *электронная коммерция, институциональная среда, международные индексы, корреляционный анализ, регрессионное моделирование.*

Авторлар туралы ақпарат:

Жанбозова Ақсауле Болатханқызы* – *PhD, аға ғылыми қызметкер, ҚРҒЖБМ ҒК Экономика институты, Алматы, Қазақстан, e-mail: aksaulew@mail.ru, ORCID ID: https://orcid.org/0000-0002-7143-5680*

Жұманазаров Қасымхан Бекбауұлы – *э.ғ.к, С. Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Астана, Қазақстан, e-mail: zh_kb10@mail.ru, ORCID ID: https://orcid.org/0000-0001-6502-0692*

Тапалова Әсел Айтқалиқызы – *экономика ғылымдарының магистрі, Жәңгір хан атындағы Батыс Қазақстан аграрлық-техникалық университеті, Экономика, ақпараттық технологиялар және кәсіби білім беру институты, Орал, Қазақстан, e-mail: tapalova-a@mail.ru, ORCID ID: https://orcid.org/0000-0002-7592-536*

Әбуова Рано Қарсыбекқызы – *аға оқытушы, Алматы гуманитарлық-экономикалық университеті, Алматы, Қазақстан, e-mail: Kari.kz@mail.ru, ORCID ID: https://orcid.org/0009-0000-0757-1939*

Информация об авторах:

Жанбозова Аксауле Болатхановна* – *PhD, старший научный сотрудник, Институт экономики КН МНВО РК, Алматы, Казахстан, e-mail: aksaulew@mail.ru, ORCID ID: https://orcid.org/0000-0002-7143-5680*

Жуманазаров Касымхан Бекбауович – *к.э.н, Казахский агротехнический исследовательский университет им. С. Сейфуллина, Астана, Казахстан, e-mail: zh_kb10@mail.ru, ORCID ID: https://orcid.org/0000-0001-6502-0692*

Тапалова Асель Айткалиевна – *магистр экономических наук, Западно-Казахстанский аграрно-технический университет им. Жангир хана, Институт экономики, информационных технологий и профессионального образования, Уральск, Казахстан, e-mail: tapalova-a@mail.ru, ORCID ID: https://orcid.org/0000-0002-7592-5361*

Абуова Рано Карсибековна – *старший преподаватель, Алматинский гуманитарно-экономический университет, Алматы, Казахстан, e-mail: Kari.kz@mail.ru, ORCID ID: https://orcid.org/0009-0000-0757-1939*

Information about authors:

Zhanbozova Aksaule Bolatkhanovna* – *PhD, Senior Researcher, Institute of Economics CS MSHE RK, Almaty, Kazakhstan, e-mail: aksaulew@mail.ru, ORCID ID: https://orcid.org/0000-0002-7143-5680*

Zhumanazarov Kasymkhan Bekbauovich – *Candidate of Economic Sciences, Associate Professor, Department of Land Use Planning, S. Seifullin Kazakh Agrotechnical Research University, Astana, Kazakhstan, e-mail:: zh_kb10@mail.ru, ORCID ID: https://orcid.org/0000-0001-6502-0692*

Tapalova Assel Aitkalievna – *Master of Economic Sciences, Institute of Economics, Information Technologies and Professional Education, Zhangir Khan West Kazakhstan Agrarian-Technical University, Uralsk, Kazakhstan, e-mail: tapalova-a@mail.ru, ORCID ID: https://orcid.org/0000-0002-7592-5361*

Abuova Rano Karsibekovna – *Senior Lecturer, Almaty Humanitarian and Economic University, Almaty, Kazakhstan, e-mail: Kari.kz@mail.ru, ORCID ID: https://orcid.org/0009-0000-0757-1939*

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