

Risk modelling as a way to diagnose corruption in procurement system: Practice and legislation

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Abstract. The study aimed to analyse risk modelling methods for diagnosing and preventing corruption in public procurement. The research methods included an analysis of the existing legislation of Kazakhstan in the field of public procurement and an in-depth study of cases that illustrate the real experience of implementing methods of diagnosing corruption in this area. In the context of the intensified fight against corruption in Kazakhstan, state and municipal procurement systems were emphasised. One of the methods of diagnosing corruption risks in such systems is risk modelling, which helps to identify potential weaknesses and abuses in the tender and procurement process. The study identified the main factors contributing to corruption in the public procurement system and offers recommendations for improving legislative and organisational mechanisms to increase transparency and accountability in the tender process. The study also identified key factors contributing to corruption in Kazakhstan's public procurement system, including insufficient transparency of tender procedures, lack of effective control mechanisms, and collusion between tenderers. An analysis of the existing legislation of Kazakhstan in the field of public procurement was conducted, and regulatory gaps that impede corruption prevention were identified. Recommendations for improving legal regulation are offered legal regulation, taking into account international experience and standards. The key conclusion is that risk modelling is becoming substantial in the fight against corruption, as it allows for the advanced prediction and elimination of possible threats,

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thereby improving the efficiency of the public procurement system. Practical application of the proposed methodological approaches, integration of social data and modern technologies, such as artificial intelligence, in the monitoring of public procurement opens opportunities to increase transparency and efficiency of anti-corruption mechanisms

Keywords: compliance control; digital audit tools; fraud prevention; control efficiency; transparency

Introduction

Corruption in the public procurement system remains one of the most acute problems for many countries, including Kazakhstan. In the context of the digitalisation of the economy and the growing focus on transparency in government processes, the need to identify corruption risks at an early stage is becoming a strategic objective (Ternov *et al.*, 2024). The introduction of new monitoring tools based on big data analysis, machine learning and risk modelling can significantly improve the effectiveness of anti-corruption policy. One of the most promising ways to combat corruption in public procurement is to use social data, such as the level of public trust in the government, the level of transparency of government agencies, analysis of social media content, the results of opinion polls, and data on procurement, taxation and company profits. These parameters were used not only to record the facts of violations but also to predict potential corruption schemes based on statistical and behavioural analysis.

In global practice, there are already models for assessing corruption risks that integrate social data into anti-corruption strategies. For instance, the Bayesian Corruption Indicator allows for the consideration of many factors that affect the likelihood of corruption schemes. However, such methods have not yet become widespread in Kazakhstan, which creates a gap in the effectiveness of government control over procurement. An important aspect of the study is the analysis of the current legislation of Kazakhstan in the field of public procurement. Despite the existence of regulations aimed at increasing the transparency of tender procedures, practice shows that legislative mechanisms do not always allow for the detection of complex schemes to circumvent laws (Rysin & Sukh, 2024). In this regard, the question of the possibility of introducing new mathematical models for diagnosing corruption, which would address the specifics of Kazakh legislation and be adapted to national realities, becomes relevant. Corruption in the public procurement system remains one of the key issues affecting the efficiency of budget allocation and economic development (Busol & Romaniuk, 2024). One of the modern methods of identifying and preventing corruption risks is mathematical modelling. This review examines the existing research on corruption in procurement, the risk models used and the legal and regulatory aspects governing this process in Kazakhstan.

Zh. Khamitov *et al.* (2023) highlight a close relationship between corruption, public procurement and political instability in Kazakhstan. The authors emphasise that corruption schemes in public procurement are significantly exacerbated in conditions of political instability, which threatens the effectiveness of public administration. However, there is still a gap in the study of issues related to the practical implementation of the proposed measures in a rapidly changing political situation, which requires further analysis.

Zh. Khamitov (2023) analyses public spending, where the author monitors tender procedures, identifying patterns and weaknesses in the public procurement system. In particular, the study focuses on the shortcomings in the process of planning, implementation and control of procurement,

suggesting the use of digital technologies to increase transparency and prevent corruption. At the same time, the study does not address the possible problems associated with the introduction of such technologies at the level of public authorities, including problems with staff training and integration of digital solutions into existing systems. O. Ramashov *et al.* (2024) noted that despite the existence of a legal framework, the effectiveness of anti-corruption measures is limited by shortcomings in oversight mechanisms and weak interaction between state bodies and civil society.

D.A. Urbina and G. Rodríguez (2022) analysed the impact of corruption on economic growth, human development and the natural resources sector in Latin America and the Nordic countries using Bayesian panel video assistant referee (VAR) analysis. They conclude that corruption has a negative impact on living standards and sustainable development, emphasising the need for a comprehensive approach to fighting corruption. A.R. Dipierro and A. Relia (2024) propose a cultural approach to studying the perception of corruption, emphasising that cultural differences are central in shaping public opinion about corruption. The study emphasises the importance of considering local specifics when developing anti-corruption strategies. A. Ekici and Ş.Ö. Ekici (2021) applied Bayesian networks to model bribery in business transactions, offering an innovative method for analysing corruption risks. The authors emphasise that the use of mathematical models can improve the accuracy of diagnosing corruption schemes. P.F. Villar (2021) evaluated the Extractive Industries Transparency Initiative (EITI) using a Bayesian corruption indicator, noting that this methodology can be an effective tool for monitoring and assessing corruption risks in this sector. M. Gnaldi and S. Del Sarto (2024) investigate methods for measuring corruption risks in public procurement in times of emergency. Their findings highlight the importance of adaptive risk assessment models to ensure transparency in crises. J.Á. Lafuente *et al.* (2022) analysed the convergence of perceptions of corruption in different countries, identifying trends towards convergence of views on corruption risks on an international scale. Their findings highlight the importance of global cooperation in the fight against corruption.

In general, current research confirms the need to introduce mathematical models to combat corruption in public procurement but also points to the complexities and challenges associated with their practical application and the need for a closer correlation between theoretical developments and real mechanisms of public administration. The gap remains in terms of the insufficient adaptation of existing models to the real conditions of public institutions and the necessary changes in the regulatory framework to effectively integrate such methods into everyday practice.

The study aimed to explore the possibilities of using social data to diagnose corruption. The objectives of the study were to analyse key models of anti-corruption compliance; to analyse the legislation on public procurement of the Republic of Kazakhstan, to propose methodological additions

to mathematical models that would facilitate better consideration of social data in the fight against corruption in the procurement process in Kazakhstan.

Materials and methods

Regulatory and legal analysis was used to identify the key regulations that define the legal framework and processes governing procurement in Kazakhstan. Among such acts are the Law of the Republic of Kazakhstan No. 434-V “On Public Procurement” (2015), the Resolution of the Government of the Republic of Kazakhstan No. 127 “On Definition of a Special Procedure for Public Procurement” (2020), the Code of the Republic of Kazakhstan “On Taxes and Other Obligatory Payments to the Budget” (2017), Resolution of the Government of the Republic of Kazakhstan No. 269 “On Approval of the Concept of Digital Transformation, Development of the Information and Communication Technology Industry and Cybersecurity for 2023-2029” (2023).

The comparative method was used to analyse successful practices from Kazakhstan, the United Kingdom, and the United States, such as the Decree of the President of the Republic of Kazakhstan No. 802 “Anti-Corruption Policy Concept of the Republic of Kazakhstan for 2022-2026” (2022), the “United Nations E-Government Survey 2024: Accelerating digital transformation for sustainable development” (United Nations, 2024), and the Government procurement of the Republic of Kazakhstan (n.d.), which provides up-to-date information on past and current tenders. The platform allows tracking the results of tenders and identifying possible anomalies or suspicious activities, which is an important tool for analysing and forecasting corruption risks.

The study used compliance control methods based on international standards. In particular, the standard ISO 37001 (2025) was used, which was adopted in Kazakhstan. This standard regulates the implementation and maintenance of effective anti-corruption mechanisms in organisations. Additionally, the approach to risk management set out in the document Enterprise Risk Management (Committee of Sponsoring Organizations, n.d.), was analysed. This methodological tool can be used to integrate risk management into strategic planning and increase the effectiveness of control over corruption threats.

International indices are used to assess the level of corruption and the effectiveness of anti-corruption measures, including the Corruption Perceptions Index (CPI) (n.d.) published by Transparency International. This index can be used for a comparative analysis of anti-corruption policies in different countries and an assessment of the dynamics of corruption risks. In addition, the study used report of the World Bank Group (2021). To determine the impact of trust factors on the perception of corruption risks in the public sector, an analysis was conducted using data from the Bureau of National Statistics (2024), which provides relevant information for analysing and monitoring corruption risks in the country.

Results

One of the key areas in the fight against corruption in public procurement is the implementation and development of anti-corruption compliance systems. Compliance is a set of measures and procedures aimed at preventing and minimising corruption risks in public and private organisations. Modern models of anti-corruption compliance are based on

a risk-based approach, which analyses the probability of corruption depending on several factors.

One of the most widely used tools is the international standard ISO 37001 (2025). This standard is designed to create a universal system for controlling and preventing corruption in organisations. ISO 37001 provides for the development and implementation of measures to identify corruption risks and requires effective internal controls, reporting and independent monitoring mechanisms. In Kazakhstan, this standard is adapted as ST RK ISO 37001 and is recommended for application in various sectors, including public institutions. For instance, in 2020, methodological recommendations on the implementation of this standard were developed to help organisations correctly interpret and apply its requirements (Methodological recommendations for..., 2023). The practical application of ISO 37001 in the field of public procurement is confirmed by specific examples. Thus, the Joint Stock Company (JSC) “Kazakhstan Housing Company” announced a tender for a certification audit of the anti-corruption management system for compliance with ISO 37001. This demonstrates the willingness of state organisations to comply with international anti-corruption standards.

Another significant anti-corruption control model is the risk management concept proposed by the Committee of Sponsoring Organizations’ (n.d.) of the Treadway Commission (COSO). This model focuses on comprehensive Enterprise Risk Management (ERM) and includes analysing and assessing the factors that contribute to corruption. COSO suggests using a multi-layered approach to identifying corruption threats, ranging from regulatory analysis to a detailed review of an organisation’s internal processes. In Kazakhstan, the risk management concept proposed by the Committee of Sponsoring Organizations the COSO is being actively implemented to strengthen anti-corruption controls and increase the transparency of processes, including public procurement. KazMunayGas JSC (KMG) has an internal control system based on the COSO model, which includes five interrelated components: control environment, risk assessment, control procedures, information and communications, and monitoring. This system is aimed at ensuring operational efficiency, reliability of financial reporting and compliance with the legal requirements of the Republic of Kazakhstan. JSC Kazakhstan Electricity Grid Operating Company (KEGOC) has implemented and operated a risk management system based on the COSO guidance “Enterprise Risk Management” (Society of Corporate Compliance and Ethics & Health Care Compliance Association, 2020). The corporate risk management system is a key component of corporate governance aimed at the timely identification of risks, their assessment and the development of management measures, which contributes to the achievement of the company’s strategic and operational objectives.

Kazakhstan actively uses the Corruption Perceptions Index (n.d.), published annually by Transparency International, to assess and monitor the level of corruption. This index is based on expert and sociological data reflecting the perception of corruption in the public sector in various countries. In 2024, Kazakhstan ranked 88th out of 180 countries in the Corruption Perceptions Index, scoring 40 points out of a possible 100. This is an increase of 1 point compared to the previous year when the country scored 39 points. Since 2016, Kazakhstan has improved its score by 11 points, rising from 29 to 40, indicating gradual progress in

the fight against corruption. Despite the positive dynamics, Kazakhstan is still among the countries with high levels of corruption, as a score below 50 indicates significant problems in this area. To further improve the position, systemic reforms are needed to strengthen the independence of the judiciary, increase the transparency of government processes and the active participation of civil society in anti-corruption activities. In the regional context, Kazakhstan is the leader among Central Asian countries, ahead of Uzbekistan (32 points, 121st place), Kyrgyzstan (25 points, 146th place) and Turkmenistan (17 points, 165th place). However, further efforts and implementation of effective anti-corruption measures are needed to reach the level of countries with low corruption perceptions. Incorporating social data (such as survey results, social media and other sources of public opinion) into anti-corruption models such as ISO 37001 and COSO is an innovative step in the fight against corruption. Social data enables more accurate and timely identification of corruption risks, as well as helps to predict and prevent potential corruption cases.

Singapore is one of the countries actively using social data to fight corruption. For example, by analysing social media and conducting public opinion polls on the transparency of public procurement, government agencies can quickly identify suspicious activities and corruption risks. According to Transparency International, Singapore consistently ranks high in the corruption perception ranking, which is largely due to the active use of social data and technology to monitor public opinion (Thach & Ngoc, 2021). In the UK, social data has been used to assess the risks of corruption in tenders and public spending. The use of social network analysis and other data identified “dark spots” in tenders that could be associated with corruption risks. In some cases, the use of social data established links between contractors and politicians, which subsequently led to the renegotiation of public contracting decisions (Nguyen & Duong, 2022). In the US, social data is actively used to analyse corruption risks in

public procurement. Polls, opinion surveys and social media data help predict potential corruption risks associated with transparency in the management of public funds. In addition, machine learning algorithms are actively used as part of social data analysis to help identify risk patterns at an early stage (Saunoris & Payne, 2024).

According to Transparency International, 69% of the 180 countries in which corruption perceptions were analysed use social data to monitor and prevent corruption risks (Corruption Perceptions Index, n.d.). In Singapore, according to a Singapore’s Corruption Control Framework (n.d.), the use of social data in anti-corruption initiatives has helped reduce corruption in public procurement by 10% over the past 5 years. According to a World Bank Group (2021) report, 42% of countries using social data report a 25% increase in the effectiveness of their anti-corruption strategies.

One of the most significant indicators of corruption risks is the level of trust of citizens in state institutions. Sociological studies show that a high level of corruption directly correlates with a low level of public trust in government (Abikenov *et al.*, 2019; Abbasova *et al.*, 2023). If citizens do not believe in the fairness of public procurement, it indicates the presence of systemic problems that require detailed analysis. In Kazakhstan, data on trust in government bodies can be obtained from public opinion polls conducted by both government and independent analytical centres. The level of trust of Kazakh citizens in state institutions is an important indicator of the effectiveness of public administration and the fight against corruption. According to the Kazakhstan Institute for Strategic Studies under the President of the Republic of Kazakhstan (2024), the level of trust in the President of the Republic of Kazakhstan, Kasym-Jomart Tokayev, is 77.1%. However, the level of trust in other state bodies, such as the prosecutor’s office, the police and the judiciary, is significantly lower. According to the Bureau of National Statistics (2024), the share of those who trust the prosecutor’s office is 66%, the police 61.6%, and the judiciary 61.8% (Fig. 1).

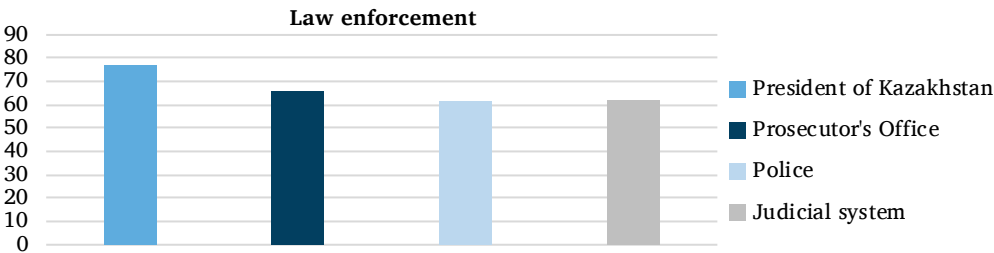


Figure 1. The level of public trust in various government agencies in Kazakhstan in 2024

Source: compiled by the authors based on Kazakhstan Institute for Strategic Studies under the President of the Republic of Kazakhstan (2024), Bureau of National Statistics (n.d.)

These data indicate the need to increase citizens’ trust in state institutions, which can be achieved through increased transparency, improved quality of services and active involvement of citizens in decision-making processes. Another important component of monitoring is indicators of government transparency. International organisations such as Open Data and E-Government are developing methodologies to assess the availability of information on public finance, procurement and expenditure. The more open government data is, the lower the probability of corruption, as public control makes it more difficult for shadow schemes to materialise. Kazakhstan has a functioning public procurement

portal, but the issue of its transparency and data availability remains relevant. The integration of international transparency standards, such as the Open Contracting Data Standard (OCDS), can significantly improve the effectiveness of anti-corruption monitoring. According to the United Nations (2024) “United Nations E-Government Survey 2024” study, Kazakhstan ranks 28th on the e-Government Development Index and 8th on the Online Services Index. This indicates a high level of e-services development and transparency in the country. In 2018, Kazakhstan moved up from 83rd to 40th place, and in 2023 it ranked 31st out of 195 countries, reflecting improvements in cybersecurity and data

protection (Resolution of the Government of the Republic of Kazakhstan No. 269, 2023).

These tools and indicators demonstrate Kazakhstan's commitment to improving the transparency and efficiency of public administration. However, further improvements will require the continued development and integration of new technologies, such as artificial intelligence, to analyse and monitor open data, as well as the active involvement of citizens in decision-making and oversight of government agencies. Content analysis of social networks and media is essential for identifying red flags indicating possible corruption risks in the public procurement system. Active discussion of tender procedures, suspicious comments and negative feedback can serve as indicators of potential violations. For instance, in 2023, the Almaty Akimat paid almost 260 million tenge for monitoring publications in the media and social networks, including analyses of criticism of the work of local authorities. It is also known that in 2022, 574,063 users were registered on the portal goszakup.gov.kz, which indicates a high level of involvement of citizens in the process of public procurement. In 2024, Almaty Akimat entered a contract for 249,600,000 tenge to procure media and social media monitoring services. The main requirements included the collection of information on the most important events affecting the development of the city, materials on problems requiring prompt response, and conducting social surveys among the population. As of 20 February 2025, the number of registered users on the public procurement portal of the Republic of Kazakhstan was 577,888 people (Government procurement of the Republic of Kazakhstan, 2022).

Analysis of open data on public procurement, taxation and revenue is an important tool for increasing transparency and fighting corruption in Kazakhstan. Access to such data allows citizens, businesses and government agencies to effectively monitor financial flows and identify potential violations. The web portal of government procurement of the Republic of Kazakhstan (n.d.) provides centralised access to information on tenders held, contracts awarded and their execution. Data on procurement plans, bidding results and contract performance reports is available on the portal. According to the World Bank Group (2023), in 2022, Kazakhstan's public expenditure is 22.5% of gross domestic product (GDP). At the end of 2022, the volume of public procurement in Kazakhstan totalled more than 5.8 trillion tenge. At the same time, 80% of purchases were made from small and medium-sized enterprises (Results of 2022..., 2023).

RBC Group (n.d.) is actively using machine learning methods to analyse public procurement data, which allows it to effectively identify anomalies and potential corruption schemes. In particular, the use of machine learning algorithms allows the processing and analysis of huge amounts of tender data, including information on participating companies, contract sizes, tender winners and their connections to government agencies. Thus, the use of social data in anti-corruption monitoring of public procurement opens up new opportunities for identifying and preventing corruption risks. The inclusion of public trust indicators, transparency indicators, media analysis and a detailed study of financial data will create a comprehensive monitoring system capable not only of recording corruption facts but also of preventing their emergence.

To improve the fight against corruption risks in Kazakhstan's public procurement system, it is possible to propose

the integration of social data and automation within the framework of existing legislative and methodological acts. One of the key methodological improvements is the integration of social data, such as survey results, citizen feedback, and content analysis of public discussions, into the public procurement monitoring system. According to the Law of the Republic of Kazakhstan No. 434-V (2015), information on tenders and winners should be open and available through the portal goszakup.gov.kz. However, to improve the effectiveness of monitoring and identifying corruption risks, it is important to integrate data on the perception of public bodies and tender procedures, as well as analysing comments and publications on social media. For instance, analysing comments on social platforms can identify suspicious patterns and red flags, such as links between bidders, which will serve as an additional indicator for deeper audits. Singapore's Corruption Control Framework (n.d.) indicated that the use of social data in anti-corruption initiatives led to a 10% reduction in corruption in tenders. This was achieved by monitoring publications and analysing negative feedback on public procurement processes. Incorporating social data into monitoring algorithms can be an important step towards predicting corruption risks.

An important part of the Decree of the President of the Republic of Kazakhstan No. 802 (2022) is compliance control, which includes monitoring and control over compliance with anti-corruption standards. Legislation requires government agencies to monitor compliance with anti-corruption standards, but for effective control to be implemented, it is necessary to address the opinions of citizens and experts, which is possible through the integration of data from social media portals and independent surveys. In this context, the creation and implementation of a platform that collects data from social media and combines it with tender data will not only identify violations but also predict corruption risks.

The Code of the Republic of Kazakhstan (2017), which regulates taxation in the field of public procurement, is also of substantial role. This code describes issues related to the tax obligations of tenderers and contractors, such as value added tax (VAT) and other mandatory payments. The tax aspects are important for the correct calculation of the value of tenders and contracts, as well as for assessing how efficiently public funds are used. To clarify and supplement the regulations in this area, various Resolutions of the Government of the Republic of Kazakhstan were also adopted, such as the Resolution of the Government of the Republic of Kazakhstan No. 127 (2020), which regulates more detailed aspects of tenders and auctions. This resolution defines the rules by which tenders, auctions and other forms of public procurement should be conducted and aims to increase their transparency and reduce administrative barriers.

The main tool for monitoring public procurement in Kazakhstan is the portal goszakup.gov.kz. This resource is used not only to publish information on tenders and contractual agreements but also to analyse procurement data. The portal provides access to detailed information on tender contract distribution and the recipients. However, the portal is not always fully used to diagnose corruption. One of the most effective ways to reduce corruption risks is to automate the processes of checking tenderers, which is already provided for in some parts of the legislation. In particular, the integration of machine learning and big data processing systems on the goszakup.gov.kz platform will allow not

only to collection of information on tenders but also to automatic identify suspicious connections and anomalies. For instance, algorithms can analyse historical data and identify similar patterns in submitted bids, which facilitates the automatic exclusion of those who may be linked to corruption schemes. In the US, the Anti-Corruption Bureau uses statistical methods, including machine learning, to analyse tender procedures and identify suspicious patterns of behaviour in government contracts. This allows for more effective detection of corruption without relying solely on the subjective judgement of inspectors (Saunoris & Payne, 2024). In 2023, the Almaty Akimat paid almost 260 million tenge to monitor media and social media publications, including analysing criticism of local government performance (Saparov, 2025). This shows an interest in using social data to monitor processes. Integrating such data into the broader context of procurement automation through machine learning systems will reduce corruption risks.

In summary, Kazakhstan's public procurement legislation already contains the foundations for ensuring transparency and minimising corruption risks. However, its current mechanisms require improvement and integration with new monitoring methods, including the use of social data and automated analysis tools. In the context of the fight against corruption in the public procurement system of Kazakhstan, key gaps in the legislation were identified that significantly limit the possibilities of effective anti-corruption monitoring. These shortcomings relate to both the insufficient use of social data to diagnose corruption risks and the lack of modern technologies to predict and prevent possible violations. In particular, the absence of systematic monitoring using artificial intelligence, as well as limited opportunities for automating the verification of procurement participants, create gaps in anti-corruption activities.

To increase the effectiveness of anti-corruption monitoring in the public procurement system using social data, several methodological additions should be made to integrate new technologies and consider behavioural factors in corruption risk assessment models. These additions can significantly improve the accuracy of diagnosing corruption schemes and increase the level of transparency in tender procedures. One of the most important steps in improving anti-corruption monitoring is to incorporate behavioural and social factors into existing mathematical models used to assess corruption risks. Currently, most models, such as the Bayes Corruption Indicator, focus on the analysis of economic, legal and operational data, but they do not consider an important social component, such as the level of citizens' trust in the authorities, the perception of corruption in society, and the behaviour of bidders. The inclusion of these factors allows for a more accurate assessment of the risks associated with corrupt behaviour. For instance, if there is a high level of citizen dissatisfaction with transparency in procurement in a region, this may be an indicator of an increased risk of corruption. Such social data can be collected through opinion polls, analysing content on social media and monitoring interactions between bidders. To integrate such factors into mathematical models, it is necessary to use approaches that combine qualitative and quantitative data, considering their mutual influence on the level of corruption (Kazbekova *et al.*, 2024).

Another important step is to use machine learning to predict possible corruption schemes. Machine learning

technologies can analyse huge amounts of data on tenders, contracts and their executors, and identify patterns that may indicate possible manipulation or corruption. Machine learning can be used to develop systems that predict high risks of corruption based on the analysis of historical tender data and identified anomalies in the procurement process. For instance, algorithms can detect a pattern of reciprocal contracts between certain bidders, identify anomalies in pricing, or detect recurring patterns among contractors that win most tenders in the same region. These predictions can be substantial for government control bodies in identifying potential corruption schemes in advance and preventing them.

Lastly, the system of red flags should be expanded to include data from social media and surveys. Red flags are signals that may indicate increased risks of corruption. In traditional practice, such flags are based on economic and legal indicators (e.g., unreasonably low or high bids in tenders, and participation in tenders by companies with dubious reputations). In the modern environment, when information from social media and online resources has become available and can be used to analyse public opinion, it is necessary to include data on public perception of corruption, the level of trust in the authorities, and reactions to public scandals and investigations in the red flag system. Analysing social media content, such as reviews of public procurement or discussions of tenders on forums, can help identify negative public perceptions of a process. For instance, if a tender involving dubious companies is frequently discussed online, or if the discussions are accompanied by allegations of corruption, this may be a signal for monitoring. The inclusion of such data in the red flag system will allow for a more effective response to potential corruption threats and timely intervention in tender processes.

Thus, methodological proposals for improving anti-corruption monitoring through social data include a comprehensive approach that combines behavioural and social factors with modern technologies such as machine learning, as well as the expansion of the red flag system to identify corruption risks more accurately and timely. These measures will help create a more effective anti-corruption control system that will consider not only economic indicators but also social perceptions and behaviour of participants in tender transactions.

To improve the effectiveness of the fight against corruption in the public procurement system in Kazakhstan and improve anti-corruption monitoring, it is necessary to refine the existing legislation by introducing several innovative mechanisms (Yelshibayev *et al.*, 2021). Recommendations to improve legal regulation will focus on the integration of modern technologies such as artificial intelligence and the use of social data to identify and prevent corruption risks. The first recommendation is to introduce mandatory analysis of social data in the public procurement system. Social data, including public opinion, levels of public trust in state institutions, as well as information from social networks and the media, can serve as an important source of information for diagnosing corruption risks. The introduction of mandatory collection and analysis of this data will allow for the consideration of public perceptions, which in turn will increase transparency and reduce the possibility of manipulation in the procurement process. Legislation should provide for the establishment of a regulatory framework for regular monitoring of social data and its use for assessing

corruption risks. This will allow for prompt responses to possible problems and improve public perception of public procurement processes.

The second recommendation is aimed at integrating AI analysis of tender feedback into the public procurement monitoring system. Modern machine learning and natural language processing technologies can be used to automatically analyse feedback from tenderers, as well as comments from citizens on social media and specialised platforms. Integration of such a tool will help identify possible signs of corruption, such as systematic price gouging or manipulation of the selection of contractors. By using AI to analyse public feedback, it is possible to more accurately determine which tenders are causing public concern or suspicion, which facilitates prompt intervention by regulatory authorities. This will also enable timely response to potential corruption schemes, improving the quality of monitoring and increasing public confidence in the procurement system.

The third recommendation is to create a national platform for predictive analytics of corruption risks. This would be a specialised online platform that would use all available data, including open databases on tenders, and financial reports, as well as data from social media and feedback from participants, to predict the probability of corruption schemes. A platform that uses machine learning and predictive analytics algorithms can effectively identify high risks in the public procurement process by predicting potential anomalies and signs of corruption. The creation of such a platform will require the development of regulations governing the collection and processing of data, as well as confidentiality and data protection issues. The implementation of this system will allow the integration of various anti-corruption control mechanisms into one convenient tool available to government agencies, law enforcement agencies and public organisations. This will increase the effectiveness of monitoring and create opportunities for more active involvement of citizens in the processes of ensuring transparency and integrity of tender procedures.

In summary, the revision of legislation to include the introduction of mandatory social data analysis, the use of AI to monitor tender feedback and the creation of a predictive analytics platform for corruption risks will significantly improve the public procurement system in Kazakhstan. These measures will not only increase the level of transparency but also make the process more predictable and controllable, minimising the risks of corruption and increasing public trust in the government.

Discussion

This study was used to identify key approaches to diagnosing corruption in the procurement system, based on modern risk modelling methods. Notably, corruption in public procurement is a complex phenomenon caused by many factors, including political competition, discretionary powers of officials, length of time in office, and the level of public scrutiny. This includes the analysis of quantitative and qualitative methods of identifying corruption risks, the use of machine learning algorithms, network analysis, and the integration of legislative mechanisms into the diagnostic process.

Overall, the results of the study expand the understanding of the relationship between corruption and public procurement, while focusing on risk patterns and legislative aspects, unlike existing studies that often limit themselves

to only one of these factors. Similarly, to studies by A. Al-fada (2019) and J. Ferwerda *et al.* (2016), the study recognises the importance of corruption for economic growth but addresses the detection of corruption in the public procurement system through the integration of risk models. In contrast to approaches that consider only the economic impact of corruption, the proposed approach is focused on creating quantitatively based tools for early warning and diagnosis of corruption. In addition, contrary to most existing studies, this study emphasised the adaptation of models to the specific conditions of national legislation and the dynamics of its changes, which allows for increased diagnostic accuracy and minimisation of false positives.

F. Cao and C. Wang (2023), and D. Coviello and S. Gagliarducci (2017) addressed the accountability and discretionary powers of officials, which is also present in this study. However, the proposed model complements these aspects with a risk modelling mechanism that allows for more accurate identification of possible points of corruption in the context of public procurement. Additionally, contrary to the studies, the model incorporates the cumulative impact of risk factors at different stages of the tender process, which increases its predictive value.

The studies of F. Decarolis and C. Giorgiantonio (2022), and M. Fazekas *et al.* (2021), dedicated to identification of corruption indicators using statistical methods, employed similar approach. However, the proposed model integrates indicators into risk models, which can be used not to identify corruption but also to incorporate legal restrictions and practices. An important difference is the development of a system of weighting factors that allows the model to be adapted to national legislation and to identify violations following regulatory requirements.

M.J.G. Rodríguez *et al.* (2022) and M.S. Lyra *et al.* (2022) analysed machine learning methods for detecting corruption in public procurement. In contrast, this study integrates machine learning algorithms within a single risk model that incorporates legal and administrative factors. Particular attention is devoted to the interpretability of the models, which allows the results of the analysis to be used as a basis for making managerial decisions and improving the regulatory framework.

The studies by R. Broms *et al.* (2019) and M. Liscandra *et al.* (2021) highlight the impact of political and tender competition on corruption risks. In the present study, these aspects are integrated with risk models, which allows identifying and mitigating corruption risks in a more comprehensive manner. Contrary to previous studies, the developed model can dynamically adapt risk parameters to changes in the political and economic situation, which ensures greater relevance of forecasts. In contrast to a study by F. Martínez-Plumed *et al.* (2019), which analysed technical solutions to detect corruption in administrative management, this study focuses on public procurement, incorporating legislative mechanisms and practices. The integration of quantitative and qualitative methods improves the accuracy of diagnostics and offers recommendations for improving the legal framework.

The study by I. Suardi *et al.* (2024) demonstrated how effective procurement management reduces corruption risks. The study constructed risk models that can be used for prediction and minimisation of corruption risks in practice, while addressing legislative aspects. In addition, the

proposed model evaluated the effectiveness of anti-corruption measures at different stages of the procurement process, which contributes to the improvement of the state control system. O.P. Vivien *et al.* (2023) used a non-linear approach to estimate the impact of corruption on economic growth. This study also incorporates economic consequences but focuses on risk modelling for early detection of corruption in public procurement. An important difference is the consideration of the multifactorial interaction between economic, legal and organisational aspects, which allows for the identification of hidden corruption schemes (Kostiuk & Iryna, 2024).

The network analysis methods proposed by O.M. Granados and J.R. Nicolás-Carlock (2021) are similar to the approach used in this study. However, the proposed model focuses on legislative factors and their impact on the procurement system. Contrary to the network methods used in other studies, the model integrates information on regulations and their changes, which allows for the legal context to be considered when analysing corruption risks. Analysis by L. Xie *et al.* (2019) emphasises the importance of public participation in the accountability of public projects. The study considers public participation as one of the elements of the risk model, along with legislative and administrative aspects. In addition, the model incorporates the dynamics of public control and its impact on the level of corruption risks at different stages of the procurement process.

Thus, the study comprehensively integrated risk models, legislative aspects and procurement management practices, which provides a more accurate and effective approach to diagnosing and preventing corruption in the public procurement system. The comprehensive approach ensures high adaptability of the model to changes in legislation and economic situation, which is efficient in increasing transparency and efficiency of public procurement.

Conclusions

Risk modelling with social data in the public procurement system is an important and necessary step to effectively fight

corruption. The inclusion of social data, such as public opinion, levels of public trust in government institutions, as well as content from social networks and the media, significantly improves the diagnosis of corruption risks. These data can not only improve the accuracy of existing corruption assessment models but also provide additional sources of information to identify hidden threats that traditional economic and legal data cannot capture. Social data is central in creating more dynamic, sensitive and adaptable monitoring systems, allowing for timely response to changes in public perception or behaviour of tenderers.

Practical application of the proposed methodological approaches, integration of social data and modern technologies, such as artificial intelligence, in the monitoring of public procurement opens opportunities to increase transparency and efficiency of anti-corruption mechanisms. The introduction of machine learning systems for predicting corruption schemes and automatic analysis of social data not only identifies risks more quickly but also prevents them before developing into corruption scandals. The use of such tools can improve government agencies, as well as increase public and business confidence. Moreover, the development and implementation of a national platform for predictive analytics of corruption risks will create an integrated system that will not only use current data but also predict possible threats, thus improving the quality of public procurement management.

Prospects for further research include an in-depth analysis of the relationship between social data and economic indicators, as well as expanding the use of big data technologies and neural network algorithms. It is necessary to continue researching the impact of tenderers' behaviour and public perception of corruption risks.

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Conflict of interest

None.

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Моделювання ризиків як спосіб діагностики корупції в системі закупівель: практика та законодавство

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Анотація. Дослідження мало на меті проаналізувати методи моделювання ризиків для діагностики та запобігання корупції у державних закупівлях. Методи дослідження передбачали аналіз чинного законодавства Казахстану у сфері державних закупівель та поглиблене вивчення кейсів, які ілюструють реальний досвід впровадження методів діагностики корупції у цій сфері. У контексті посилення боротьби з корупцією в Казахстані наголошено на державних і муніципальних системах закупівель. Одним із методів діагностики корупційних ризиків у таких системах є моделювання ризиків, яке допомагає виявити потенційні недоліки та зловживання в процесі проведення тендерів та закупівель. У дослідженні визначено основні фактори, що сприяють корупції в системі державних закупівель, і запропоновано рекомендації щодо вдосконалення законодавчих та організаційних механізмів для підвищення прозорості та підзвітності тендерного процесу. Дослідження виявило ключові фактори, що сприяють корупції в системі державних закупівель Казахстану, включаючи недостатню прозорість тендерних процедур, відсутність ефективних механізмів контролю та змову між учасниками тендеру. Проведено аналіз чинного законодавства Казахстану у сфері державних закупівель та виявлено нормативні прогалини, які перешкоджають запобіганню корупції. Запропоновано рекомендації щодо вдосконалення правового регулювання з урахуванням міжнародного досвіду та стандартів. Ключовий висновок полягає в тому, що моделювання ризиків набуває суттєвого значення в боротьбі з корупцією, оскільки дозволяє заздалегідь прогнозувати та усувати можливі загрози, тим самим підвищуючи ефективність системи державних закупівель. Практичне застосування запропонованих методологічних підходів, інтеграція соціальних даних та сучасних технологій, таких як штучний інтелект, у моніторинг державних закупівель відкриває можливості для підвищення прозорості та ефективності антикорупційних механізмів.

Ключові слова: контроль відповідності; засоби цифрового аудиту; запобігання шахрайству; ефективність контролю; прозорість