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An Assessment of Financial Stability of Artificial Intelligence-based Monitoring Project in Kazakhstan

Timur Narbaev[1] | **Bauyrzhan Aitkhozha**[1] | **Andrey Samoilov**[1,2*] | **Gabriel Castelblanco**[3]

[1] Kazakh-British Technical University, Almaty, Kazakhstan

[2] Institute of Advanced Research and Sustainable Development, Almaty, Kazakhstan

[3] University of Florida, USA

Corresponding author:
*Andrey Samoilov – PhD candidate, Institute of Advanced Research and Sustainable Development, Almaty, Kazakhstan.
Email: an_samoilov@kbtu.kz

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ABSTRACT

Today, public-private partnership (hereinafter – PPP) projects, which apply digital technologies and artificial intelligence (hereinafter – AI), are becoming essential for improving infrastructure delivery and transparency. This study aims to assess the financial stability and risks of the Sergek project, an AI-based traffic video monitoring system in Almaty implemented under the PPP model with fixed government payments. The study examines the macroeconomic and operational risks of the project using system dynamics (SD) modeling. The data inputs for the SD model were collected from project documentation, national economic statistics, and expert interviews. In the baseline scenario, with a stable exchange rate (0.1% growth per year) and timely government payments, the internal rate of return (hereinafter – IRR) increases from -1.0% in 2021 to 0.37% by 2026. In an alternative scenario with an annual devaluation of 20%, the IRR only reaches 0.3%, and the break-even point is delayed by one year. However, the return significantly declined under scenarios simulating currency depreciation, underscoring the AI project's sensitivity to external economic risks. This study provides methodological and practical contributions to the field, specifically within the contracts of availability-payment mechanisms in emerging economies like Kazakhstan. The proposed simulation model is an adaptable tool for stakeholders to forecast investment outcomes and enhance project monitoring and control based on AI applications in PPPs.

KEYWORDS: Artificial Intelligence, Public-Private Partnerships, Digital Business, Sergek, Financial Stability, Project Financing, Investment Risk

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1. INTRODUCTION

The long-term partnership of the government with private businesses reduces the burden of the public budget, successfully implements socially significant projects, and improves the efficiency of infrastructure development. As governments in developing countries struggle with budget deficits, a private-sector partnership will be essential in bridging infrastructure gaps. Due to the investments and knowledge of the private sector, the public-private partnership (hereinafter – PPP) provides another way of funding alongside the traditional one (Chileshe et al., 2022).

PPPs were established in Kazakhstan to attract private investment into public infrastructure development and to develop management skills in the field (Narbaev & Charman, 2017). The Law 'On Concessions' of 2006 was the first attempt to formalize PPP arrangements, later supplemented by the Law 'On Public Private Partnerships' of 2015, which broadened the scope of private sector participation and introduced availability-based contracts. As of December 2024, Kazakhstan had 1,333 PPP projects valued at 2 292,6 billion KZT. With 14 projects at the republican level, amounting to 1,309.7 billion KZT, and 1,057 projects at the local level, valued at 982.9 billion KZT. Most (87.9%) of these projects are concentrated in the social sector, covering education, healthcare, housing, and utilities. According to the Kazakhstan PPP Center (2025), 37% of total investments implementing the PPP mechanism fall on large-scale transport and road infrastructure facilities.

Furthermore, the Kazakhstan Ministry of National Economy has already taken focused measures to get the PPP mechanism to work more effectively, such as the Comprehensive Plan for the Development of PPP in the Social Sphere for 2024-2028. As a result, the Government outlines a strategic pathway of action to modernize economic infrastructure by establishing onshore development with competence centers to enhance the spectrum of localized industrial production. Moreover, Kazakhstan's long-term development strategy "Kazakhstan-2050" highlights the development of PPPs to strengthen entrepreneurship and create sustainable development (Akorda, 2012).

This study evaluates the financial sustainability and risk dynamics of the availability-based PPP project in Kazakhstan. Specifically, the study analyzes artificial intelligence (hereinafter – AI) based on the Sergek video monitoring system project in Almaty. The Sergek's main objective is to monitor traffic safety on roads. AI's applications in monitoring and controlling PPP projects have proliferated in recent years. Availability-based PPPs focus on fixed payments from the government to the operational partners, as opposed to directly charging end-users to create revenue streams; this means that the PPPs with hard-toll payment mechanisms are more susceptible to challenges such as delayed payments, inflation over the lifespan of the project, operating cost overruns, and currency exchange risks (Samoilov et al., 2024b).

PPPs usually have a term of 25–30 years to recoup the investments (Mangano et al., 2025; Narbaev et al., 2025), so the five-year Sergek term brings up essential issues as to its financial viability. Accordingly, this study specifies goals of assessing Sergek's economic viability, determining major risk factors, employing SD modeling to quantify risk factors, and defining and analyzing Internal Rate of Return (hereinafter – IRR) results under various scenarios. The study addresses these challenges by examining key aspects related to the financial and operational uncertainties inherent in PPPs with availability payment mechanism, the impact of fixed government payments on financial performance, the relevance of SD modeling to capture the changing risks, and the effectiveness of IRR calculations for assessing project success.

The paper begins with a literature review, placing this paper within the context of essential works on PPPs, including attention to risk management and financial sustainability. Next, the following methodology section

describes the SD modeling technique, the empirical data sources, and the structure of the analytical framework. The findings and discussion section analyzes the Sergek project, presents the financial consequences of the revealed risks, and compares the results according to various scenarios. Finally, the conclusion synthesizes key findings, PPP policymaking implications, and future research directions.

2. LITERATURE REVIEW

An interest in applying a PPP mechanism as an alternative to a traditional public procurement scheme continues growing in developed and developing countries. In the past decade, the PPP literature witnessed tremendous growth in academic and industry publications. To enhance our knowledge of the field, a brief literature review is provided, and the novelty of the current study is formulated.

Existing literature on PPPs has dramatically helped to investigate risk management (Bing et al., 2005; Osei-Kyei et al., 2023), financial sustainability, concession period (Mangano et al., 2025), and governance structures, particularly within developed and developing economies (Narbaev, 2022). It is worth noting that modern technologies have been recently gaining popularity in project management, including the implementation of AI applications (Kozhakhmetova et al., 2024), which effectively addresses sound decision-making based on big data analysis, including traffic analytics and safety management in urban spaces (Assaf & Assaad, 2024). Thus, Levine et al. (1993) investigated the travel time in Houston area and found that PPP approach is an effective mechanism in traffic management using modern intelligent systems. Traffic monitoring is becoming more and more important over time given the rapid development of technology, e.g., Turner (1995) examined the studies on traffic monitoring and revealed a rapid growth in techniques for analyzing travel time. Meanwhile, reviewing recent research on AI and digitalization, we can note the intensive development of Smart City concept in big cities of Kazakhstan, which also includes traffic management and road safety using AI-based technologies (Mendybayev, 2022; Nurbatsin et al., 2023).

Most studies on transport PPPs analyzed the success of projects based on economic metrics, concession period and return on investment for the private partner, which are reflected in the relevant risks that need to be appropriately allocated between partners (Bing et al., 2005). Also notable is the focus of most studies on the user-fee payment mechanism, where the private partner bears the demand risk, from which the complete financial model of the project is built (Castelblanco et al., 2005; Mangano et al., 2025). But there have been few studies on project models with the availability-payment mechanism, where the government transfers the payments to the private partner for project operation, which consequently assumes no demand risk for the private partner.

According to research, the theoretical frameworks in this context include transaction cost economics and SD theory to assess financial risk, governance, and project feasibility. However, these studies are limited mainly in integrating multiple theoretical perspectives, where risks and sustainability are commonly seen in isolation rather than as interconnected (Castelblanco et al., 2025). Thus, SD modeling, which became popular for its ability to model complex interactions between risk factors and cash flows over time, remains, for the most part, empirically unconsolidated against empirical project data (Khallaf et al., 2024). Additionally, variations in risk stratification methods between studies impede comparability (Biziorek et al., 2023). The IRR has consistently received attention as an essential financial performance measure for availability-based PPPs with fixed government payments (Xu et al., 2012). However, many studies do not comprehensively evaluate long-term financial sustainability, especially on contract renegotiations and external economic shocks, thus limiting the robustness of these assessments.

Other limitations relate to qualitative methods predominating the field, which,

although rich in context and detail, lead to subjectivity bias and limited statistical power (Mouraviev & Kakabadse, 2017). In addition, the PPP literature primarily focuses on individual project-level analysis, overlooking systemic risks from multiple concurrent projects (De Marco & Narbaev, 2021; Biziorek et al., 2023).

Among the studies on PPP projects in Kazakhstan using SD modeling, it is worth highlighting the research of Castelblanco et al. (2024), where authors analyzed the PPP project pipeline in Kazakhstan, noting weaknesses and suggesting how the PPP program could be improved. Samoilov et al. (2024a), using SD, modeled the BAKAD project. They analyzed the critical risks that could arise if the BAKAD project had a "hard toll" payment mechanism, meaning that the managing consortium would collect tolls from highway users.

A lack of research on PPPs in the field of road monitoring in Kazakhstan has been identified in the existing literature. Unlike previous studies conducted in the field, the current research investigates the financial sustainability of the AI-based road monitoring project based on the PPP mechanism. To address this research gap, this study utilizes empirical validation on SD modeling for availability-based PPPs, integrates a dynamic scenario-oriented risk assessment process, and applies a portfolio perspective. These contributions will lead to more robust risk assessment tools and further knowledge regarding the financial sustainability of PPP infrastructure investments.

3. RESEARCH METHODS

This study uses a case-based modeling framework using the SD approach to simulate the financial and operational risks of availability-based PPPs. SD modeling was established by Jay Forrester at the Massachusetts Institute of Technology in the 1960s and is centered around analyzing system complexity that evolves. SD researchers may simulate different nonlinear system interdependencies, feedback structures (Sterman, 2000), and delays over certain time bounds to forecast the impacts/of interconnected variables (Haraldsson & Ab, 2004).

The primary dependent variable is IRR, which is used as a key output to determine whether the availability-based PPP model yields a sustainable and attractive return for private partners under given financial conditions. While Net Present Value is commonly used in project finance, this study prioritizes IRR due to its effectiveness in evaluating the timing and adequacy of investment return under dynamic financial and operational risk factors. IRR is a more practical indicator of financial success in project management in PPP projects based on an availability-payment mechanism, where the revenue stream is guaranteed through fixed government-backed payments. IRR reflects the financial capacity to generate returns relative to its initial investments, allowing decision-makers to assess the project's long-term financial success and viability. It determines whether the net cash flows from the project are sufficient to recover initial investment and provide acceptable returns to private investors. IRR is widely used in PPP investment to indicate project attractiveness over time (Wibowo, 2024). It is especially relevant in modeling long-term financial outcomes through forecasting, e.g., using SD (Castelblanco et al., 2024).

The structure of the methodological framework includes six stages: case selection, risk identification, SD inputs, model validation, and sensitivity analysis (Figure 1).

The Sergek video monitoring system project was chosen as a case study to evaluate financial sustainability and risk dynamics in availability-based PPPs using SD modeling. Unlike concession-based PPPs, which generate revenues commonly from tariffs, Sergek operates under a fixed-payment model, where the government provides fixed payments to private partners. The project is developed using AI applications to monitor and control road

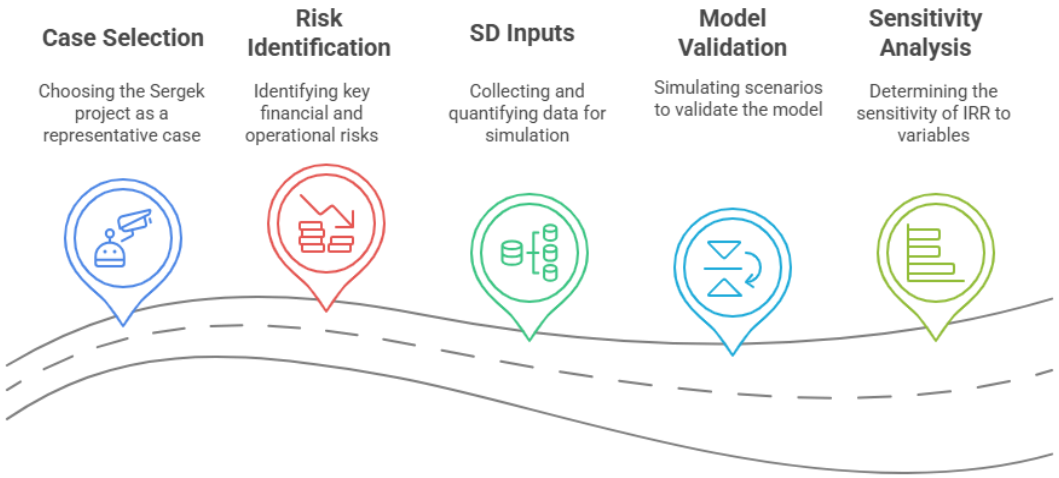

FIGURE 1. Stages of the SD-based analytical framework for PPP evaluation

traffic. LLP "Korkem Telecom" is the private partner responsible for financing, deploying, operating, and maintaining monitoring systems. At the same time, the Department of Urban Mobility of Almaty and the Department of Police of Almaty oversee regulatory compliance and disburse contractual payments. The project integrates AI-driven traffic monitoring systems across Almaty to improve road safety and manage urban mobility.

Sergek is used in Almaty, Astana, and other regional cities in Kazakhstan, and its practice development as a PPP has not been sufficiently studied, which calls for this research. Based on a real-world case, this research promotes methodological approaches within the framework of PPP used. It helps the stakeholders better assess the financial feasibility of availability-based PPPs in Kazakhstan.

The identified risks are taken from project documentation and expert assessments. The findings confirm that government payment stability, financial risks, and macroeconomic conditions play the most critical roles in the financial sustainability of availability-based PPPs like the Sergek project. These risks directly impact the ability of the project to maintain operational continuity, financial stability, and long-term feasibility. The structured risk ranking outlined in Table 1 serves as the basis for scenario analysis in the SD model. The classification reflects financial risk factors (such as government payment delays, inflation, and exchange rate fluctuations) and operational risks (including operational cost overruns, technical issues, and political uncertainties), providing a comprehensive overview of potential challenges in the Sergek PPP project.

Based on the revealed risk factors, the most significant ones were chosen based on experts' assessment for further modeling in SD, simulation running, and sensitivity analysis (Table 1).

TABLE 1. Key risk factors identified for the Sergek project

Risk rank	Risk name	Justification	Unit of measurement
1	Government Payment Risks (Policy and Budget Fluctuations)	Delays or reductions in government payments can cause liquidity shortages, directly affecting project financial stability.	% of CAPEX
2	Commercial Risk	Cost overruns from rising material, transportation, equipment prices, and video	% of CAPEX

		monitoring equipment damage or loss risks can increase financial strain.	
3	Exchange Rate Fluctuation Risk	The cost of video monitoring equipment components depends on imported technology; currency depreciation increases procurement costs.	% of video monitoring equipment
4	Key Interest Rate Risk	Higher interest rates increase the cost of borrowed funds, raising debt servicing expenses and reducing financial predictability.	% of borrowed funds
5	Inflation Rate Risk	Rising inflation increases operating costs, procurement expenses, and financial burdens, making the project more expensive.	% of the cost of services
6	Political Risk	Changes in legislation, contract terms, or political instability (e.g., coups, revolutions, strikes) can worsen project conditions.	% of CAPEX
7	Technical Risk	Poor installation work or equipment failure can lead to system malfunctions, increased maintenance costs, and operational disruptions.	% of installation work costs

Note: compiled by authors using expert evaluations

Scenario Construction

The primary inputs to the SD model include initial CAPEX, OPEX adjusted according to the annual inflation rate, bank loan rate, and scheduled government payments complemented by a final asset handover at project completion. Two clearly defined SD models (the Basic Scenario and the Currency Risk Scenario) were created, providing distinct conditions to explore the impact of specific risks on project sustainability. The Basic Scenario (Table 2) represents favorable economic conditions, assuming scheduled government payments, stable inflation, and minimal currency exchange rate growth.

TABLE 2. Basic scenario inputs for the SD model

Data Type	Value	Description
CAPEX	4.5 billion KZT	Initial investment and setup costs
OPEX	2.1 billion KZT/year, adjusted for inflation	Annual operating costs adjusted for inflation
Loan Amount	1.12 billion KZT	Borrowed funds from financial institutions
Government Payment	4.5 billion KZT	Scheduled fixed government-backed payments
State Handover of video monitoring equipment	7.6 billion KZT	Final payment upon asset transfer to the public sector
Inflation Rate	7% annually	Annual percentage increase in operational costs
Loan Repayment	Fixed five-year term	Scheduled loan repayment duration
Currency Rate Growth	1.001 1/year	Annual incremental currency fluctuation rate

Note: based on the analysis of the Sergek case study using project documentation and interview data

This scenario establishes a baseline against which the project's financial performance can be measured, highlighting the expected financial viability and return on investments under perfect economic conditions. The Currency Risk Scenario (Table 3) explicitly introduces the risk of currency fluctuations by integrating a fixed annual currency fluctuation factor. This scenario evaluates how sustained currency depreciation impacts the project's capital expenditures, particularly imported equipment costs. By comparing this scenario against the baseline, stakeholders can understand the project's sensitivity to external economic risks and devise effective financial risk management strategies.

TABLE 3. Currency risk scenario inputs for the SD model

Data Type	Value	Description
CAPEX	4.5 billion KZT	Initial investment and setup costs
OPEX	2.1 billion KZT/year, adjusted for inflation	Annual operating costs adjusted for inflation
Loan Amount	1.12 billion KZT	Borrowed funds from financial institutions
Government Payment	4.5 billion KZT	Scheduled fixed government-backed payments
State Handover of video monitoring equipment	7.6 billion KZT	Final payment upon asset transfer to the public sector
Inflation Rate	7% annually	Annual percentage increase in operational costs
Loan Repayment	Fixed five-year term	Scheduled loan repayment duration
Currency Rate Growth	1.2 1/year	Annual incremental currency fluctuation rate

Note: based on the analysis of the Sergek case study using project documentation and interview data

Model Validation and Sensitivity Testing

Given that the developed SD model is a simplified representation of a complex real-world PPP mechanism, comprehensive validation techniques were applied to ensure model reliability and analytical soundness. The validation process included behavior reproduction tests, which assessed the model's capacity to replicate logical trends in financial sustainability, such as the transition of IRR from negative to positive over time in both the Basic and Currency Risk Scenarios. Sensitivity analysis was conducted to observe how variations in key parameters such as government payments, equity levels, inflation rate, and currency exchange rate fluctuations affected IRR outcomes, reinforcing IRR as the core metric of project financial performance in this study.

Extreme condition testing was applied to examine the model's behavior under minimum and maximum plausible values for key variables, including inflation rate, government payment schedule, and CAPEX levels. Structural assessment ensured internal consistency of causal relationships and feedback loops identified during Stock and Flow Diagram modeling. Finally, dimensional consistency was confirmed by verifying the correct use of measurement units across all related variables.

The model structure incorporates key variables and feedback loops relevant to the project's financial performance. Stocks in this scenario include "Equity to Return," "Loans to Return," "CAPEX," "OPEX," and "NPV" (Net Present Value), each of which accumulates or decreases over time depending on associated inflows and outflows. For instance, CAPEX reflects the capital expenditures needed during the initial implementation period, while OPEX increases annually based on inflation. Equity and loan contributions are spread over five years, while loan repayments are distributed equally over the same period.

Flows such as "Project Financing", "Investment Return", "Principal Repayments", and "Inflation" dynamically affect the stocks and provide a temporal structure for cash flow. The model assumes that government payments are disbursed as performance-based monthly tariffs and are aligned with service levels agreed upon in the PPP contract. The SD sketch modeled in Vensim PLE shows all Sergek project elements interacting with each other (Figure 2).

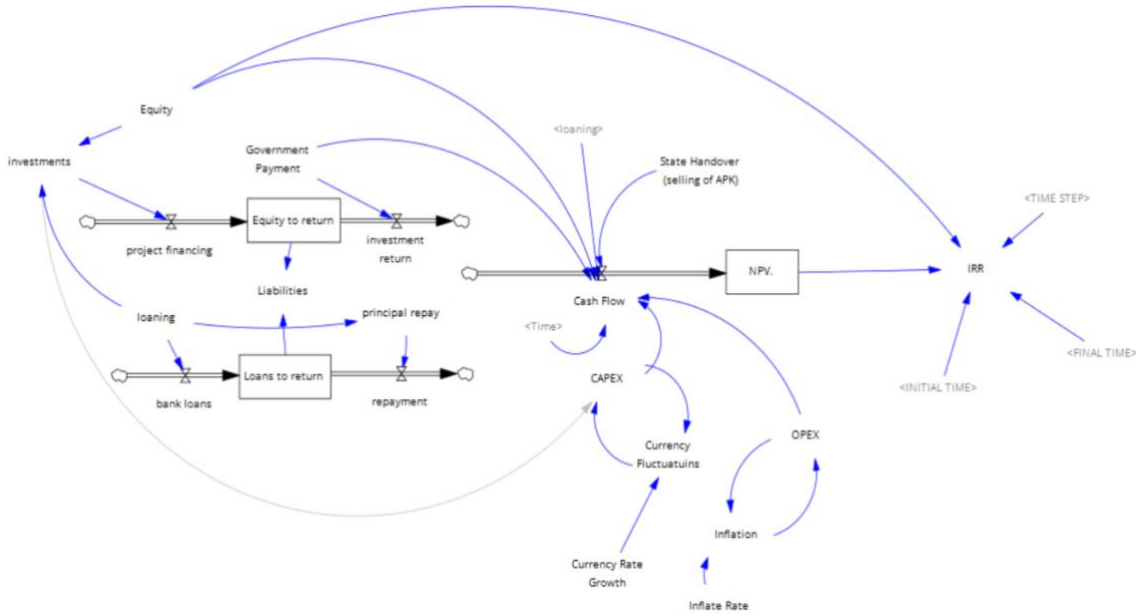

FIGURE 2. SD model structure for the Sergek PPP project

The primary project metric in this model is the IRR variable, which is impacted more or less by all system variables. SD model illustrates a system-dynamic model developed to analyze the financial stability of the Sergek project in the context of PPP mechanisms with fixed government payments. The model reflects the key relationships between investment flows, transaction costs, macroeconomic parameters, and financial performance indicators.

This study also includes sensitivity analysis, a well-known method in SD modeling that evaluates how changes in the values of variable inputs affect the dependent variable (Saltelli et al., 2004). Sensitivity analysis in the context of PPP projects facilitates researchers in determining variables such as inflation rate, equity size, and payment delays, which can significantly affect financial performance indicators (Barlas, 1994).

Sensitivity analysis is a helpful tool for addressing uncertainty in project management because it allows us to identify how sensitive model results can be to changes in initial inputs. It also helps to prioritize issues in risk management, which variables posing the most significant financial risk should be given more attention. Thus, the use of sensitivity analysis directly corresponds to the purpose of the study - to test how external risks affect the success of PPP projects with availability payment mechanisms.

Sensitivity analysis was performed for both the Basic Scenario and the Currency Risk Scenario to assess how variations in key parameters affect the IRR. As the primary metric in this study, IRR evaluates the financial viability and success of Sergek by changing the values of impacting variable inputs by – and + 10% to see to which variable the IRR is most sensitive. This allowed for a clearer understanding of which financial parameters are most critical to project viability under differing assumptions.

4. FINDINGS AND DISCUSSIONS

This section presents the key findings of a study examining economic and environmental factors impact on adopting responsible manufacturing standards (ISO 14001) across various countries. The first part presents a cross-country comparative analysis that examines the differences in regulatory frameworks, the level of ISO 14001 implementation, and the specifics of

responsible manufacturing in the United States, Japan, China, Germany, and Sweden. The second part presents the results of a quantitative analysis based on a panel regression model that assesses the impact of GDP per capita, the share of renewable energy, and CO_2 emissions on the number of ISO 14001 certifications. This approach helps identify patterns and determine the key factors contributing to responsible manufacturing standards' global adoption.

This section presents simulation modeling results based on an SD approach aimed at assessing the financial stability of the AI-based "Sergek" monitoring PPP project with fixed government payments. The analysis covers two scenarios: a basic one characterized by stable macroeconomic conditions and an alternative one considering currency risks. The results demonstrate the dynamics of the IRR depending on the parameters of the model set and the sensitivity of this indicator to changes in key variables.

Figure 3 compares IRR trajectories under both scenarios.

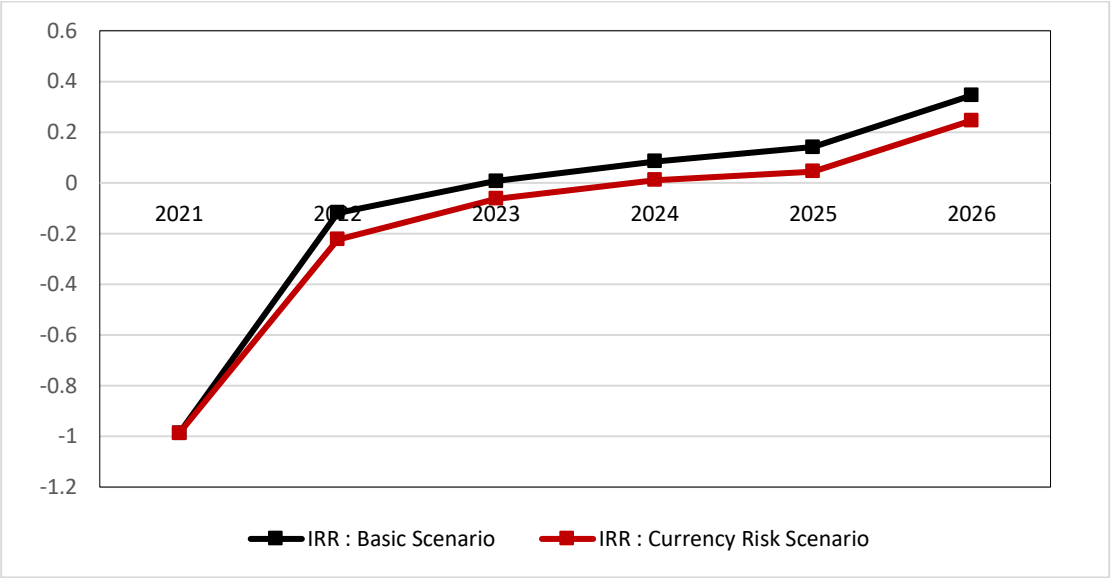

FIGURE 3. IRR of basic and currency risk scenarios

It illustrates the divergence in financial performance caused by currency fluctuation. The Basic Scenario line shows IRR rising steadily from 2022 onward, while the Currency Risk Scenario line reflects delayed and weaker growth. In the Basic Scenario, IRR improved from -1.0 in 2021 to -0.13 in 2022, reached 0.03 in 2023, and steadily increased to approximately 0.37 by 2026, confirming that the availability-based model can be financially sustainable if the contractual assumptions hold.

In contrast, the Currency Risk Scenario demonstrated how external macroeconomic risks, particularly currency depreciation, directly affect capital expenditures and reduce project profitability. With a currency fluctuation constant of 1.2, the IRR in this case improved from -1.0 in 2021 to -0.22 in 2022, reaching 0.01 in 2024 and ending at a lower 0.30 by 2026 compared to the basic case. The delay in achieving a positive IRR, combined with overall declining returns, emphasizes the weakness of short-term PPPs with fixed payments to factors beyond the control of project stakeholders.

Scenario Analysis Results

In the Basic Scenario, IRR becomes positive by the third operational year and continues to grow steadily, suggesting a financially sustainable project under stable conditions. In contrast, the Currency Risk Scenario demonstrates how currency

depreciation reduces IRR and delays investment recovery, highlighting the project's sensitivity to external financial risks. These findings offer a structured understanding of how risk exposure alters project outcomes in availability-based PPPs and support evaluating whether contractual and policy adjustments are necessary to improve fiscal reliability and investment security.

The Basic Scenario represents an ideal condition where macroeconomic factors such as inflation and currency remain stable, and government payments follow the contractual schedule without delays. This scenario reflects the core assumptions under which the Sergek PPP project was planned and approved.

Figure 4 displays the IRR curve for both scenarios.

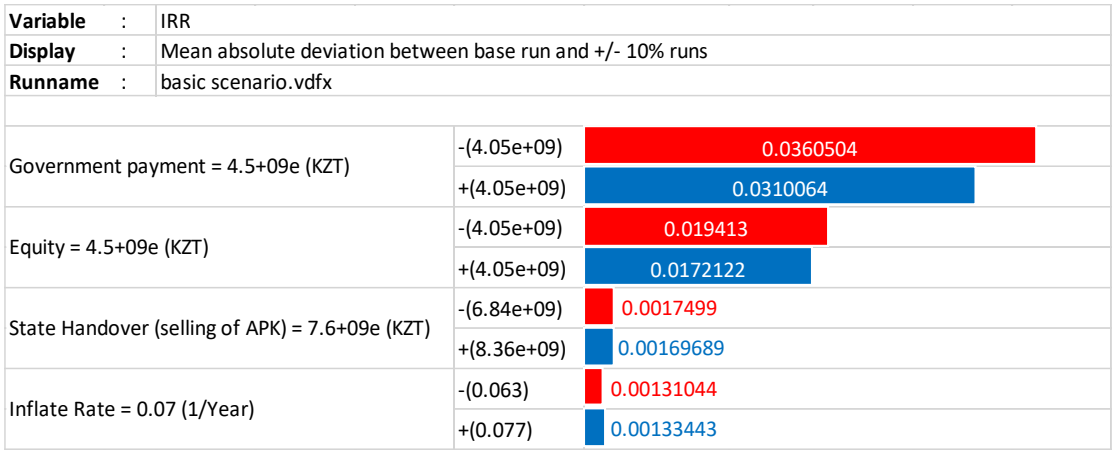

FIGURE 4. Sensitivity analysis of the basic scenario

The IRR begins below zero due to high initial capital outflows but turns positive by the third year of operations, indicating the onset of investment recovery. By the final year, the IRR stabilizes at a financially viable level, reinforcing the notion that the Sergek model is sustainable under stable economic conditions. The government's timely disbursement of fixed payments and the containment of operational costs play a decisive role in achieving these outcomes.

The Currency Risk Scenario builds on the structure of the Basic Scenario but introduces the financial impact of currency depreciation. In this version of the model, a fixed currency fluctuation factor is applied to capital expenditures, reflecting the increased cost of imported components. This change directly influences the CAPEX variable, increasing overall investment requirements and reducing the efficiency of financial recovery.

The model structure retains the same core stocks. It flows used in the Basic Scenario: "Equity to Return", "Loans to Return", "CAPEX", "OPEX", and "NPV", along with flows such as "Project Financing", "Investment Return" and "Repayments". However, the key difference lies in recalculating "CAPEX" using a constant value for currency fluctuation instead of a gradual growth rate. The model applied a fixed currency fluctuation factor of 1.2 1/year to simulate the effect of sustained depreciation on the cost of imported technology, directly increasing the initial capital requirements and impacting cash flow projections. This adjustment leads to higher capital expenditures during the operating phase, negatively affecting cash flow and postpones the transition to a positive IRR.

The IRR growth remains negative for a more extended period than the Basic Scenario, becoming positive only at the later stages of the project. The final IRR value is also lower, reflecting reduced returns on investment due to increased capital costs. These results demonstrate how exchange rate fluctuations can diminish the financial viability of availability-based PPP.

This simulation run highlights the project's sensitivity to macroeconomic changes beyond the control of the project stakeholders. Without financial risk-sharing arrangements, it is assumed that partners in such uncertain economic conditions typical for developing economies may face the challenge of generating the desired return on investment if currency risk is accepted. The scenario also emphasizes properly allocating currency risk during PPP contracts' planning and negotiation phases.

Sensitivity Analysis Outcomes

The sensitivity analysis covered both the Basic Scenario and the Currency Risk Scenario, focusing on the most significant impacting variables: government payment consistency, equity investment levels, inflation rate, and currency fluctuation rate. Figure 4 presents the sensitivity tornado diagram for the Basic Scenario, showing positive and negative changes in IRR across stable values of government payments, equity size, final state handover, and inflation rate.

The IRR was most sensitive to government payment and equity variations in the Basic Scenario. Reducing government payments by 10% led to the IRR declining by 3.6%; in contrast, increasing them by 10% will cause the IRR to grow by 3.1%. The equity input change by -10% will decline the IRR by 1.9%; in contrast, changing this variable input by +10% will increase the IRR by 1.7%. Variables "State Handover" and "Inflation Rate" adjustments revealed less pronounced effects.

Figure 5 presents the sensitivity chart for the Currency Risk Scenario, illustrating how changes in currency fluctuation, equity, and government support affect IRR.

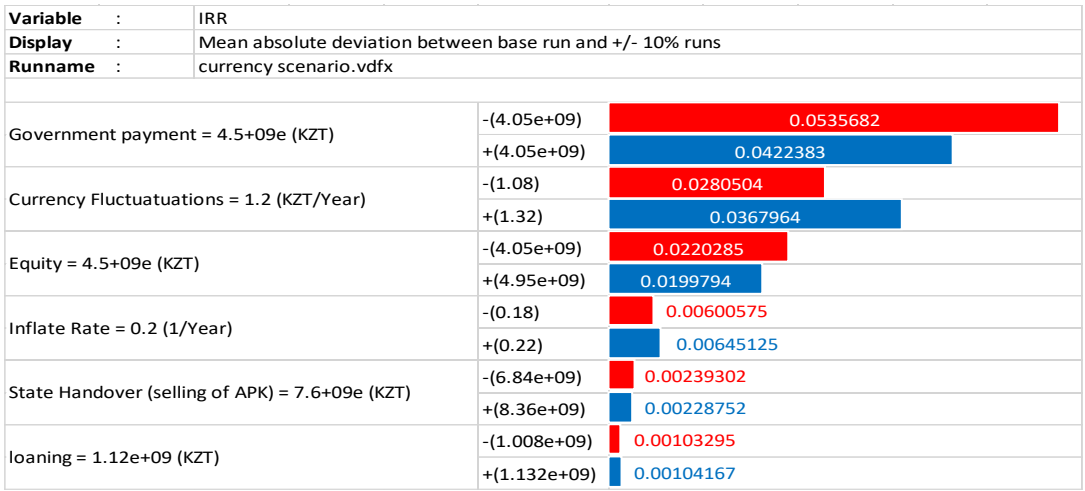

FIGURE 5. Sensitivity analysis of the currency risk scenario

In the Currency Risk Scenario, the model was susceptible to changes in the following variables "Government payment", "Currency Fluctuations", and "Equity". Thus, the -/+10% change in the variable "Government payment" will impact the IRR by -5.4% and +4.2, respectively. The fall of currency fluctuations by -10% will cause an IRR growth of 3.7%; in contrast, the growth of currency fluctuations will decline the IRR by 2.8%. Finally, the change in the variable "Equity" of -/+10% will affect the IRR by -2.2% and +2.0 respectively. The change in the inputs of other variables will not affect the IRR.

Overall, the sensitivity analysis supports the model's validity by showing logical and interpretable shifts in IRR in response to changes in risk variables. It highlights the necessity for proper risk management, careful planning, contracting, and policy consideration in mitigating financial uncertainty in availability-based PPPs like Sergek.

5. CONCLUSIONS

This paper assessed the financial sustainability, risk allocation, and effectiveness of the Sergek project in Almaty delivered under the availability-based payment PPP mechanism. Using SD modeling, the study presented a simulation-based analysis of vital financial and operating elements, which specifically related to the research questions and objectives of the study.

The IRR was used as the primary criterion for project success. Confirmed through simulation, the following findings conclude that the overall IRR of the Sergek project can be positive if the macroeconomic environment remains stable; however, the project is threatened by some financial risks, especially by delayed payments from the government as well as fluctuations in the exchange rate, and equity share.

The study found that PPP contracts with an availability-payment mechanism, where the public partner provides regular fixed annual transfers to the private partner for its services, are extremely sensitive to government payment delays, equity size, and currency exchange rate increases.

The study also has limitations like estimated financial data and assumptions around macroeconomic indicators. Political, legal, and institutional risks were not explicitly modeled. Future researchers might include assessments of political economy factors into the discussion of enforceability in law to give a more complete picture of PPP sustainability. Furthermore, aggregating this framework to other availability-based PPP projects in different PPP areas like infrastructure, healthcare, transport, education, and energy in Kazakhstan or other countries would provide valuable insights into its cross-sectoral applicability and validation.

AUTHOR CONTRIBUTION

Writing – original draft: Timur Narbaev, Bauyrzhan Aitkhozha, Andrey Samoilov.
Conceptualization: Timur Narbaev, Bauyrzhan Aitkhozha, Andrey Samoilov.
Formal analysis and investigation: Timur Narbaev, Andrey Samoilov.
Development of research methodology: Gabriel Castelblanco, Andrey Samoilov.
Resources: Timur Narbaev, Andrey Samoilov.
Software and supervisions: Timur Narbaev, Andrey Samoilov.
Data collection, analysis and interpretation: Bauyrzhan Aitkhozha, Andrey Samoilov.
Visualization: Bauyrzhan Aitkhozha, Andrey Samoilov.
Writing review and editing research: Gabriel Castelblanco, Andrey Samoilov.

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AUTHOR BIOGRAPHIES

Timur Narbaev – PhD, Kazakh-British Technical University, Almaty, Kazakhstan. Email: timur.narbaev@gmail.com, ORCID ID: https://orcid.org/0000-0002-6401-2700

Bauyrzhan Aitkhozha – MS, Kazakh-British Technical University, Almaty, Kazakhstan. Email: b_aitkhozha@kbtu.kz, ORCID ID: https://orcid.org/0009-0002-7495-9006

***Andrey Samoilov** – PhD candidate, Institute of Advanced Research and Sustainable Development, Almaty, Kazakhstan. Email: an_samoilov@kbtu.kz, ORCID ID: https://orcid.org/0009-0006-0548-4982

Gabriel Castelblanco – PhD, University of Florida, Gainesville, USA. Email: gabriel.castelbl@ufl.edu, ORCID ID: https://orcid.org/0000-0001-6820-6644