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AI ENGINEERING SUPPORT FOR ENHANCING THE QUALITY OF PUBLIC ADMINISTRATION IN KAZAKHSTAN

Abstract: *The research aims to develop a scientific and methodological approach to providing AI engineering support for enhancing Public Administration Quality 5.0 in Kazakhstan. To this end, the authors conducted an econometric analysis using the practical experience of 22 countries in Eastern Europe and Central Asia in 2025. The scientific novelty of the proposed approach lies in applying an AI engineering mechanism to improve the quantitative and qualitative parameters of public administration. This overcomes the limitations of the previous approach and expands the objectives of the AI engineering mechanism to include the enhancement of Public Administration Quality 5.0. The essence of the new approach consists in a systemic understanding of Public Administration Quality 5.0 and the robustness of its AI engineering support in Kazakhstan in 2025; reliance on an associative model of Public Administration Quality 5.0 in Kazakhstan and neighboring developing countries of Eastern Europe and Central Asia in 2025; and consideration of the prospects for changes in Public Administration Quality 5.0 in Kazakhstan depending on its AI engineering support during the Decade of Action through 2030.*

Keywords: *AI engineering, institutional quality management, public administration, Quality 5.0, developing countries, Kazakhstan.*

1. Introduction

The quality of public administration is crucial to the proper functioning of the government apparatus. The importance of the qualitative dimension of national regulatory institutions is underscored by the fact that it is the principal criterion distinguishing developed from developing countries. Previously used supplementary criteria, such as income level and involvement in the Fifth Industrial Revolution, are no longer applicable because

some developing countries, particularly BRICS+ members, have made a dramatic leap in economic and technological development in recent years. As a result, they have officially attained high-income status, while several developing countries now occupy leading positions in international digital development rankings (Mayilyan & Torosyan, 2023).

Despite their economic and technological achievements, however, developing countries continue to face difficulties in providing adequate institutional support for

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their economic systems. The quality of public administration, therefore, remains a key indicator of the progressiveness of a national economy. This makes an in-depth scientific examination of public administration quality in developing countries highly relevant. These countries include Kazakhstan, which currently remains in the upper-middle-income category but is expected to transition to high-income status in the coming years. For many years, Kazakhstan has consistently ranked highly in leading international assessments of high-technology development and digital competitiveness (Tadevosyan, 2023).

Nevertheless, the insufficient quality of public administration remains a major obstacle to improving Kazakhstan's global standing and must therefore be treated as a priority during national reforms. The Fifth Industrial Revolution has created the necessary preconditions and opportunities for such improvement, as advanced artificial intelligence (AI) technologies are rapidly evolving, acquiring broader functionality, and becoming increasingly widespread. Given their potential, growing demand, and proven effectiveness in various areas of economic activity, AI technologies are being actively introduced into the government apparatus of developing countries, including Kazakhstan.

The problem is that the prevailing approach to AI-driven government modernization in developing countries, including Kazakhstan, primarily pursues objectives unrelated to quality and instead focuses on improving the quantitative parameters of the national economy's regulatory apparatus (Aldehim et al., 2026). These objectives include ensuring universal access to public services by increasing labor productivity in the electronic delivery of such services through AI technologies and by making them faster and more convenient to obtain anywhere and at any time (Moosavihaghighi, 2026). Under the current approach to technological modernization, AI-based automation of public administration also seeks to improve

the efficiency of the government apparatus by reducing the cost of delivering public services (Sharma et al., 2026).

Although improvements in the quantitative parameters of a country's regulatory system undoubtedly make a substantial contribution to institutional development, they are insufficient to narrow the global gap in institutional environments. Improving the quality of public administration in developing countries is also necessary. The need to overcome the pronounced differentiation among countries in terms of institutional development stems from the fact that it is one of the key causes of global inequality. The critically high level of inequality among countries, manifested in the clear division between developed and developing economies, has been recognized at the global level, and international efforts to combat this inequality are being undertaken under the auspices of the United Nations.

The novelty of this research lies in its proposal to improve the approach to AI-driven government modernization in developing countries, including Kazakhstan, by overcoming its existing limitations and extending the application of AI technologies to an additional area: the quality of public administration. This area was not previously covered by automation and, in the context of the Fifth Industrial Revolution during the Decade of Action, has evolved into Public Administration Quality 5.0. Accordingly, the research aims to develop a scientific and methodological approach to providing AI engineering support for enhancing Public Administration Quality 5.0 in Kazakhstan. This aim is achieved through the following tasks.

The first task is to monitor Public Administration Quality 5.0 and the robustness of its AI engineering support in Kazakhstan. The second task is to model the dependence of Public Administration Quality 5.0 in developing countries, including Kazakhstan, on AI engineering.

The third task is to determine the prospects for improving Public Administration Quality 5.0 in Kazakhstan through 2030 by optimizing its AI engineering mechanism.

2. Literature Review

2.1. Sustainability as a Reflection of Public Administration Quality

The scientific and theoretical concept of public administration quality serves as the fundamental basis for the research conducted in this article. The principles of this concept are presented in numerous published sources, including the work of Mkrtchyan and Navasardyan (2024). The essence of this concept is that public administration quality should be defined with reference to the contemporary context and reassessed as that context changes; it must also be continuously monitored and improved (Sozinova et al., 2023).

During the Decade of Action, the sustainability of public administration is a central manifestation of its quality. It encompasses the proper functioning of public institutions; the completeness of the country's legislative framework and the timeliness of its revision; the transparency and predictability of public policy; the openness and accountability of the government apparatus; and the presence or absence of institutional traps in public administration, such as excessive and unjustified bureaucracy and corruption (Margaryan & Terzyan, 2023).

The results achieved in implementing SDG 16 provide a statistical basis for quantitatively assessing public administration quality from the perspective of its sustainability. They also enable international comparisons and the monitoring of changes in this quality over time. In accordance with the United Nations global sustainable development initiative, not only has a universal criterion for measuring public administration quality been introduced, but a time limit has also been

established within which this quality must be raised to the target level and standardized across all countries (Karimov et al., 2024).

Thus, SDG 16, together with the other 17 goals adopted in 2015, is expected to be fully achieved by 2030. This provides a reliable theoretical, methodological, informational, and statistical foundation for strategically planning improvements in public administration quality in developing countries, as well as for interpreting the level of public administration quality achieved and the progress made in enhancing it (Bazinyan & Mayilyan, 2024).

2.2. AI Engineering of Public Administration

Under the contemporary conditions of the Fifth Industrial Revolution, the technological modernization of public administration relies on AI engineering (Hamidi et al., 2026; Liu et al., 2026), which comprises the following three principal components:

- Infrastructure support, including telecommunications services and technical support for the application of AI technologies (Masud et al., 2026);
- The technological landscape, characterized by the prevalence of AI technologies, their innovativeness, uniqueness, and accessibility for practical implementation (Bhogale et al., 2026);
- The social environment, which determines the level of development of the information society, the prevalence and level of digital competencies within it, and its readiness and receptiveness to AI innovations (Bratukhina et al., 2025; Kaliyeva et al., 2025; Sukhodolov et al., 2018).

The AI engineering mechanism determines the pace of technological modernization of the national government apparatus and ensures the coordination (and, consequently,

the coherent and highly efficient operation) of all intelligent technologies integrated into a unified cyber-social system of public administration (Bogoviz & Mezhev, 2015; Ualtayev et al., 2024).

2.3. Public Administration Quality 5.0 as a Unity of Sustainability and AI Automation: A Literature Gap Analysis

The combined impact of the Fifth Industrial Revolution and the United Nations global initiative during the Decade of Action on the public administration of national economies worldwide has led to the emergence of a new type of administrative quality: Quality 5.0. A distinctive feature of this recently emerged type of quality is that it integrates the sustainability and technological sophistication of public administration (Stefanovic et al., 2024).

As noted above, the sustainability of public administration is identified with the implementation of SDG 16 and the results achieved under this goal. In turn, the technological sophistication of public administration is achieved through AI automation and is assessed from the perspective of the quality of services delivered through an AI-based e-government system (Özlu, 2025), as well as the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making in the national economy (Trivedi & Nilakshi, 2024).

In the “Public Administration Quality 5.0” concept, the focus is on the transformation of government regulation with the help of leading technologies. This concept is based on the use of the Internet of Things (the IoT – e.g., to improve monitoring), blockchain (to raise cyber security), artificial intelligence (AI), and high-speed and high-precision Big Data analytics (e.g., for improved forecasting and planning, rationalization of decision-making, and rapid reaction to events in the economy that require regulation) to raise effectiveness,

transparency, and proactivity of public administration, due to which the growth of its quality is achieved.

The difference between the general quality of management and the “Public Administration Quality 5.0” concept is that management quality has wider coverage, reflecting the extent to which the state’s goals conform to public interests, public management is effective, and effectiveness and democratism are balanced in it.

The difference between the quality of institutions and the “Public Administration Quality 5.0” concept is that the quality of institutions refers to the strength of the rules, autonomy of bureaucracy, transparency of selection mechanisms, and promotion of employees. The “Public Administration Quality 5.0” concept does not reject the importance of institutions, but shows how leading technologies can strengthen their work, not just replace certain obsolete past institutions that are no longer effective.

The difference between e-government quality and the “Public Administration Quality 5.0” concept is that e-government quality is a specialized technological concept aimed at optimizing individual processes (provision of services, data exchange) with the help of information and communication technologies and digital infrastructure, including online services, portals, and electronic interaction with citizens and business.

The “Public Administration Quality 5.0” concept is more complex: it includes not only digitalization of services but also proactive management, risk management, and using data for decision-making in state regulation.

Thus, the new concept of “Public Administration Quality 5.0” is based on traditional concepts, such as management quality, the quality of institutions, and e-government quality, having adapted them to the conditions of the digital age. Embodying the best features of previous conceptual approaches to ensuring quality of state

regulation (effectiveness, citizen-centricity, transparency, stability, and predictability), the concept of “Public Administration Quality 5.0” supplemented them with powerful high-tech tools for achieving a new – much higher – level of quality of state regulation in the conditions of quick technological changes, predetermined by the Fifth Industrial Revolution.

The review of the relevant literature on the research topic revealed that, despite the large number of published sources, a gap remains because the relationship between AI engineering in the technological modernization of public administration and Public Administration Quality 5.0 has not been sufficiently examined and remains unclear.

Based on the identified literature gap and to address it, this research poses the following research question: “How does the application of an AI engineering mechanism for the technological modernization of public administration, comprising the infrastructure, technological, and social components of this mechanism, affect Public Administration Quality 5.0 in terms of its sustainability, as related to SDG 16, and its technological sophistication, as related to the quality of services delivered through an AI-based e-government system and the quality of AI-enabled public policy?”

Drawing on the previously published studies of Lu et al. (2024), Margaryan and Margaryan (2022), and Yang et al. (2026), which provide some evidence from developed countries that the qualitative characteristics of public administration improve as AI modernization advances, this article proposes the hypothesis that the AI engineering mechanism can enhance Public Administration Quality 5.0 in developing countries, including Kazakhstan, but requires careful calibration of its components.

3. Materials and Methods

3.1. Sample, Variables, and Empirical Basis of the Research

To obtain results that are as reliable and useful as possible for Kazakhstan, the study uses a sample of 22 countries from the Eastern Europe and Central Asia region, to which Kazakhstan is assigned in the United Nations (UN, 2025) materials. The research covers 2025. The empirical basis of the study is presented in Table 1.

In accordance with the data presented in Table 1, abbreviated designations were introduced for the statistical indicators examined in this study, thereby making their values suitable for econometric processing. In applying the mathematical framework of the study, the indicators of AI engineering for the technological modernization of public administration are used as factor variables characterizing its components: the level of infrastructure development ($EG_{AI(1)}$), the favorability of the technological landscape ($EG_{AI(2)}$), and the degree of readiness of the social environment ($EG_{AI(3)}$) for the diffusion of AI technologies, based on Oxford Insights (2025) statistics.

The dependent variables are the indicators of Public Administration Quality 5.0, including the sustainability of public administration in terms of performance under SDG 16 ($Q_{5.0(1)}$), based on UN (2025) statistics; the technological sophistication of public administration in terms of the quality of services delivered through an AI-based e-government system ($Q_{5.0(2)}$); and the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making in the national economy ($Q_{5.0(3)}$), based on Oxford Insights (2025) statistics.

Table 1. AI engineering and public administration Quality 5.0 indicators in Kazakhstan and other sample countries in 2025, scores on a 0–100 scale

Country		AI engineering			Quality 5.0		
		Enabling technical infrastructure	AI technology diffusion	Societal transition	e-Government delivery	Government digital policy	Goal 16 Score
		EG _{AI(1)}	EG _{AI(2)}	EG _{AI(3)}	Q _{5.0(1)}	Q _{5.0(2)}	Q _{5.0(3)}
Asian states	Afghanistan	37,57	14,33	22,13	53,59	0	39,83
	Armenia	60,86	42,38	40,16	69,81	45	75,03
	Azerbaijan	74,93	45,34	46,03	93,47	40,48	62,06
	Georgia	65,67	46,18	42,92	59,88	35	72,91
	Kazakhstan	74,35	45,9	41,44	85,98	61,2	63,77
	Kyrgyzstan	57,59	25,88	36,27	81,68	12,12	53,41
	Tajikistan	42,31	35,63	40,34	44,44	2,94	60,33
	Turkmenistan	57,75	37,53	29,33	6,27	10	70,98
	Uzbekistan	62,26	45,14	42,75	64,87	63,97	58,32
European states	Albania	69,01	41,04	49,87	86,86	51,03	64,34
	Belarus	53,5	41,49	40,42	47,65	0,4	64,01
	Bosnia and Herzegovina	51,57	35,7	44,32	87,51	16,15	65,43
	Bulgaria	69,24	51,14	59,05	94,32	35	70,72
	Croatia	64,17	50,46	56,76	88,34	55	69,48
	Cyprus	74,49	43,99	53,62	87,04	75,54	65,32
	Malta	67,92	46,86	63,72	67,62	65,54	70,2
	Moldova	57,19	27,19	55,46	84,66	80	70,92
	Montenegro	62,87	28,47	56,6	79,54	25,03	69,48
	North Macedonia	52,18	29,39	44,62	83,1	10	65,83
	Romania	69,51	51,6	58,44	82,87	28,45	75,68
	Russia	66,6	54,48	44,25	73,42	66,15	54,75
	Serbia	67,63	46,62	55,5	87,85	80	64,82
Arithmetic mean		61.78	40.31	46.55	73.22	39.05	64.89

Source: Developed by the authors based on the materials from Oxford Insights (2025) and UN (2025).

3.2. Research Design

The research design adopted in this article involves the sequential completion of the three stated tasks. The first task, which consists of monitoring Public Administration Quality 5.0 and the robustness of its AI engineering support in Kazakhstan, is addressed using comparative and trend analysis methods. These methods are used to compare the values of the statistical indicators for Kazakhstan presented in Table 1 with the arithmetic means for the sample. In addition, the 2025 value of Q_{5.0(3)} from Table 1 is compared with the archived value of this indicator for Kazakhstan in 2020, thereby identifying its five-year trend.

To ensure that variables studied in this paper do not duplicate each other, a multicollinearity test is conducted, with the calculation of coefficients of cross-correlation of variables (R²) from Table 1.

The second task, which involves modeling the dependence of Public Administration Quality 5.0 in developing countries, including Kazakhstan, on AI engineering, is addressed using regression analysis. This method is used to construct multiple linear regression equations that mathematically describe the dependence of each dependent variable (EG_{AI}), considered separately, on the full set of factor variables (Q_{5.0}). The research model is specified as follows:

$$EG_{AI}=a+b_1Q_{5.0(1)}+b_2Q_{5.0(2)}+b_3Q_{5.0(3)} \quad (1)$$

The reliability of the research model (1) is assessed by calculating standard errors and multiple R coefficients and conducting Fisher's F-test. For the robustness check of the research model (1), analysis of residuals for this model and a heteroscedasticity test with scatter plots are conducted.

A test for the stability of model (2) –Chow test – is also performed. For this, the data in Table 1 are divided into two sub-samples. The first sub-sample contains data on 9 Asian states, including Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.

The second sub-sample contains data on 13 European states, including Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Malta, Moldova, Montenegro, North Macedonia, Romania, Russia, and Serbia. Regression is evaluated for each sub-sample separately. The F-test is used to check whether the quality improved significantly (whether the sum of squares of residuals decreased) if the data are not combined into one sample of 22 observations.

The third task, which consists of determining the prospects for improving Public Administration Quality 5.0 in Kazakhstan through 2030 by optimizing its AI engineering mechanism, is addressed through forecasting based on three alternative scenarios.

The first forecast assumes the continuation of the preceding five-year trend observed in 2020–2025, namely, a decline in performance under SDG 16 and a crisis of Public Administration Quality 5.0 in Kazakhstan during 2026–2030.

The second forecast assumes that the potential of the AI engineering mechanism for the technological modernization of public administration is only partially realized. To prepare this forecast, the highest values of the factor variables (EG_{AI}) observed among the sample countries are substituted into the regression model of Public Administration Quality 5.0.

The third forecast assumes the full realization of the potential of the AI engineering mechanism for the technological modernization of public administration. To prepare this forecast, the maximum possible values of all three factor variables (EG_{AI}), equal to 100 points, are substituted into the regression model of Public Administration Quality 5.0.

4. Results

4.1. Monitoring Public Administration Quality 5.0 and the Robustness of Its AI Engineering Support in Kazakhstan

As part of addressing the first research task, the arithmetic means for the sample were calculated using the statistics presented in Table 1 and compared with the corresponding values for Kazakhstan to monitor Public Administration Quality 5.0 and the robustness of its AI engineering support in Kazakhstan in 2025. The monitoring results are presented in Figure 1.

The monitoring showed that the sustainability of public administration in Kazakhstan in terms of performance under SDG 16 amounted to 63.77 points in 2025, equivalent to 0.98 times the average for the sample of developing countries (64.89 points). Simultaneously, the quality of services delivered through Kazakhstan's AI-based e-government system (85.98 points) was 1.17 times the sample average (73.22 points), while the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making was 1.57 times higher (61.20 points in Kazakhstan compared with a sample average of 39.05 points).

The monitoring results also indicate that the level of development of AI infrastructure support in Kazakhstan (74.35 points) was 1.20 times higher in 2025 than the average for the other developing countries in the sample (61.78 points).

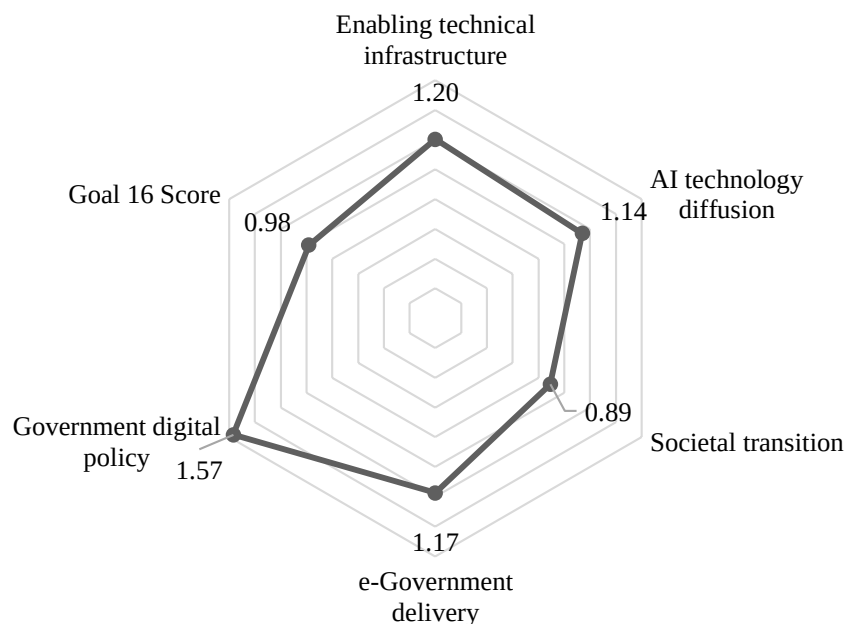


Figure 1. Results of monitoring public administration Quality 5.0 and the robustness of its AI engineering support in Kazakhstan in 2025.

Source: Developed by the authors

Similarly, Kazakhstan's technological landscape for the use of AI technologies (45.90 points) was 1.14 times more favorable than the average for the other sample countries (40.31 points).

Nevertheless, the readiness of Kazakhstan's social environment for the diffusion of AI technologies (41.44 points) was only 0.89 times the sample average (46.55 points). A comparison of Kazakhstan's public administration sustainability in terms of performance under SDG 16 in 2025 (63.77 points) with the archived value of this indicator for 2020 (72.98 points) revealed a decline of 12.62%.

Thus, the monitoring results indicate that Public Administration Quality 5.0 in Kazakhstan was relatively high in 2025 in terms of technological sophistication but comparatively low in terms of sustainability. The five-year trend in the sustainability of public administration, as reflected in Kazakhstan's performance under SDG 16,

was downward in 2025, indicating a decline in the quality of public administration and a crisis during the Decade of Action.

A possible reason for this situation is the fragmented nature of AI engineering support for the technological modernization of public administration in Kazakhstan in 2025. Despite robust infrastructure support and a favorable technological landscape, the social environment remains insufficiently prepared for the diffusion of AI technologies.

4.2. A Model of the Dependence of Public Administration Quality 5.0 on AI Engineering, Incorporating Kazakhstan's Experience

To ensure that variables studied in this paper do not duplicate each other, a multicollinearity test was conducted, with calculation of the values of the coefficients of cross-correlation of variables (R^2) from Table 1. The results are presented in Table 2.

Table 2. Cross-correlation of variables.

R^2	$EG_{AI(1)}$	$EG_{AI(2)}$	$EG_{AI(3)}$	$Q_{5.0(1)}$	$Q_{5.0(2)}$	$Q_{5.0(3)}$
$EG_{AI(1)}$	1	-	-	-	-	-
$EG_{AI(2)}$	0.7299	1	-	-	-	-
$EG_{AI(3)}$	0.5985	0.5087	1	-	-	-
$Q_{5.0(1)}$	0.4989	0.2127	0.6098	1	-	-
$Q_{5.0(2)}$	0.6779	0.5007	0.5750	0.4739	1	-
$Q_{5.0(3)}$	0.4585	0.4708	0.6022	0.1007	0.2369	1

Source: Developed by the authors

Since all calculated values of the coefficients of cross-correlation (R^2) in Table 2 were low (none of them exceeded 0.90), the multicollinearity test was successfully passed. Therefore, duplicate variables are absent, and exclusion of any variables from further research is not required.

As part of addressing the second research task, a regression analysis of the statistical

data presented in Table 1 was conducted. This made it possible to develop the following associative model (2) of Public Administration Quality 5.0 in developing countries, including Kazakhstan, as a function of AI engineering for the technological modernization of public administration in 2025:

$$\begin{cases} Q_{5.0(1)} = 39.29 + 0.01EG_{AI(1)} + 0.18EG_{AI(2)} + 0.39EG_{AI(3)}, \\ Q_{5.0(2)} = -5.21 + 1.00EG_{AI(1)} - 0.84EG_{AI(2)} + 1.08EG_{AI(3)}, \\ Q_{5.0(3)} = -81.17 + 1.47EG_{AI(1)} - 0.08EG_{AI(2)} + 0.70EG_{AI(3)}. \end{cases} \quad (2)$$

The associative model (2) indicates that, in developing countries, including Kazakhstan, in 2025, a one-point increase in the level of AI infrastructure development increases performance under SDG 16 by 0.01 points, improves the quality of services delivered through an AI-based e-government system by 1.00 point, and enhances the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making by 1.47 points.

A one-point increase in the favorability of the technological landscape for the use of AI technologies increases performance under SDG 16 by 0.18 points but also reduces the quality of services delivered through an AI-based e-government system by 0.84 points and decreases the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making by 0.08 points.

A one-point increase in the readiness of the social environment for the diffusion of AI technologies is associated with a 0.39-point

improvement in performance under SDG 16, a 1.08-point increase in the quality of services delivered through an AI-based e-government system, and a 0.70-point improvement in the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making. The results of the reliability assessment of model (2) are presented in Table 3.

Based on the calculations presented in Table 3, model (2) can be considered reliable overall, as all of its equations successfully passed Fisher's F-test. In model (2), the equation for $Q_{5.0(1)}$ is statistically significant at the 0.05 level (Significance F = 0.02; observed F = 3.99). The equation for $Q_{5.0(2)}$ is statistically significant at the 0.05 level (Significance F = 0.02; observed F = 3.99). The equation for $Q_{5.0(3)}$ at the 0.02 level (Significance F = 0.01; observed F = 5.44), and the equation for $Q_{5.0(3)}$ is statistically significant at the 0.01 level (Significance F = 0.005; observed F = 6.11).

Table 3. Reliability assessment of model (2)

Equation	Variance analysis				F test		Regression statistics	
	Scope of analysis	df	SS	MS	F	Significance of F	Multiple R	Standard error
Q _{5.0(1)}	Regression	3	558.74	186.25	3.99	0.02	0.63	6.83
	Residual	18	840.66	46.70	Passed at a significance level of 0.05			
	Total	21	1399.40					
Q _{5.0(2)}	Regression	3	4333.08	1444.36	5.44	0.01	0.69	16.30
	Residual	18	4782.49	265.69	Passed at a significance level of 0.05			
	Total	21	9115.57	-				
Q _{5.0(3)}	Regression	3	7704.03	2568.01	6.11	0.005	0.71	20.50
	Residual	18	7566.24	420.35	passed at a significance level of 0.01			
	Total	21	15270.28	-				

Source: Developed by the authors

All standard errors in model (2) are relatively small: the standard error is 6.83 for the Q_{5.0(1)} equation, 16.30 for the Q_{5.0(2)} equation, and 20.50 for the Q_{5.0(3)} equation. The obtained multiple R values indicate that the AI engineering mechanism for the technological modernization of public administration explains 63% of performance under SDG 16, 69% of the quality of

services delivered through an AI-based e-government system, and 71% of the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making.

For the robustness check of model (2), an analysis of residuals for the model was conducted. The results are presented in Table 4.

Table 4. Analysis of residuals in the model (2)

Observation	Predicted Q _{5.0(1)}	Residuals	Predicted Q _{5.0(2)}	Residuals	Predicted Q _{5.0(3)}	Residuals
1	44.3632	9.2268	-11.6298	11.6298	50.6782	-10.8482
2	63.6633	6.1467	33.0485	11.9515	62.7723	12.2577
3	81.6402	11.8298	57.5754	-17.0954	65.6764	-3.6164
4	68.2820	-8.4020	41.7502	-6.7502	64.5466	8.3634
5	75.6358	10.3442	53.4553	7.7447	63.9901	-0.2201
6	70.0288	11.6512	26.7786	-14.6586	58.3427	-4.9327
7	50.8956	-6.4556	6.4969	-3.5569	61.5150	-1.1850
8	52.9259	-46.6559	21.2450	-11.2450	57.6972	13.2828
9	65.5473	-0.6773	36.7112	27.2588	64.2719	-5.9519
10	83.4472	3.4128	51.9249	-0.8949	66.3654	-2.0254
11	57.3004	-9.6504	22.5099	-22.1099	62.6604	1.3496
12	64.4288	23.0812	22.8644	-6.7144	63.1419	2.2881
13	85.1071	9.2129	57.9459	-22.9459	71.6999	-0.9799
14	78.1162	10.2238	48.9554	6.0446	70.6535	-1.1735
15	90.5201	-3.4801	62.3697	13.1703	68.3795	-3.0595
16	92.4117	-24.7917	59.6207	5.9193	72.7497	-2.5497
17	89.2319	-4.5719	39.5844	40.4156	66.0117	4.9083
18	95.0911	-15.5511	48.6148	-23.5848	66.7221	2.7579
19	70.6600	12.4400	24.4509	-14.4509	62.1555	3.6745
20	84.3341	-1.4641	57.8777	-29.4277	71.5462	4.1338
21	63.6859	9.7341	43.4154	22.7346	66.5262	-11.7762
22	83.4533	4.3967	53.4346	26.5654	69.5175	-4.6975

Source: Developed by the authors

According to the results of the analysis of residuals from Table 4, a graphic analysis of residuals in model (2) was conducted for the diagnostics of model (2) for heteroscedasticity. Its results are illustrated for the equation for Q5.0(1) in Figure 2, for the equation for Q5.0(2) in Figure 3, and for the equation for Q5.0(3) in Figure 4.

Scatter plots from Figure 2 demonstrate a visual absence of a “funnel”, i.e., the variance of residuals does not grow and does not reduce with an increase in the regressor, which is a sign of the absence of heteroscedasticity in the equation for Q5.0(1) of the model (2).

Scatter plots from Figure 3 demonstrate a visual absence of the “funnel”, i.e., the variance of residuals does not grow and does not reduce with an increase in the regressor, which is a sign of the absence of

heteroscedasticity in the equation for Q5.0(2) of the model (2).

Scatter plots from Figure 4 demonstrate a visual absence of the “funnel”, i.e., the variance of residuals does not grow and does not reduce with an increase in the regressor, which is a sign of the absence of heteroscedasticity in the equation for Q5.0(3) of the model (2).

Additionally, the test for the stability of the model (2) in Table 5 – Chow test – was conducted. For this, the data in Table 1 are divided into two sub-samples (for Asian states and European states), and regression for each sub-sample separately is assessed. The F-test was used to check whether the quality improved significantly (whether the sum of squares of residuals was reduced) if the data are not united.

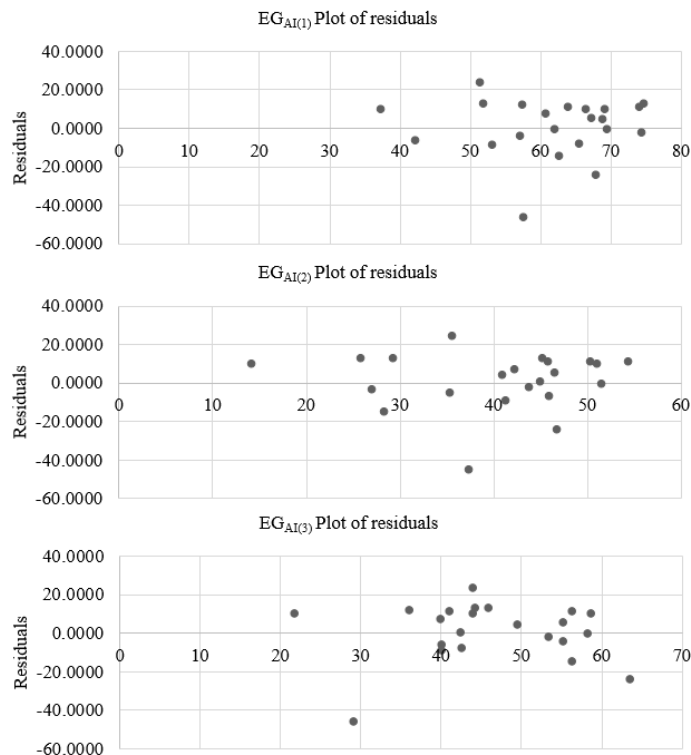


Figure 2. Graphical analysis of residuals in the equation for Q5.0(1) of the model (2)

Source: Developed by the authors

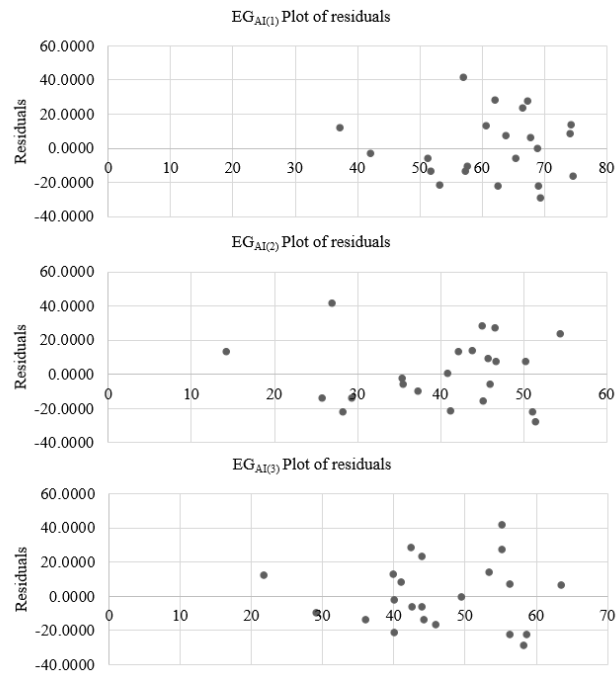


Figure 3. Graphical analysis of residuals in the equation for Q5.0(2) of the model (2)
Source: Developed by the authors

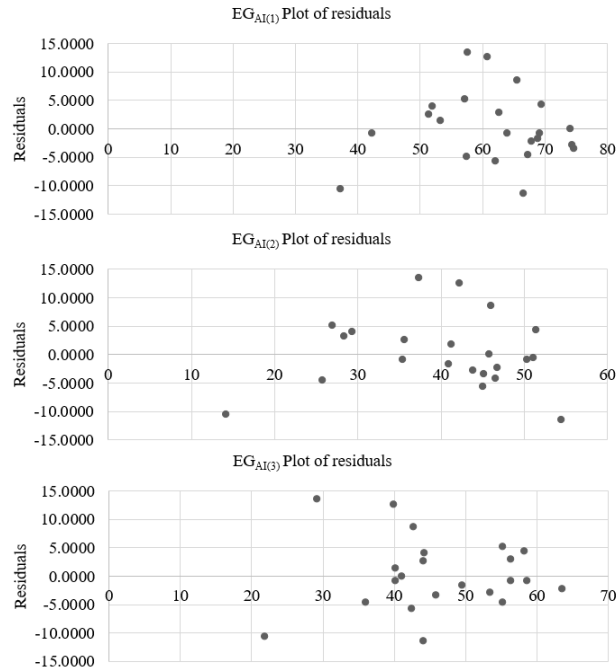


Figure 4. Graphical analysis of residuals in the equation for Q5.0(3) of the model (2)
Source: Developed by the authors

Table 5. Chow test for the stability of the model (2)

Equation	In Asian countries				In European countries			
	F test		Regression statistics		F test		Regression statistics	
	F	Significance of F	Multiple R	Standard error	F	Significance of F	Multiple R	Standard error
Q _{5.0(1)}	7.61	0.03	0.91	14.07	0.74	0.55	0.45	12.53
	Passed at a significance level of 0.05				Passed at a significance level of 0.60			
Q _{5.0(2)}	3.51	0.10	0.82	17.65	1.94	0.19	0.63	24.91
	Passed at a significance level of 0.15				Passed at a significance level of 0.20			
Q _{5.0(3)}	4.01	0.08	0.84	7.48	6.24	0.01	0.82	3.32
	Passed at a significance level of 0.10				Passed at a significance level of 0.05			

Source: Developed by the authors.

Since the regression parameters hardly change, the null hypothesis of the test is confirmed – the coefficients are stable in the entire sample. Therefore, the model (2) is stable and reliable.

Thus, the developed model of Public Administration Quality 5.0, incorporating Kazakhstan's experience in 2025, revealed its substantial and statistically significant dependence on AI engineering. According to the model, all three components of AI engineering enhance the sustainability of public administration, whereas its technological sophistication increases only under the influence of the infrastructure and social components.

4.3. Prospects for Improving Public Administration Quality 5.0 in Kazakhstan through Optimization of Its AI Engineering Mechanism

As part of addressing the third research task, the highest values of the factor variables (EG_{AI}) observed among the sample countries

were substituted into model (2) to determine the prospects for improving Public Administration Quality 5.0 in Kazakhstan through 2030 under the partial realization of the potential of its AI engineering mechanism. It was also established that, should the preceding negative trend in SDG 16 performance observed in 2020–2025 continue, the crisis of Public Administration Quality 5.0 in Kazakhstan will deepen, and the sustainability of public administration will decline to 55.72 points by 2030.

To determine the prospects for improving Public Administration Quality 5.0 in Kazakhstan through 2030 under the full realization of the potential of its AI engineering mechanism, the maximum possible values of all three factor variables (EG_{AI}), equal to 100 points, were substituted into model (2). The expected percentage increase in all examined indicators by 2030 relative to 2025 under both alternative scenarios, based on the associative model, is illustrated in Figure 2.

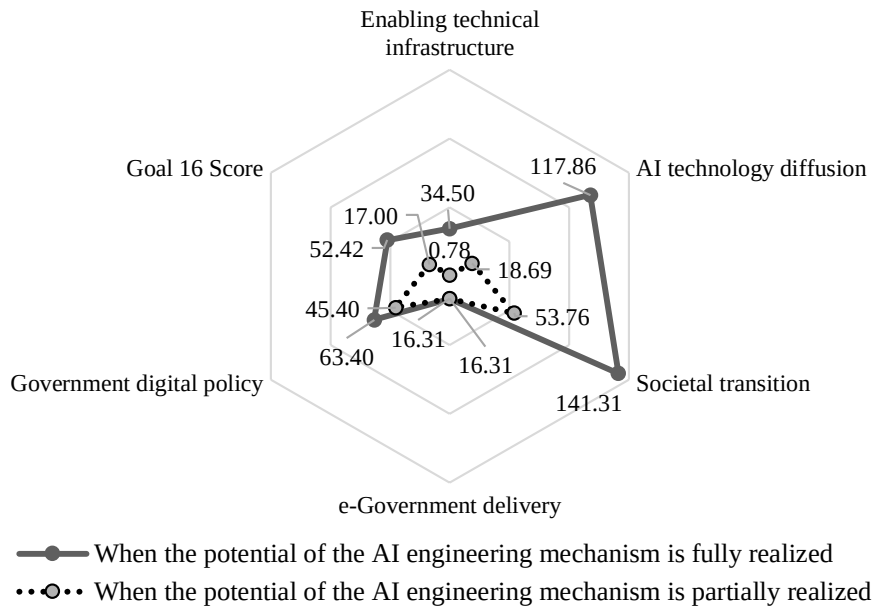


Figure 2. Prospects for improving Public Administration 5.0 in Kazakhstan through the optimization of its AI engineering mechanism by 2030.

Source: Developed by the authors

As shown in Figure 2, partial optimization of the AI engineering mechanism in Kazakhstan through 2030 entails raising the components of this mechanism to the maximum values observed among the developing countries in the sample from the corresponding region. To achieve this, Kazakhstan will need the following:

- Increase the level of AI infrastructure development by 0.78%, from 74.35 points in 2025 to 74.93 points by 2030;
- Improve the favorability of the technological landscape for the use of AI technologies by 18.69%, from 45.90 points in 2025 to 54.48 points by 2030;
- Increase the readiness of the social environment for the diffusion of AI technologies by 53.76%, from 41.44 points in 2025 to 63.72 points by 2030.

This will result in a limited improvement in Public Administration Quality 5.0 in Kazakhstan. Partial optimization of the AI engineering mechanism of public administration will ensure the following:

- A 17.00% increase in the sustainability of public administration, with performance under SDG 16 rising from 63.77 points in 2025 to 74.61 points by 2030;
- A 16.31% increase in the quality of services delivered through an AI-based e-government system, from 85.98 points in 2025 to 100.00 points by 2030;
- A 45.40% increase in the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making, from 61.20 points in 2025 to 88.98 points by 2030.

To realize the potential of the AI engineering mechanism for the technological modernization of public administration in Kazakhstan as fully as possible through 2030, the following will be necessary:

- Increase the level of AI infrastructure development by 34.50%;
- Improve the favorability of the technological landscape for the use of AI technologies by 117.86%;
- Increase the readiness of the social environment for the diffusion of AI technologies by 141.31%.

As a result, Public Administration Quality 5.0 in Kazakhstan will become nearly optimal. In particular, the technological sophistication of public administration will reach the maximum level of 100 points: the quality of services delivered through an AI-based e-government system will increase by 16.31%, while the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making will rise by 63.40%. The sustainability of public administration will reach 97.20 points, with performance under SDG 16 increasing by 52.42%.

It should be emphasised that the described scenarios for 2030 are scenarios based on the associative model, not real forecasts. Due to this, the presented numerical values are frameworks.

Thus, without adjustments to the AI engineering mechanism for the technological modernization of public administration in

Kazakhstan, its Quality 5.0 will continue to decline sharply. Partial optimization of the AI engineering mechanism will make it possible to overcome the crisis of Public Administration Quality 5.0 in Kazakhstan, but will result in only limited improvement. The fullest possible realization of the potential of the AI engineering mechanism will enable Kazakhstan to successfully achieve SDG 16 and attain the highest level of Public Administration Quality 5.0 through comprehensive improvements in both its sustainability and technological sophistication.

5. Discussion

The contribution of this research to the literature of Mkrtchyan and Navasardyan (2024) and Sozinova et al. (2023) lies in the fact that its findings advance the scientific and theoretical concept of public administration quality by reinterpreting public administration in the contemporary context of the Fifth Industrial Revolution during the Decade of Action,” refining the conceptualization of Public Administration Quality 5.0, and clarifying the relationship between AI engineering for the technological modernization of public administration and Public Administration Quality 5.0 in Kazakhstan and neighboring developing countries in Eastern Europe and Central Asia (Table 3).

Table 3. Refined analysis of the contribution of AI engineering to Public Administration Quality 5.0 in Kazakhstan compared with previous literature (Developed by the authors)

Components of AI engineering	Previous literature on components	Contribution to improving the quality of public administration in Kazakhstan from the perspective of (regression):		
		sustainability	service quality	policy quality
Infrastructure	Masud et al. (2026)	made (0.01)	made (1.00)	made (1.47)
Technological landscape	Bhogale et al. (2026)	made (0.18)	not made (-0.84)	not made (-0.08)
Social environment	Bratukhina et al. (2025), Kaliyeva et al. (2025), Sukhodolov et al. (2018)	made (0.39)	made (1.08)	made (0.70)

The materials presented in Table 3 summarize the findings of this research, concisely present the evidence developed in support of Lu et al. (2024), Margaryan and Margaryan (2022), and Yang et al. (2026), and confirm the initial hypothesis by demonstrating that the AI engineering mechanism offers broad opportunities for improving Public Administration Quality 5.0 in developing countries of Eastern Europe and Central Asia, including Kazakhstan. However, realizing these opportunities requires the careful calibration of the mechanism's components in light of the identified differences in their effects on the dimensions of Quality 5.0.

In calibrating the AI engineering mechanism for improving Public Administration Quality 5.0 in Kazakhstan, primary attention should be given to developing its infrastructure component, confirming the findings of Masud et al. (2026), and its social component, confirming the conclusions of Bratukhina et al. (2025), Kaliyeva et al. (2025), and Sukhodolov et al. (2018), because these components exert the strongest positive influence on Public Administration Quality 5.0. By contrast, the technological component, contrary to the results of Bhogale et al. (2026), is of secondary importance and requires less development because its influence on Public Administration Quality 5.0 is contradictory: it enhances sustainability while reducing technological sophistication.

Extending the series of studies by Bogoviz and Mezhev (2015), Hamidi et al. (2026), Liu et al. (2026), and Ualtayev et al. (2024), this research identifies differences in the contribution of the AI engineering mechanism to improving various dimensions of Public Administration Quality 5.0 in Kazakhstan. The AI engineering mechanism has the greatest potential to enhance the sustainability dimension of Public Administration Quality 5.0, which is consistent with the previous studies of Bazinyan and Mayilyan (2024), Margaryan and Terzyan (2023), and Karimov et al.

(2024). By contrast, and contrary to the previous publications of Özlü (2025) and Trivedi and Nilakshi (2024), the AI engineering mechanism has considerably less potential to enhance the technological sophistication dimension of Public Administration Quality 5.0.

The principal innovation of this article lies in substantiating the advisability of applying the AI engineering mechanism to improve not only the quantitative parameters of public administration, as previously noted in the literature by Aldehim et al. (2026), Moosavihaghighi (2026), and Sharma et al. (2026), but also its qualitative parameters. This overcomes the limitations of the prevailing approach to AI-driven government modernization in developing countries, including Kazakhstan, and expands the objectives of applying this mechanism to include the improvement of Public Administration Quality 5.0.

6. Conclusion

Thus, the stated objective has been achieved. The research has resulted in the development of a scientific and methodological approach to providing AI engineering support for enhancing Public Administration Quality 5.0 in Kazakhstan. The proposed approach includes the systemic understanding developed in this article of Public Administration Quality 5.0 and the robustness of its AI engineering support in Kazakhstan in 2025, compared with neighboring developing countries in Eastern Europe and Central Asia.

This perspective revealed an imbalance in Public Administration Quality 5.0 in Kazakhstan in 2025, characterized by the outstanding technological sophistication of public administration but its insufficient sustainability. It also demonstrated the unevenness of AI engineering support for the technological modernization of public administration in Kazakhstan in 2025: although infrastructure support is highly developed and the technological landscape is

favorable, the readiness of the social environment for the diffusion of AI technologies remains relatively low.

A dynamic assessment of Public Administration Quality 5.0 in Kazakhstan revealed a crisis manifested in a decline in the sustainability of public administration, as measured by performance under SDG 16, in 2025 compared with 2020. The proposed approach also includes an associative model of Public Administration Quality 5.0 in Kazakhstan and neighboring developing countries in Eastern Europe and Central Asia in 2025. The theoretical significance of the new model lies in its mathematical description of the dependence of Public Administration Quality 5.0 on AI engineering for the technological modernization of public administration.

The resulting model provided scientific evidence that the application of AI engineering largely determines Public Administration Quality 5.0 in Kazakhstan, explaining 63% of the sustainability of public administration in terms of performance under SDG 16, 69% of its technological sophistication in terms of the quality of services delivered through an AI-based e-government system, and 71% of its technological sophistication in terms of the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making.

The new model also made it possible to rank the components of AI engineering according to their contribution to improving Public Administration Quality 5.0 in Kazakhstan in 2025. The infrastructure and social components were found to be the highest priorities because they provide the strongest and most systematic support. By contrast, the technological component is of secondary importance because it supports improvements in Public Administration Quality 5.0 in Kazakhstan only partially, contributing to greater sustainability but not stimulating increased technological sophistication.

The developed approach also encompasses the identified prospects for changes in Public Administration Quality 5.0 in Kazakhstan, depending on its AI engineering support during the Decade of Action through 2030. These prospects are embodied in three alternative forecasts. The negative forecast involves a further deepening of the crisis in Public Administration Quality 5.0 in Kazakhstan due to a 12.62% decline in the sustainability of public administration by 2030 compared with 2025, to a critically low level of 55.72 points. This would signify failure to achieve SDG 16, which would be only approximately half implemented.

The moderately positive forecast involves a 17.00% increase in the sustainability of public administration in Kazakhstan in terms of performance under SDG 16, as well as improvements in its technological sophistication: 16.31% in terms of the quality of services delivered through an AI-based e-government system and 45.40% in terms of the quality of public policy development and implementation using AI-enabled intelligent support for regulatory decision-making.

Although this would enable Kazakhstan to overcome the crisis in Public Administration Quality 5.0 by preventing a decline in performance under SDG 16, this goal would still not be fully achieved by 2030 and would be attained only partially, reaching 74.61 points. This would require the development of the infrastructure component of AI engineering for the technological modernization of Kazakhstan's government apparatus by 0.78%, the technological component by 18.69%, and the social component by 53.76%. Under this scenario, the potential of the AI engineering mechanism for the technological modernization of public administration in Kazakhstan through 2030 would not be fully realized.

The highly positive forecast assumes that Kazakhstan will achieve the highest level of Public Administration Quality 5.0 by 2030,

approaching 100 points across all dimensions, including the full achievement of SDG 16. This would become possible if the potential of the AI engineering mechanism for the technological modernization of public administration in Kazakhstan were fully realized through 2030. This would require the development of the infrastructure component of AI engineering for the technological modernization of Kazakhstan's government apparatus by 34.50%, the technological component by 117.86%, and the social component by 141.31%.

The practical significance of the developed scientific and methodological approach to providing AI engineering support for enhancing Public Administration Quality 5.0 in Kazakhstan lies in the fact that its application will improve the accuracy of strategic planning for increasing Public Administration Quality 5.0 in Kazakhstan. Through more effective AI engineering, it will also help ensure the proper functioning of digital public institutions, the completeness and timely updating of the legislative framework, the transparency and predictability of public policy, the openness and accountability of the electronic government apparatus, and the elimination and prevention of institutional traps in public administration, such as excessive and unjustified bureaucracy and corruption.

The proposed scientific and methodological approach to providing AI engineering support for enhancing Public Administration Quality 5.0 in Kazakhstan will be useful for improving public policy in Kazakhstan. The multipurpose application of the AI engineering mechanism for the technological modernization of the government apparatus recommended under the new approach will increase the effectiveness of Kazakhstan's national reforms, enhance its global standing, and improve the effectiveness of public institutions regulating the national economy.

The social significance of the scientific and methodological approach developed in this article to providing AI engineering support for enhancing Public Administration Quality 5.0 in Kazakhstan lies in the fact that a shift toward the proposed approach will support the successful implementation of the United Nations global sustainable development initiative. In particular, the proposed developments will help narrow the global gap in institutional environments and therefore contribute to combating inequality among countries.

By following the proposed approach, developing countries such as Kazakhstan will be able to achieve greater progress in institutional development, thereby improving their institutional environments and performance under SDG 16, while also narrowing the gap with developed countries and improving performance under SDG 10.

In conclusion, the findings of this research are somewhat limited because they are based on the experience of countries from only one geographical region: Eastern Europe and Central Asia. This prevents the conclusions from being generalized with complete confidence to developing countries in other regions of the world. The narrow geographical focus may also reduce the effectiveness of the developed scientific and methodological approach to providing AI engineering support for enhancing Public Administration Quality 5.0 when it is applied in developing countries from other regions.

To overcome this limitation, future research extending this study should examine in detail the empirical experience of AI engineering for Public Administration Quality 5.0 in developing countries from other geographical regions and adapt the proposed approach to the specific characteristics of each region.

It should also be noted that another limitation of the conducted research is the fact that the regression analysis in it is based only on 22 observations with three predictors. Due to this, unexpected negative

coefficients for the technological component can reflect measurement problems and omitted variables or be predetermined by the small size of the sample.

This limitation should be overcome in the next scientific studies, in the course of which it would be expedient to recheck coefficients for the technological component, as well as presented assumptions on a possible crisis

and non-achievement of SDG 16 through more large-scale studies based on expanded samples.

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