Using Digital Tools in Government Procurement Analysis: Detecting Suspicious Purchases with Control Indicators

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Abstract. This article presents the results of a study on the use of digital technologies in analyzing government procurement to identify suspicious transactions. The study collected and analyzed data related to government procurement, employing statistical methods and digital tools, including the Marker-Interfax monitoring and procurement analysis system. The authors conducted correlation-regression analysis, including the construction of a linear regression model, as well as multiple regression models, specifically logarithmic, linear-logarithmic, and logarithmic-linear models. Additionally, a classification analysis was performed. The focus was on control indicators to identify potentially suspicious procurements. The study began with an analysis of existing literature and the legislative framework in government procurement, as well as IT and analytical tools used in this field. Data selection involved analyzing procurement data from the past two years in the financial services sector for government customers in St. Petersburg, Russia. Procurement data was analyzed using 140 control indicators, compiling a classification of risk groups and providing comprehensive characteristics for each group. Additionally, analysis was conducted on the number of submitted bids, initial maximum contract price, and contract price reduction for each risk group. A correlation-regression analysis identified the key factor influencing the increase in control indicators signaling potential violations in procurement procedures. In conclusion, this study confirms that utilizing digital technologies and tools can effectively detect suspicious transactions and enhance transparency and efficiency in the procurement process. The findings are valuable to government agencies, researchers, and professionals combating corruption and optimizing budgetary resource utilization.

Keywords: Contract system; Digital technologies; Digitization; Information resources; Public procurement

1. Introduction

In the rapidly evolving digital era, technology is becoming increasingly important for government entities. The digital transformation and implementation of modern digital technologies encompass virtually all industries, particularly in the realm of government procurement. Digitization in the procurement system allows for the expansion of market boundaries, attracting a greater number of procurement participants and ensuring principles of openness and transparency in information. Digitization also opens up new, more efficient possibilities for both pre- and post-contract monitoring. Additionally, it

enables the expansion of analytics for large volumes of data.

Scientists from around the world are studying the impact of digitization on government processes. For instance, Berawi *et al.* (2021) proposed a blockchain-based data storage system model to improve the organizational performance of government agencies. This model leverages blockchain technology to improve transparency, security, and efficiency in government processes.

In her interview titled "Public procurement digitalisation: a step forward or two steps back?", Halonen (2019) argues that considering the current trends in digital procurement, it is necessary to not only ponder the opportunities that these technologies bring, but also the problems that arise from increased transparency and the consequences of this procurement management approach.

Tayler, Langburd, and Wright (2018) highlight the existence of a digital divide between countries worldwide, particularly in the field of government procurement. While some countries lack even a portal to publish information on government contracts, others, such as OECD countries, are utilizing artificial intelligence and blockchain. For countries adopting these new technologies, their government procurement processes become more efficient, and they experience increased business opportunities. This growing divide underscores the fact that other countries still have to catch up on what they have missed.

The article "Digital Economy and Technology Development" written by Zagloel *et al.* (2021) highlights the importance of innovative digital technologies in balancing economic advancement and environmental regeneration. Furthermore, the article emphasizes that innovation diffusion processes are causing structural changes in different economic sectors and reshaping economic systems.

Another relevant study by Rytova *et al.* (2020) assessed the maturity level of the digital government of Saint Petersburg. The authors examined various aspects of the city's digitalization efforts. The findings of this study can provide valuable insights into the challenges and opportunities associated with digital government initiatives.

In recent years, several studies have focused on the development and implementation of digital tools, particularly in government procurement analysis. These studies highlight the significance of digital tools in government procurement analysis and emphasize the need for continuous research and development in this field. The integration of digital technologies has the potential to revolutionize procurement processes, enabling greater transparency, efficiency, and effectiveness. However, it is essential to address the digital divide between countries and ensure that all governments have access to the necessary tools and resources to leverage the benefits of digitalization in their procurement practices.

In the article "Development of digitalization in the procurement contract system" by Holkina and Shvets (2019), the authors highlight the significance of digital transformation and the adoption of modern digital technologies in the procurement system. These advancements enable the market to expand beyond geographical boundaries, attract more procurement participants, promote healthy competition, and uphold the principles of openness and transparency in sharing information about the procurement contract system.

Degtev (2020) explores the topic of digitalization and procurement management in his study titled "Digital Transformation of Moscow's Procurement Sphere". In addition, Degtev, Gladilina, and Labutina (2020) analyze the impact of digitalization on management, emphasizing the need for legislative changes and updated management tools. In the works of Prokhorov and Samoilov (2019), an analysis of the positive effects on competition in the public procurement market when implementing digital tools is presented. The authors also argue that the development of competition should be based on stimulating public control, adjusting antitrust regulation, developing innovations, and purchasing targeted effects.

Mainly, scientific publications focus on theoretical and normative-legal issues. In addition, the issue of digitalization of government procurement is addressed in the normative documents of governments of various countries and international organizations.

According to the European Commission's Procurement Strategy (European Commission, 2017), the digitization of procurement can enhance transparency in the internal market, providing businesses with the opportunity to learn about business prospects, facilitating access to public tenders and disseminating information about the awarding of government contracts.

In accordance with the EU public procurement directives, electronic submission of tender applications became mandatory in October 2018. Various accompanying regulations and standards have been developed for this purpose, such as eCertis, the European Single Procurement Document (ESPD), the European Standard for eInvoicing, and tools to facilitate digital transformation of procurement at different levels in accordance with Directive 2014/24/EU of the European Parliament and Council (European Parliament and Council , 2014).

Undoubtedly, the digitization of public procurement requires continuous identification and analysis of problem areas in the digital transformation of these processes. This includes issues related to the compatibility of software solutions such as eIdentity, eSignature, eDelivery, and eInvoicing, as well as the establishment of corresponding policies, skills, and collaboration among stakeholders necessary for the effective implementation of reforms.

Overall, the literature review on using digital tools in government procurement analysis provides a comprehensive understanding of the current state of research and highlights the importance of further investigation into this area. However, specific research on the utilization of digital technologies in the analysis of public procurement for detecting suspicious transactions is not readily available in the public domain.

The contribution and novelty of this article lie in several aspects. Firstly, it provides a comprehensive analysis of government procurement data using a wide range of control indicators. By considering 140 control indicators, the authors were able to classify risk groups and provide detailed characteristics for each group, including information on control indicators, economic activities, customer levels, and types of trades associated with each risk group. This level of granularity allows for a more targeted and efficient detection of suspicious transactions.

Secondly, the article conducts an analysis of the number of submitted bids, initial maximum contract price, and contract price reduction for each risk group. This analysis provides insights into the patterns and trends associated with potentially suspicious procurements, further enhancing the ability to detect and prevent corrupt practices.

Furthermore, the article goes beyond just data analysis and adds value by conducting a correlation-regression analysis to identify the key factors influencing the increase in control indicators signaling potential violations in procurement procedures. This analysis helps to identify the underlying causes and drivers of suspicious transactions, enabling policymakers and practitioners to address these issues more effectively.

2. Methods

In this study, the authors focused on control indicators that can be used to identify potentially suspicious procurements. These control indicators were selected based on a thorough analysis of existing scientific literature and the legislative framework in the field of government procurement. The authors also considered information technology and analytical tools commonly used in this field.

To collect the necessary data for analysis, the authors selected procurement data from

the past two years in the financial services sector for government customers in the city of St. Petersburg, Russia. This specific sector and location were chosen to provide a focused and relevant dataset for the study.

Given the vast amount of information, it was not feasible to explore all industries. Therefore, one industry was chosen - the financial services sector. The rationale for selecting this industry is outlined in the following section of the study, but the decision was also influenced by the authors' research interests.

The study was conducted in accordance with the main Federal laws in Russia regarding public procurement - 44-FZ (which regulates the procurement process for goods, works, and services to meet the needs of the government and municipalities, including contract formation and execution) and 223-FZ (which regulates procurement by specific types of legal entities).

The time period from 2021 to 2022 was chosen as a temporary constraint to reflect current statistics (the year 2020 was excluded due to numerous temporary legislative changes during the COVID-19 period). Procurement methods were not restricted.

However, the scope of the examined customers was limited to the delivery location - the city of St. Petersburg. This city was selected because the study was conducted based on the Department for Combating Cartels of the Federal Antimonopoly Service in St. Petersburg.

An analysis of the procurement data was conducted using 140 control indicators. These indicators were carefully chosen to cover a wide range of potential risk factors and suspicious activities. They included factors such as the number of submitted bids, the initial maximum contract price, and contract price reduction.

Based on the analysis of the procurement data, the authors compiled a classification of risk groups and provided comprehensive characteristics for each group. This included information on which control indicators, types of economic activities, levels of customers, and types of trades were characteristic for each risk group. This classification and characterization of risk groups can help government agencies and professionals better understand and target their efforts in identifying suspicious transactions.

In addition to the analysis of the procurement data, the researchers conducted a correlation-regression analysis to identify the key factor influencing the increase in the number of control indicators signaling potential violations in procurement procedures. This analysis helps to identify the underlying factors that contribute to suspicious transactions and provides valuable insights for improving the detection and prevention of corruption in government procurement.

3. Results and Discussion

Brief description of the procurement system. In Russia, starting from January 1, 2019, all purchases, with rare exceptions, have transitioned to electronic format. Now, any participant can take part in a tender from anywhere in the world: to participate, they simply need to complete a free registration on the EIS portal, select the desired procurement, and participate through electronic trading on the electronic platform.

The procurement system of the Russian Federation, as it exists today, has been in effect since 2014 and is regulated by the Federal Laws "On the contract system in the sphere of procurement of goods, works, services for ensuring state and municipal needs" of April 5, 2013, No. 44-FZ, and "On procurement of goods, works, services by certain types of legal entities" of July 18, 2011, No. 223-FZ. It is worth noting that since the introduction of the aforementioned laws, they have been transformed and amended several times, taking into account the peculiarities of the Russian economy, as well as the needs of society and

businesses, with the aim of increasing the efficiency of the use of the government contract system.

Federal Law (2013) 44-FZ outlines the primary types of competitive procedures, namely auctions, competitions, and requests for quotations. These procedures can now be conducted electronically. Federal Law (2011) 223-FZ permits the use of alternative procurement methods as established by the customer in their Procurement Regulations.

Let us examine the principal types of competitive procedures. An auction entails selecting a winner based on the criterion of price. The participant who offers the lowest cost for contract execution emerges as the winner. Auctions, being straightforward, are the most commonly employed procurement method. For requests for quotations, the price criterion also determines the winner. The participant who offers the lowest price for immediate execution secures the victory. However, restrictions on contract value and annual purchasing volume apply to this procurement method. In the case of a competition, non-price criteria assume a paramount role, and the victor is determined by the participant who presents the best contract execution conditions. Qualification of the participant also significantly influences the outcome in competitive bidding.

Selecting a specific sector of the national economy for research is essential in order to meet the national priorities as stated in Presidential Decree No. 400, which was issued on July 2, 2021, and pertains to the Strategy for National Security of the Russian Federation. One of these priorities is ensuring the economic security of the state. In order to achieve this goal, it is necessary to address tasks such as strengthening the financial system of the Russian Federation, developing the national infrastructure of financial markets, including payment infrastructure, reducing dependence on third countries in this sphere, expanding the practice of settlements with foreign partners in national currencies, reducing the outflow of financial assets abroad, and combating illicit financial operations.

Therefore, the financial services market is crucial to the country's economy. It is important to effectively identify and prevent violations in procurement procedures for financial services.

Choice of the industry of the national economy for research. Ensuring the economic security of the state is one of the national priorities of the Russian Federation, according to the Decree of the President of the Russian Federation of July 2, 2021, No. 400 "On the Strategy of National Security of the Russian Federation". One of these priorities is ensuring the economic security of the state. In order to achieve this goal, it is necessary to address tasks such as strengthening the financial system of the Russian Federation, developing the national infrastructure of financial markets, including payment infrastructure, reducing dependence on third countries in this sphere, expanding the practice of settlements with foreign partners in national currencies, reducing the outflow of financial assets abroad, and combating illicit financial operations.

Therefore, the market for financial services is one of the most important components of the country's economy. It is crucial to ensure effective identification and prevention of violations in the procurement procedures for financial services.

Information technology for the search, analytics, and monitoring of government procurement. Information systems in the field of government procurement, which are widely used by both clients and suppliers, include software products such as Marker-Interfax, Tenderplan, Bicotender, Konutr.Zakupki, SberA (Sberbank-AST) analytical portal, and others. These information systems empower participants in government procurement to efficiently search, analyze, and monitor nearly all existing tender procedures. They ensure transparency and openness in the implementation of government procurement.

The Marker-Interfax program is a market procurement monitoring and analysis system

that consolidates and analyses data on procurement, clients, and suppliers from over 300 trading platforms.

The Tenderplan provides the opportunity to search for tenders and perform comprehensive analysis of the selected sample, the customer, the supplier, and the relationships between them. It also supports collaborative work on the platform and is a cloud-based service.

On the other hand, Bicotender offers the ability to search for targeted tenders and includes a module for industry analysis, suppliers, and customers. It provides an API service for integrating the tender system with CRM systems.

Konutr.Zakupki is an information system specialized in searching for government and commercial procurement on various platforms. It allows for the analysis of customers and suppliers.

The SberA analytical portal provides a wide range of analytical information on government procurements, including statistics, market analysis, and decision-making support.

These information systems greatly enhance the work of customers and suppliers involved in government procurement by enabling them to easily access information and analyze market conditions. Additionally, they promote transparency and openness in government procurement and enhance market competitiveness.

In the context of this study, the search and analysis of information on government procurement were conducted using an automated program called Marker, which was developed by Interfax. The results of the analytical study are presented below.

Correlation-regression analysis. With the aim of identifying factors that influence the increase in the number of control indicators signaling potential violations in the provision of financial services procurement procedures, excluding insurance and pension provision services (OKPD2 - 64), a correlation regression analysis was conducted. The independent variables selected were the initial maximum contract price (NMC), type of tender, number of submitted bids, and the customer's field of activity. Multiple regression models were constructed using the Stata software program.

The initial hypothesis suggested that the increase in the contract value (NMC) has the greatest influence on the increase in the number of "suspicion" indicators in procurement. However, the obtained multiple linear regression model does not yield satisfactory results. Four selected variables in the model are statistically significant, but they only explain 13% of the variance in the number of control indicators. The residual plot, Cook's and Vaisberg's tests, as well as the White test indicate the heteroscedasticity of the residuals in the model. Partial residual plots for linearity show a non-linear relationship between the number of control indicators and the factors under investigation. Furthermore, the model specification test suggests there are specification errors, hence rendering the coefficient estimates for the variables inconsistent. The results of the Shapiro-Wilk and Shapiro-Francia tests indicate that the residual distribution does not follow a normal distribution.

Consequently, the linear regression model does not sufficiently describe the relationship between the number of control indicators and the examined indicators. Building other multiple regression models, namely logarithmic, linear-logarithmic, and logarithmic-linear, also yield unsatisfactory results.

Classification analysis. Taking into account a large number of indicators of "suspiciousness" in procurement procedures, all analyzed procurements were divided into three risk groups. The first group included 692 procurements with one to three indicators. The second group consisted of 158 procurements with four to seven indicators. The third and most risky group consisted of 14 procurements with eight to ten indicators.

Next, the indicators characteristic of each risk group were identified. In all three groups, the majority of procurement procedures contained indicators such as "Request for clarification of provisions in the documentation" and "Some documents are unavailable for search". For the least risky procurements, which made up the first group, a distinguishing feature was a high proportion, specifically 10.65% of the total number of procurements in this group, containing the control indicator "Participant's reduction exceeds 25%". Additionally, in the first and second groups, there is a significant proportion of procedures, amounting to 10.65% and 12.57%, respectively, that have the indicator "Contract savings exceed 25%". Analysis of the control indicators for the highest-risk procurement procedures has revealed that in this group of procurements, there is a high proportion of procedures (11.48% of the total number of third group procurements) that have the indicator "Contract price increased under the Federal Law (2011) 44 (Code of Administrative Offenses)", whereas in other groups, their percentage is significantly lower. For this group, the indicators "Penalties, fines for the contract with the supplier under the Federal Law (2011) 44" (9.84% of the total number of third group procurements), "Partial termination by mutual agreement under the Federal Law (2011) 44" (9.02% of the total number of third group procurements), and "Existence of non-participating applications " (8.02% of the total number of third group procurements) are characteristic. Additionally, only in the third-risk group are there procurements that contain the control indicator "Participant included in the Register of Unreliable Suppliers (evasion of contract conclusion)" (4.92% of the total number of third group procurements).

The research analyzed the economic activities of customers based on the OKVED classification, which corresponds to each risk group. It was found that the procurement activities of customers mainly involved in healthcare services posed the highest risk. This OKVED category was one of the most frequent across all risk groups, accounting for 27.89% of the total customers in the first group, 64.56% in the second group, and 14.29% in the third group. Additionally, it is worth noting that within the first risk group, 39.31% of customers were involved in activities corresponding to the OKVED category "Provision of electrical energy, gas, steam, and air conditioning". Furthermore, in the third risk group, which consisted of customers engaging in the riskiest procurements, a majority of them were involved in activities corresponding to the OKVED category "Land and pipeline transportation activities" (85.71% of the total customers in the third group).

At the next stage, an analysis of the levels of organizations that act as customers was conducted within each risk group. As a result, it was found that such organizations are most commonly affiliated with the level of a regional of the Russian Federation (54.77% of the total number of organizations in the first risk group, 81.29% of the total number of organizations in the second group, and 100% of the organizations in the third group). Procurements with indicators are less frequently carried out by customers belonging to the municipal level. Further analysis of the types of trading in the studied procurement procedures allowed us to conclude that the most common method for these procurements was through electronic auctions (70.81% of the total number of procurements in the first risk group, 96.20% of the total number of procurements in the second group, and 100% of the procurements in the third group). At the same time, 10.84% of the procurements in the least risky first group were conducted with a sole supplier.

Furthermore, the study also investigated how the contract price decreased during procurement procedures in each risk group. For further analysis, data preprocessing was conducted, and instances with missing values for terms were removed. As a result, procurement in the first risk group mainly had a reduction ranging from 6% to 25% (38.77% of the total number of procurement in the first group), while the majority of

procurement in the second group had a decrease ranging from 25% to 50% (52.87% of the total number of procurement in the second group). On the other hand, the overwhelming majority of procurement in the third group, which had the highest number of control indicators, were carried out with a reduction of only up to 2% (64.29% of the total number of procurement in the third group). The results are presented in Table 1.

Table 1 Analysis results of procurement risk groups based on price reduction (Compiled by the author)

Price reduction	I group		II group		III group	
	number of procurement	%	number of procurement	%	number of procurement	%
up to 2%	188	31.28%	19	12.10%	9	64.29%
up to 6%	51	8.49%	15	9.55%	3	21.43%
up to 25%	233	38.77%	31	19.75%	2	14.29%
up to 50%	102	16.97%	83	52.87%	0	0.00%
up to 75%	20	3.33%	7	4.46%	0	0.00%
more than 75%	7	1.16%	2	1.27%	0	0.00%

While analyzing the number of applications submitted for the procurement procedure in each risk category, it was observed that for the least risky procurements, the range of applications varied from 0 to 2 (constituting 59.39% of the total number of applications in the first group). In the second risk category, the most common range of applications is 3 to 5 (56.96% of the total number of applications in the second group), and in the third risk category, it is 6 to 16 applications (42.86% of the total number of applications in the third group). The results are presented in Table 2.

Table 2 Analysis results of procurement risk groups based on the number of submitted applications (Compiled by the author)

Number of applications submitted	I group		II group		III group	
	number of procurement	%	number of procurement	%	number of procurement	%
0	98	14.16%	-	-	-	-
1	110	15.90%	18	11.39%	2	14.29%
2	203	29.34%	50	31.65%	2	14.29%
3	142	20.52%	68	43.04%	-	-
4	63	9.10%	10	6.33%	-	-
5	52	7.51%	12	7.59%	4	28.57%
6	7	1.01%	-	-	-	-
7	-	-	-	-	6	42.86%
16	17	2.46%	-	-	-	-

Furthermore, the analysis of the NMC in each risk category showed that the majority of procurements in the first and second groups have an NMC ranging from 1 million to 100 million roubles (49.86% and 44.94% of the total number of procurements in the first and second groups, respectively) (see Table 3).

In addition, a significant proportion of procurements in these groups have an NMC up to 500 thousand roubles (21.39% and 24.86% of the total number of procurements in the first and second groups, respectively). Meanwhile, in the third risk category, procurements with an NMC ranging from 100 million to 500 million roubles predominate (42.86% of the total number of procurements in the third group), as well as a significant proportion of procurements with an NMC ranging from 500 million to 1 billion roubles (28.57% of the total number of procurements in the third group).

Table 3 Analysis results of procurement risk groups based on the NMC (Compiled by the author)

NMC, rub.	I group		II group		III group	
	number of procurement	%	number of procurement	%	number of procurement	%
up to 500 K	148	21.39%	39	24.68%	0	-
up to 1 M	53	7.66%	21	13.29%	2	14.29%
up to 100 M	345	49.86%	71	44.94%	0	-
up to 500 M	74	10.69%	13	8.23%	6	42.86%
up to 1 B	37	5.35%	4	2.53%	4	28.57%
more than 1 B	35	5.06%	10	6.33%	2	14.29%

Control authorities in the field of public procurement should pay attention to procurement procedures that exhibit the following characteristics:

- The presence of control indicators such as "request for clarification of provisions in the documentation", "Bidder (winner) offers a reduction exceeding 25%" / "Contract savings exceed 25%", "Some documents are not searchable", "Partial termination by mutual agreement under Federal Law (2011) 44-FZ".

- The customer is engaged in activities corresponding to the OKVED codes "Healthcare activities", "Education", "Land and pipeline transportation activities", "Electricity, gas, steam and air conditioning supply".

- The procurement procedure was conducted through electronic auctions or with a single supplier.

- The procurement process involved 2-3 applications.

4. Conclusions

In conclusion, this study has demonstrated the relevance and promise of utilizing digital technologies and tools for analyzing government procurement through control indicators. The findings indicate that digitization positively impacts the transparency of procurement procedures and enables more effective analysis and monitoring. The investigation has provided valuable insights into potentially suspicious government procurement in the financial services sector of Saint Petersburg, which can be utilized by regulatory bodies. While there are some limitations, such as the need to improve the classification of risk groups and data processing, this study presents significant opportunities for future research. The approach can be applied to other regions and sectors, allowing for a more comprehensive understanding of how digital technologies can enhance government procurement analysis. Furthermore, the implementation of a machine-learning model for detecting suspicious procurements and the establishment of an automated system will further enhance transparency and efficiency in government procurement, mitigating the risk of corrupt practices. Ongoing research in this field will contribute to the development and implementation of innovative technologies and tools that effectively combat potential violations and promote transparency in government procurement.

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