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Evaluating Public-Private Partnership Dynamics: the Kazakhstan Toll Road Case

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Abstract

The holistic collaboration between the government and business through public-private partnerships (PPPs) is crucial in developing economies in transition. With the help of the PPP mechanism, emerging economies realize new and maintain existing social and economic infrastructure projects in education, energy, transportation, and healthcare. This lessens the funding burden on the state budget and attracts private investment and expertise into the economy. However, one of the critical tasks is to engage a suitable private partner with whom a long-term relationship can be built for mutual benefit. The most vital issue in establishing and maintaining the PPP collaboration with such a partner is related to the appropriate management of business risks. This study focuses on the success of an infrastructure project for a private partner by analyzing the critical risks inherent in PPP projects. The research uses system dynamics (SD) modeling, which qualitatively and quantitatively determines how each risk affects the project realization. The study examines the largest PPP project in Central Asia, the Big Almaty Ring Road. This toll road project is taken as a case to demonstrate the impact of the most critical risks on the success of the PPP projects. For the simulation, the "hard tolls" form, which is one of the popular payment mechanisms in the global PPP practice, is considered where the private partner bears most of the risks. The findings show the riskiness of such a payment mechanism in implementing toll road projects with existing traffic and tariffs under conditions of uncertainty typical for Kazakhstan and other similar developing countries.

Keywords: Economics, Economic Infrastructure, Project Management, Public-Private Partnership, Risk, System Dynamics, Toll Road

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1. INTRODUCTION

Attracting private investment and resources through public-private partnerships (PPPs) is becoming an increasingly popular method of infrastructure development in developing countries (Wang et al., 2019; Charman & Narbaev, 2017). This practice of long-term partnership between the government and private business allows to reduce the budget load on the government, successfully manage socially essential projects, and increase efficiency in the renovation and maintenance of infrastructure facilities due to the professionalism and experience of the private sector (De Marco & Narbaev, 2021). Also, implementing infrastructure projects through the PPP mechanism allows for the most optimal distribution of risks among all participants in implementing PPP projects (Castelblanco et al., 2024). Therefore, proper qualitative and quantitative risk assessment in long-term PPP projects at the project negotiation stage plays a crucial role in risk allocation between private and public partners, where traditional risk assessment methods may not always be practical (Boateng et al., 2012).

In Kazakhstan, PPP was enacted in the early 2000s to attract private financing, build management capacity, and fill a niche in the infrastructure development gap (Law on PPP, 2015). As of January 01, 2023, there are 1,244 PPP projects in the country (of which are being implemented – 1055, at the bidding stage – 189) valued at 2,522.4 billion tenges. Most of these projects are in the social sector, including education, healthcare (hospitals, sports, and recreation centers), housing and communal services, and large-scale transport and road infrastructure projects. To stimulate PPPs, the state is implementing several strategic initiatives. For example, under the initiative related to the establishment of competence centers for Industry 4.0 of the strategic development plan of the Republic of Kazakhstan until 2025 (Kazakhstan PPP Center, 2023), the government plans not only to modernize economic infrastructure with local and foreign developer companies but also based on this infrastructure, to create competence centers to facilitate further industrial production. In addition, under the initiative related to the development of PPP and attraction of private investment into education, it is planned to create new or modernize existing infrastructures in education. The most important strategic document of Kazakhstan, Strategy "Kazakhstan-2050" (Akorda, 2012), in addition to the above, aims to improve entrepreneurship and increase the competitiveness of the local market through PPPs.

However, the management of PPP projects encounters multiple risks, such as inefficient project delivery, immature regulatory framework, poor concessionaire selection, complexity in attracting investment, lack of government guarantee, and vague technical-economic specifications of projects (Narbaev et al., 2020). In addition to such poor risk management, the government and PPP participants do not adequately consider the capabilities of critical success factors, which can increase the successful completion of PPP projects.

The current study aims to analyze the risks peculiar to PPPs in delivering infrastructure projects. To achieve its purpose, the study employs the system dynamics (SD) modeling, which helps to understand the risk dynamics. The SD method is a simulation approach to model the risks pertinent to the PPP projects. SD, created at MIT in the 1950s by Jay Forrester, is a method of computer modeling complex systems' actions and behavior. It studies the dynamic relationships of constantly changing variables, flows, and levels linked by feedback loops, constituting a system of circular causes and effects (Sterman, 2000). The case of the toll road project from Kazakhstan is used to demonstrate the applicability and practicability of the proposed model.

The concession agreement for the toll road case project included an "availability payment" mechanism, where the government bears the risks for user demand and the optimal tariff. On the other hand, this study using SD will examine the risks for the SPV under the scenario of

implementing the “hard tolls” mechanism to demonstrate the project’s profitability for private investors in a specific investment environment.

The study brings original contributions to the PPP literature. The proposed methodology, based on the SD simulation, can be used to solve the problems related to a comprehensive assessment of risks, which would enhance the likelihood of the successful completion of PPP projects in developing countries. The study models can help assess the impact level of various risks for the more effective operation of a particular purpose vehicle (SPV) company in delivering PPP projects. In such large projects, the consortium members establish an SPV, which manages all processes at all stages of PPP project delivery, assuming financial, legal obligations and risks under the signed concession agreement (Mittal et al., 2023).

The paper is structured as follows. Next, the pertinent literature on PPPs and SPV performance risks is reviewed. Then, the study methodology is presented, including the toll road PPP project case, the selection of the risks for the study, and the input data for the SD simulation. The following section presents the simulation results and discusses the study's main findings. Lastly, the conclusion section summarizes the study and highlights the future research directions.

2. LITERATURE REVIEW

In the last decade, there has been an increase in research in PPP in social (economics, finance, public administration, project management) and engineering (construction engineering, transport engineering) sciences, both globally (Chou & Pramudawardhani, 2015; Osei-Kyei & Chan, 2015; Hodge & Greve, 2017; Narbaev et al., 2020) and in Kazakhstan (Chikanayev, 2016; Mouraviev & Kakabadse, 2017; Oinarov et al., 2019). The international academic experience suggests that the three main areas of research in the field circumvent the assessment of risks and critical success factors for effective risk allocation between the owner (public authority) and the private partner (Bing et al., 2005). Also, the literature emphasizes the need to study an SPV organization’s economic and management aspects. In this regard, the SPV organization is responsible for constructing and operating a PPP infrastructure project, therefore allowing for the successful completion of a PPP agreement with the government.

The most critical research issue in the literature was understanding the nature of PPP project risks. So, the study by Boateng et al. (2012) examined the main social and environmental risks affecting the construction of megaprojects using the Edinburgh Tram Network project as an example through a case study. In their empirical study, Nasirzadeh et al. (2008) analyzed risks in construction projects using SD modeling.

Second, the emphasis was on critically analyzing critical success factors in PPPs. Ahamd et al. (2018) studied successful PPP projects in Malaysia and noted that some of the essential issues for SPV are meeting construction deadlines and not exceeding construction and operating costs. Meeting construction timelines is significant because cash flow for the SPV as user fees starts when the facility is commissioned. At the same time, debt repayments must be made at a particular time, regardless of the start of service delivery. Cost overruns or high operating costs (which may result from design errors or poor-quality construction) also significantly impact cash flow and profitability, as the SPV bears all additional fees and is usually not reimbursed by the owner.

Lastly, another line of research was around understanding the successful operation of the SPV organization, which is the primary stakeholder in the PPP agreement with governments. To understand the vital critical tasks of an SPV, Sainati et al. (2020) investigated economics and management functions in delivering infrastructure megaprojects. Conversely, Alasad and Motawa (2015) analyzed large PPP infrastructure projects that did not achieve the expected outcome. A 3.6 km long tunnel project in Sydney (Lane Cove Tunnel) was found to be

unprofitable and sold to a new operator after three years. The reason for the loss was low traffic, with approximately 50,000 actual users against 120,000 in the original estimates. Another example is Sydney Cross Tunnel, which opened for general tolling in August 2005 and was declared insolvent in December 2006. Actual traffic was 30 percent less than the original forecasts.

Among the approaches used to understand the dynamics of PPP project realization, SD modeling, which involves a simulation, has received significant attention (Alasad et al., 2013). This tool is widely used in modeling complex economic and business systems such as infrastructure projects and megaprojects (Boateng et al., 2012). For example, Castelblanco et al. (2024) proposed an SD framework with causal diagrams of Kazakhstan's PPP portfolio as a closed-loop system where different variables, such as social attractiveness, economic growth, and infrastructure shortage, interact. The authors noted from the analysis that private investors submit most PPP projects as unsolicited proposals, which may not meet the needs and direct interests of the public partner. Also, using the SD approach, an analysis of the real estate market of Almaty was undertaken, where Jumasseitova et al. (2023) found that such factors as economic growth, infrastructure development, demographic dynamics, government policy, and bank interest rate critically influence the real estate market and housing costs.

Our brief literature review of the PPP market shows a lack of knowledge to investigate risks and critical success factors, specifically in emerging markets like Kazakhstan. There are also insufficient studies at the micro-level (aimed at studying the SPV company itself and the PPP project), in contrast to studies at the macro-level (PPP market analysis, PPP public administration issues). Therefore, in the current paper, the SD approach is used to close this research gap and bring an original contribution to the PPP literature by understanding the relationship between various risks and critical success factors that can have a positive or negative impact on the success of the SPV company which realizes a PPP project. In the long term, a proper understanding and management of risks and critical success factors in delivering social and economic infrastructure contribute to the economic development of a country. The expected economic effects can be related to a more rational use of budgetary funds, a reduction in the financial burden on the government, the adoption of foreign experience in PPP management, and the implementation of projects on time and within the budget.

3. Methodology

The toll road case

The Big Almaty Ring Road (BAKAD) project was selected as a case study to implement an SD modeling to analyze the risks. An SPV organization investigated in this study is the BAKAD Investments and Operations LLP, established by a Turkish-Korean consortium (Alsim Alarko, Makyol, SK Ecoplant, Korea Expressway) to manage the project. In February 2018, a 20-year concession agreement was signed, which included the construction and operation phases of the project. The BAKAD project is the first PPP infrastructure megaproject in Kazakhstan and Central Asia in the form of a concession agreement (Smagulova et al., 2023). It is a 66-kilometer toll bypass road encircling the city of Almaty from west to east on the northern side and is part of the Western Europe-Western China trans-Eurasian transport corridor. The purpose is to increase international transit traffic while relieving the city's streets of lorries, reducing traffic jams and thus improving the environmental situation (Nugmanova et al., 2019). According to the studies, infrastructure megaprojects are an ideal subject for investigating risks and critical success factors influencing the success of a PPP project (Sainati et al., 2020).

The main inputs for the study modeling are the following: length of the road - 66 km (4-6 lanes), including interchanges bridges; project cost - $750 mln; concession period - 20 years (5

years construction, 15 years operation); construction cost - $540 mln; concession agreement type - Build-Transfer-Operate (BOT); public partner - Ministry of Transport of the Republic of Kazakhstan; private partner – the SPV, the BAKAD Investments and Operations LLP; lenders - the European Bank for Reconstruction and Development, the Islamic Development Bank, the Eurasian Development Bank; the consortium own funds - $165 mln (circa 22%); borrowed funds - $585 mln (circa 78%).

The major milestones of the project are the signing of the concession agreement (07.02.2018), the establishment of the SPV (28.06.2018), the operation and maintenance agreement (27.05.2020), financial close (11.08.2020), completion of construction (31.03.2023), and the BAKAD case into operation (15.06.2023).

Selection of the risks

The risks for the study were taken from the recent survey of Serikbay et al. (2023), who routinely studied the impact of risks on PPP projects in Kazakhstan. They analyzed the risk based on a survey of PPP practitioners from the private and public sectors and academics who previously published studies on PPPs. They identified the top 10 most critical risks for PPP projects in Kazakhstan (Table 1). The detailed methodology of their survey, risk analysis, and risk ranking are thorough in their paper. For the current study, the authors selected five risk variables: exchange rate fluctuation, inflation rate fluctuation risk, construction cost overrun, high financing cost, and change in demand.

TABLE 1. Top 10 most critical risk factors in PPPs in Kazakhstan

Risk rank	Risk name
1	Exchange rate fluctuation
2	Inflation rate fluctuations
3	Delays in approvals and permits
4	Changes in legislation
5	Poor decision-making by the government authority
6	Construction cost overruns
7	High cost of financing
8	Political interference
9	Interest rate fluctuations
10	Corruption
Note: compiled by authors Serikbay et al. (2023)	

The SD model inputs

Appropriate risk allocation and sharing are critical success factors affecting the efficiency of an SPV, among which the most crucial role is played by the chosen mechanism of payment and return of private partners' investments and financial obligations. Therefore, Burke Demirag (2019) emphasized three payment mechanisms for an SPV. They include the one based on: "availability payment", where the government bears the risk of demand and there is no additional income; "shadow payments", where each toll is paid from the state treasury (the risk of demand lies either with an SPV company or the state); and "hard tolls", where an SPV company bears the risk of demand and there is an opportunity to receive additional income (by increasing traffic or fares).

The authors limit the scope of the current study, considering the scenario based on the "hard tolls" only. In this model, the private partner bears all financial and economic risks. The most likely risks in this model for the private partner are exchange rate fluctuations that affect construction costs, repayment of borrowed funds, and risks related to user demand. Low traffic may be due to incorrect calculations in forecasting at the planning stage, high toll costs that do not compensate for time and fuel costs, and the availability of alternative travel options. Proper estimation of demand and, consequently, future traffic is a success factor that is essential for a private partner in such a toll collection mechanism. All data for modeling, such as the number of users (only two tariff types were used instead of 6), traffic growth, fare, exchange rate, and payment index, were taken from public sources.

The data for the five risks were taken from open sources or privately from the SPV company upon their agreement to use the data for research purposes only. The exchange rate of the US dollar, one of the currencies used to make settlements in the BAKAD project, was taken based on the National Bank of Kazakhstan exchange rate statistics from 2018 to 2023. The BAKAD toll included a tariff of 0.07 of one payment index (the monthly estimated rate) for passenger cars and 0.14 of one monthly estimated rate for trucks, KZT241.5 and KZT483.0 for 2023, respectively. The model includes two tariffs for the main modes of transport (passenger car and lorry). The forecast on tariff growth is based on the dynamics of the payment index growth from 2018 to 2023, which is an average annual increase of 1.075.

The Vensim software, released in 1990 by Ventana Systems and with a circa 54% market share among simulation software in the systems thinking field (Kedir et al., 2023), was used to create the simulation models. Vensim provides a graphical simulation interface with stock, flow, and cause-and-effect diagrams. It is user-friendly and allows, when running a simulation, a real-time visual representation of system changes and the behavior of individual elements as variables change.

4. Results and Discussion

The model incorporates a dynamic pricing strategy for toll collection, aimed at optimizing revenue generation while maintaining affordability for users. Figure 1 shows the model with the SPV's mechanism for charging users of the BAKAD tolls, the "user fees" or "income from tariff" scenario.

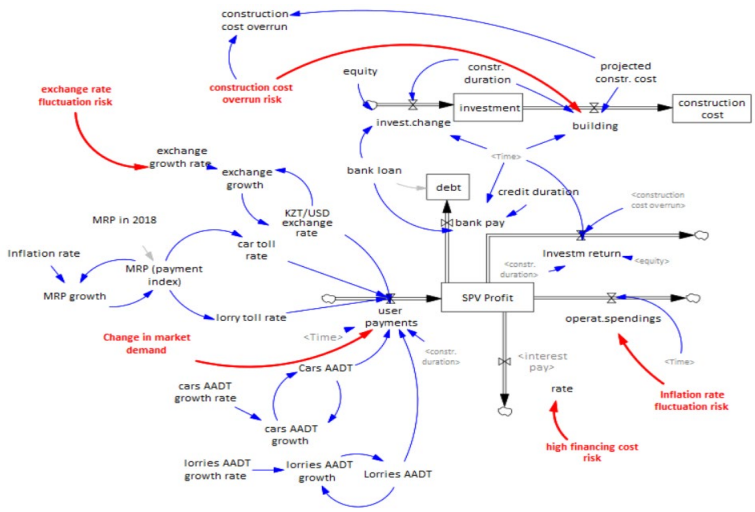

FIGURE 1. SD diagram of the SPV efficiency model under the mechanism of "charging tariff to users"

Note: compiled by authors

In the simulation model with a tolling mechanism, where the SPV charges the toll road, the selected risks (construction cost overruns, fluctuations in inflation, changes in market demand, exchange rate fluctuations, and high financing costs) impact the SPV's performance.

Figure 2 shows how each risk affects the project's profitability.

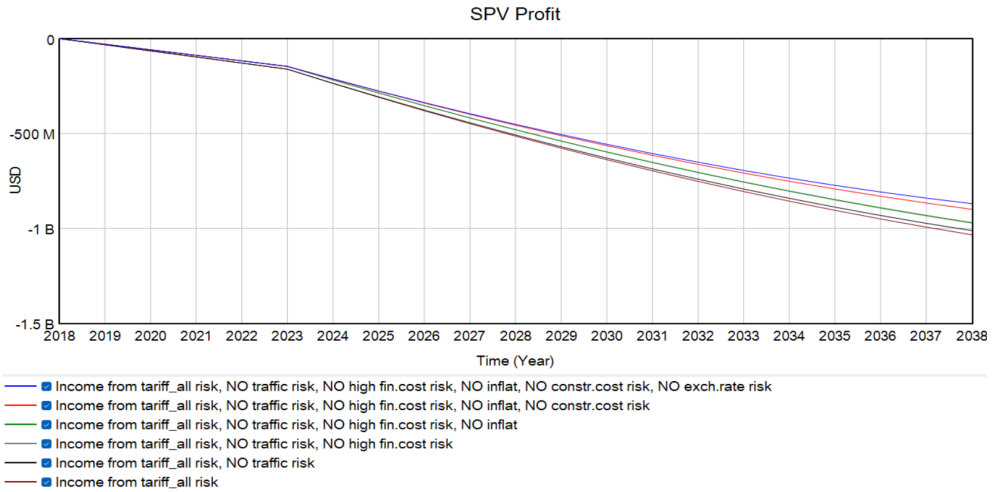

FIGURE 2. Impact of risks on SPV profit

Note: compiled by authors

When each risk is removed from the model, its effect on the variables is canceled. The success rate of the SPV increases. However, the break-even point of the project has still not been reached. This model, even without all risks, is inefficient due to low traffic and insufficient tariffs. From the model with negative development, where all the risks given in the model will have an impact, the SPV will not be able to cover its obligations to creditors banks due to the shortage of cash due to the projected traffic and actual tariff. Two factors affect the increase in toll road revenue: the annual average daily traffic (AADT) and the increase in the toll rate.

For the SPV to break even (Figure 3), the simulation shows that annual traffic growth must be increased from the projected 5% to 16%.

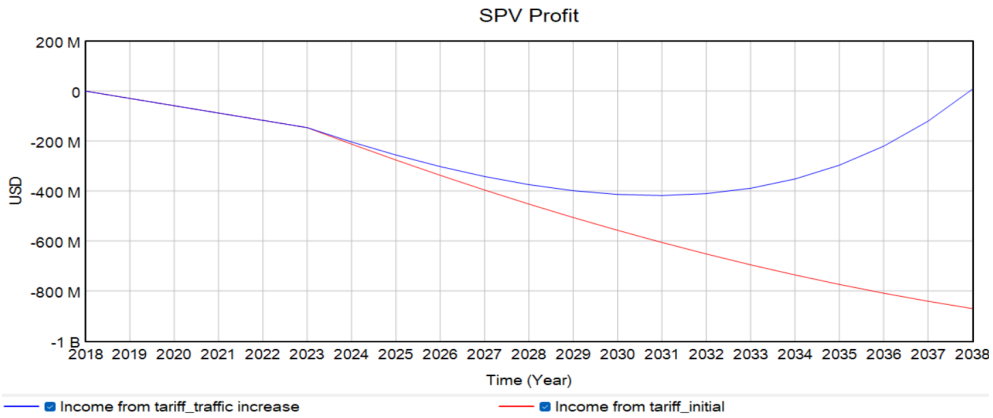

FIGURE 3. SPV profit graph when annual average daily traffic grows by 5% and 16%

Note: compiled by authors

This simulation shows that for the project to be profitable (without changing the tariff increase dynamics), the total BAKAD users, including all modes of transport, should reach approximately 872,000 vehicles per day by 2038.

In the model where a toll rate increase is required for the project, the simulation showed that an annual toll increase of 20.0 percent was needed (Figure 4). Considering the dynamics of payment index growth from 2018 to 2023 (1.075 per year), the estimated base fare 2038 will be 718 tenge per passenger car and 1,435 tenge per lorry. According to the simulation, for the effective operation of the SPV in 2038, the passenger car fare should increase from 718 Tenge to 6,410 Tenge and the lorry fare from 1,435 Tenge to 12,820 Tenge (Figure 4).

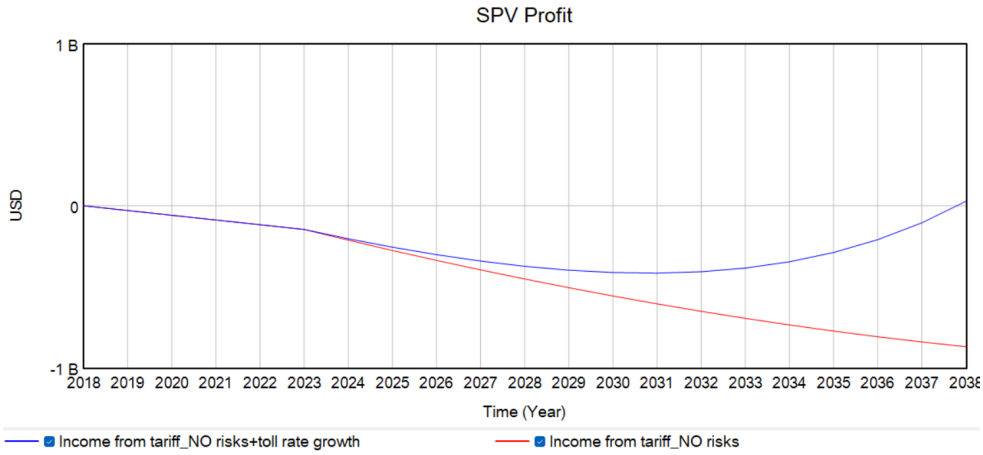

FIGURE 4. Graph of SPV profit with annual tariff increase by 20%

Note: compiled by authors

The SD model showed that with the current tariff and the predicted traffic of the toll road, such a project could not be attractive for private investment due to the risk of not covering its debt obligations in the presence of critical risks, such as unsatisfactory demand from users, currency and inflation fluctuations, excess construction costs. The simulations demonstrated that increasing the tariff and the number of users is necessary for the project's profitability. Thus, the simulation of an increase in the tariff required for the profitability of the project showed the need to increase the tariff by 20 percent annually instead of 7.5 percent included in the project, which will undoubtedly affect the attractiveness of this road, demand from motorists, and the choice of alternative routes. Also, the simulation of the traffic growth necessary for the profitability of the project showed the need to attract toll road users to ensure continuous annual traffic growth of 20 percent instead of the projected 5 percent, which, given the demographics of the Almaty conglomeration and the number of cars in it, shows that this scenario is unlikely.

5. Conclusion

This study analyzed the risks typical to infrastructure PPP projects in developing countries, using the toll road infrastructure case by modeling the “hard tolls” payment mechanism. The SD

simulation model considered the five risks from the comprehensive study conducted earlier in the PPP area in Kazakhstan. The paper considered the data on the cost and duration of construction, liabilities, traffic, tariff, growth forecasts, and other indicators necessary for the equations from the reports and other open sources. The SD modeling addressed the profitability of the SPV under the "hard tolls" mechanism if the project partners had chosen it as a return on investment.

Using available data from open sources for computer modeling, this study demonstrated the financial insolvency of a payment mechanism where the private partner covers its investment, debt, operating, and maintenance costs by collecting tolls from road users. The simulation showed that a 20-year concession, where five years are spent on construction (investment) and 15 years on operating (return on investment), is not enough to cover all the liabilities and costs of the private investor.

This study has shown the importance of adequately allocating all critical risks among all partners of a PPP project where private capital and a long-term return on investment are expected. Given the high probability and impact of financial risks (currency fluctuations, low traffic, high bank rate, and inflation) in Kazakhstan's economy, accepting such risks will incur additional costs for the private partner. This, in turn, will lead to an increase in the project's price, and where the transfer of these risks to the public partner can be an alternative in the current investment climate and uncertainty.

Since the current study only addressed the analysis of project success under the existing risks in the "hard tolls" mechanism scenario, further research will address the scenario under the "availability payment" mechanism. It is noted that this scenario is the actual mechanism of payments to the SPV company by the government in the BAKAD project used currently. Also, future researchers and SD practitioners can explore the "shadow tolls" mechanism in PPP projects and highlight all the risks and success factors for SPV, considering the flexibility of the distribution of responsibility between public and private partners under this payment mechanism.

AUTHOR CONTRIBUTION

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Resources: Andrey Samoilov.
Software and supervisions: Andrey Samoilov, Timur Narbaev.
Data collection, analysis and interpretation: Andrey Samoilov, Yerzhan Mukashev.
Visualization: Andrey Samoilov, Gabriel Castelblanco.
Writing review and editing research: Andrey Samoilov, Timur Narbaev, Yerzhan Mukashev.

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