International Journal of Human and Society (IJHS)

E-ISSN: 2710-4966 | P-ISSN: 2710-4958
Vol. 6. No. 01 (Jan-Mar) 2026 | Page 187-194

https://doi.org/10.5281/zenodo.19317062

Multidimensional Assessment of Financing Risks for Metro Projects under the China–Pakistan Economic Corridor

Muhammad Ahmad Karim	School of Economics and Business Administration, Dalian Jiaotong University, 116028, China, ahmarkhattak5574@gmail.com,
Jiang Guangtian **(Corresponding Author)**	School of Economics and Business Administration, Dalian Jiaotong University, 116028, China jgt500@163.com

Abstract: *The China–Pakistan Economic Corridor (CPEC), as a flagship project of the Belt and Road Initiative, plays a pivotal role in strengthening economic cooperation between China and Pakistan and enhancing regional connectivity. Within this framework, metro construction projects have emerged as critical components of urban infrastructure development. However, the financing of such large-scale projects involves complex risk structures that require systematic evaluation. This study conducts a multidimensional assessment of financing risks associated with metro projects under CPEC by integrating both quantitative and qualitative approaches. It examines key categories of risk, including political and policy risks as well as economic and market risks, and evaluates their impact on project feasibility and sustainability. The findings reveal that factors such as political stability, policy continuity, macroeconomic fluctuations, and market uncertainty significantly influence financing outcomes. While quantitative analysis indicates that certain risk indicators exceed controllable thresholds, qualitative evaluation provides deeper insights into the underlying causes and transmission mechanisms of these risks. Based on these findings, the study proposes targeted mitigation strategies, including enhancing bilateral policy coordination, optimizing financing structures, and strengthening risk management systems. This research offers both theoretical and practical contributions to the management of financing risks in cross-border infrastructure projects and provides valuable references for similar initiatives.*

Keywords: China Pakistan Economic Corridor (CPEC); metro project financing; financing risk assessment; PEST analysis; Analytic Hierarchy Process (AHP); entropy method

1. Introduction

The China–Pakistan Economic Corridor represents one of the most significant international cooperation initiatives under the Belt and Road framework, with rail transit development occupying a central role in promoting regional integration and economic growth. Among these projects, the Lahore Orange Line Metro stands as the first major rail transit system implemented under CPEC, symbolizing Pakistan's transition into the era of modern urban rail transportation. The project involves a complex financing structure that includes policy-based loans, commercial financing, and participation from international financial institutions, with Chinese enterprises playing a leading role in project execution. This integrated model of "Chinese standards, Chinese equipment, and Chinese financing" has established a replicable framework for subsequent infrastructure projects within the corridor.

Despite these achievements, the long-term sustainability of metro projects under CPEC

depends heavily on effective risk management, particularly in the domain of financing. Given the cross-border nature of these projects, financing risks are influenced by a dynamic interplay of political conditions, economic fluctuations, regulatory environments, and market uncertainties. Therefore, a comprehensive and systematic assessment of financing risks is essential for ensuring project success and supporting the sustainable development of the corridor.

2. Literature Review

2.1 CPEC, Transport Infrastructure, and Financing Concerns

The China-Pakistan Economic Corridor (CPEC) has attracted extensive scholarly attention as a strategic component of the Belt and Road Initiative (BRI) and as a major channel for infrastructure-led development in Pakistan. Much of the literature presents CPEC as a transformative framework for enhancing connectivity, industrialization, energy supply, and regional integration (Hussain, 2017; Ali et al., 2021). Scholars emphasize that the success of corridor-led development depends not only on physical infrastructure but also on financing structures, governance quality, and institutional coordination.

Studies on the political economy of CPEC highlight that project sustainability is closely linked to fiscal discipline, transparency, and the ability of the Pakistani state to manage long-term financial obligations (Khan & Chang, 2021). Similarly, macroeconomic analyses argue that while CPEC improves trade and connectivity, it may also create financial pressures due to reliance on external borrowing and sovereign guarantees, raising concerns about debt sustainability and repayment capacity (World Bank, 2023).

2.2 Risk Analysis in Railway and Urban Rail Projects

A large body of research examines risks in railway and urban rail projects, identifying multiple dimensions including technical, managerial, political, environmental, and financial risks (Zou et al., 2007; Hwang et al., 2017). Railway infrastructure projects are particularly vulnerable due to their complexity, large capital investment, and long implementation periods.

In the context of CPEC, the ML-1 railway project has been extensively analyzed. Ali et al. (2024) identify key risks such as administrative delays, corruption, poor planning, and design changes, highlighting the multi-dimensional nature of infrastructure risk. These findings demonstrate that systematic risk evaluation is essential for large-scale transport projects.

Recent international studies further emphasize that risks in urban rail systems are interdependent. The Emerald study on urban rail transit shows that risks such as policy conflict, cost escalation, and demand uncertainty interact with each other, creating a network of reinforcing effects.

2.3 Methods Used in Infrastructure Risk Assessment

The literature on infrastructure risk assessment has evolved from qualitative approaches to quantitative and multi-criteria decision-making (MCDM) methods. Traditional approaches rely on case studies, expert interviews, and policy analysis to identify risks (PMI, 2017). While useful, these methods often lack the ability to quantify and compare risks systematically.

To overcome these limitations, researchers increasingly use techniques such as the Analytic Hierarchy Process (AHP), entropy weighting, fuzzy logic, TOPSIS, and DEMATEL (Saaty, 1980; Shannon, 1948). AHP is widely used to derive weights based on expert judgment, while entropy provides objective weights based on data variability.

The ML-1 study applies fuzzy set theory and risk severity index methods to quantify project risks, demonstrating the effectiveness of integrating qualitative and quantitative approaches (Ali et al., 2024). Similarly, the MDPI study illustrates how structured decision-making frameworks can be used to evaluate risks in CPEC-related infrastructure projects.

2.4 Research Gap and Positioning of the Study

The review of existing literature reveals several important gaps.

First, most studies on CPEC focus on macroeconomic, geopolitical, and developmental aspects, with limited attention to project-level financial sustainability. Second, research on railway and metro projects primarily addresses construction and operational risks rather than financing risk. Third, although MCDM methods are widely used, few studies integrate macroeconomic variables with project-level financial indicators in a unified framework.

This gap is particularly significant for metro projects under CPEC, where financial sustainability depends on both external economic conditions and internal project performance. Factors such as exchange rate volatility, inflation, debt burden, and ridership uncertainty interact to determine overall financing risk.

To address these limitations, this study develops a hybrid framework integrating PEST analysis with AHP and entropy methods. This approach enables a comprehensive assessment of financing risk by combining macroeconomic and project-level indicators within a single analytical model.

3. Types of Financing Risks in Metro Projects

Financing risks in metro projects under CPEC can be systematically classified using the PEST framework, which categorizes risks into political, economic, social, and technological dimensions. These factors collectively influence the financial sustainability of metro infrastructure projects and interact in complex ways.

3.1 Political Risks

Political and policy-related risks arise from changes in governmental priorities, regulatory frameworks, and fiscal policies in both China and Pakistan. Although the two countries maintain a strong strategic partnership, variations in policy direction, infrastructure planning, and financing mechanisms can significantly affect project costs and funding availability.

For instance, reductions in government subsidies, delays in administrative approvals, or changes in loan conditions—such as increased interest rates—can elevate financing costs. Similarly, modifications in taxation policies, regulatory requirements, or procurement rules may increase both construction and operational expenditures. Governance challenges, including lack of transparency and institutional inefficiencies, further intensify financial uncertainty in large-scale metro projects.

3.2 Economic Risks

Economic risks constitute the most critical dimension of financing uncertainty in metro projects. These risks are closely linked to macroeconomic conditions, including economic growth, inflation, and exchange rate volatility.

Metro projects under CPEC are particularly sensitive to exchange rate fluctuations, as financing is often obtained in foreign currencies while revenues are generated in local currency. A depreciation of the Pakistani Rupee increases the cost of servicing external debt, thereby placing additional pressure on public finances. At the same time, high inflation raises construction, operation, and maintenance costs, reducing overall project viability.

Economic downturns further exacerbate financing risks by lowering consumer spending and reducing passenger demand, which directly affects revenue generation and financial sustainability.

3.3 Social Risks

Social risks are primarily associated with ridership demand, public acceptance, and demographic factors. Metro projects rely heavily on passenger volume to generate revenue, making demand uncertainty a significant financial risk.

If actual ridership falls below projected levels, farebox revenue becomes insufficient to cover operational costs, leading to increased dependence on government subsidies. Additionally, public perception, accessibility, and urban mobility patterns can influence the level of metro usage, thereby affecting long-term financial performance.

3.4 Technological Risks

Technological risks relate to the operational efficiency, maintenance requirements, and technical reliability of metro systems. Although these risks are often less prominent compared to economic and political factors, they can indirectly affect financing outcomes.

High maintenance costs, system failures, and technological inefficiencies can increase operational expenses and reduce service quality. This, in turn, may lead to lower ridership and reduced revenue generation, ultimately impacting the financial sustainability of metro projects.

3.5 Interaction of PEST Factors

The four dimensions of the PEST framework are highly interrelated and collectively shape financing risk. For example, economic instability may lead to fiscal tightening, which can reduce government subsidies (political factor), while technological inefficiencies may reduce service quality and ridership (social factor). These interactions highlight the need for a comprehensive, multi-dimensional approach to financing risk assessment.

4. Methodology for Financing Risk Assessment

4.1 PEST-Based Risk Identification Framework

In order to systematically identify the key factors influencing metro project financing risks under the China–Pakistan Economic Corridor, this study adopts the PEST analytical framework, which categorizes risks into four dimensions: political, economic, social, and technological. This framework provides a structured approach to capturing the external macro-environmental factors that shape financing conditions.

Within the political dimension, factors such as political stability, policy continuity, and bilateral cooperation mechanisms are considered critical, as they directly influence regulatory certainty and investment confidence. The economic dimension focuses on macroeconomic indicators, including economic growth, inflation rates, interest rates, and exchange rate volatility, all of which significantly affect financing costs and project feasibility. The social dimension captures elements such as public acceptance, labor availability, and demographic characteristics, which may indirectly impact project implementation and operational performance. The technological dimension evaluates infrastructure capability, technological maturity, and environmental regulations, which influence both construction efficiency and long-term sustainability.

Based on this framework, a set of representative indicators is selected and quantified using a scoring system ranging from 1 to 10. The resulting dataset forms the basis for subsequent weighting and risk evaluation analysis. The distribution of PEST factor scores is illustrated in Figure 1, providing an initial overview of the relative importance of each indicator.

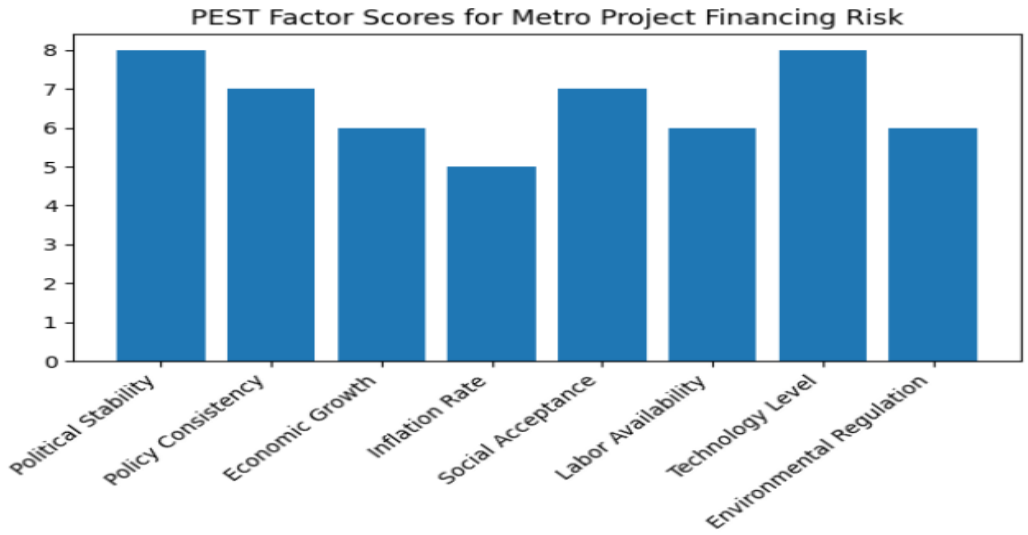

Figure 1: PEST Factor Scores for Metro Project Financing Risk

To address the complexity of financing risks, this study adopts a combined quantitative and qualitative assessment framework. The quantitative component is grounded in probability theory, statistical analysis, and risk management principles, enabling the transformation of complex risk factors into measurable indicators. The construction of the quantitative model involves the identification and selection of key risk variables, the establishment of a comprehensive indicator system, and the application of analytical techniques such as regression analysis, time series modeling, and Monte Carlo simulation. These methods allow for the estimation of risk probabilities and potential losses, thereby providing a numerical basis for evaluating financing risks.

Complementing the quantitative approach, the qualitative assessment framework focuses on capturing non-measurable but influential factors that shape financing outcomes. This framework is structured around four dimensions: political and policy, economic and market, social and cultural, and technical and environmental factors. By incorporating expert judgment and structured evaluation methods such as the analytic hierarchy process and entropy weighting, the qualitative analysis provides a holistic understanding of risk dynamics. The integration of these two approaches enhances the robustness and reliability of the overall risk assessment, enabling a more comprehensive evaluation of financing risks.

4.2 AHP-Based Weight Determination

Following the identification of risk factors, the Analytic Hierarchy Process (AHP) is employed to determine the relative importance of each PEST dimension. A hierarchical structure is constructed with the overall financing risk as the target layer, the four PEST dimensions as the criteria layer, and the corresponding indicators as the sub-criteria layer.

A pairwise comparison matrix is developed based on expert judgment, using a standardized scale to evaluate the relative importance of each criterion. The matrix is then normalized, and the eigenvector method is applied to derive the weights of each dimension. The results indicate that political factors carry the highest weight, reflecting their dominant influence on financing conditions in cross-border infrastructure projects. Economic factors rank second, highlighting the sensitivity of project financing to macroeconomic fluctuations. Social and technological factors, although comparatively less dominant, remain essential components of the overall risk structure.

The calculated AHP weights are presented in Figure 2, which visually illustrates the relative contribution of each dimension.

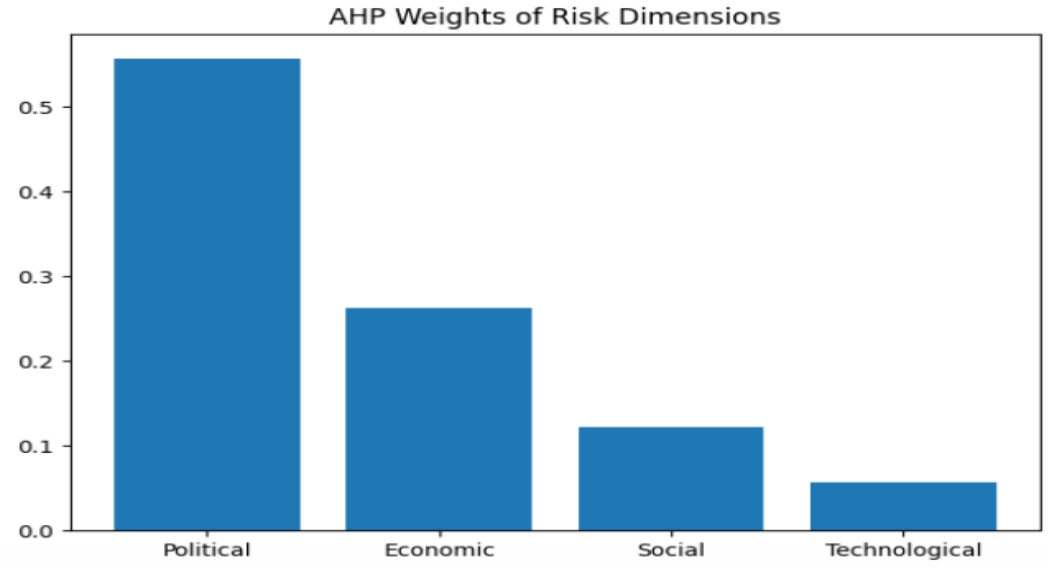

Figure 2: AHP Weights of Risk Dimensions

These weights serve as the subjective component of the hybrid weighting model and are further refined through integration with entropy-based objective weights in the subsequent analysis.

4.3 AHP–Entropy Hybrid Weighting Analysis

To enhance the robustness and objectivity of the financing risk assessment, this study integrates the Analytic Hierarchy Process (AHP) with the entropy weighting method to construct a hybrid weighting model. The AHP method is first applied to determine the relative importance of the primary risk dimensions—political, economic, social, and technological—based on expert judgment. A pairwise comparison matrix is constructed, and the normalized eigenvector is calculated to derive the subjective weights of each criterion. The results indicate that political factors carry the highest weight, followed by economic, social, and technological factors, reflecting the dominant influence of governance stability and macroeconomic conditions on project financing.

To reduce the subjectivity inherent in AHP, the entropy method is subsequently employed to compute objective weights based on the variability of observed data. Using the standardized PEST dataset, the entropy value for each indicator is calculated, and the corresponding divergence coefficients are derived to determine the entropy weights. Indicators with higher variability are assigned greater importance, thereby capturing the intrinsic information contained in the data.

The final combined weights are obtained by averaging the AHP weights and entropy weights, resulting in a balanced weighting scheme that incorporates both expert knowledge and data-driven insights. This hybrid approach improves the reliability and scientific validity of the risk evaluation model.

The entropy calculation results for individual indicators are presented in Table 1,

Factor	Category	Score
Political Stability	P	8
Policy Consistency	P	7
Economic Growth	E	6
Inflation Rate	E	5
Social Acceptance	S	7
Labor Availability	S	6
Technology Level	T	8
Environmental Regulation	T	6

Table 1: Entropy Calculation Results of PEST Indicators

while the aggregated entropy weights for each PEST dimension are integrated with AHP weights to produce the final combined weights shown in Table 2.

Criteria	Weight
Political	0.5578924751718869
Economic	0.26334511077158135
Social	0.12187261268143622
Technological	0.0568898013750955

Table 2: AHP–Entropy Combined Weights of Risk Dimensions

4.4 Results and Discussion

The empirical results derived from the PEST–AHP–Entropy framework provide important insights into the financing risk structure of metro projects under the China–Pakistan Economic Corridor. As illustrated in Figure 1, political stability and technological capability exhibit relatively high scores among the evaluated indicators, suggesting that governance conditions and infrastructure capacity play critical roles in shaping financing outcomes. In contrast, inflation rate and environmental regulation show comparatively moderate influence, although their indirect effects on cost

structures and regulatory compliance remain significant.

The AHP results, depicted in Figure 2, reveal that political factors account for the largest proportion of total weight, emphasizing the central importance of policy continuity, regulatory stability, and bilateral cooperation. Economic factors rank second, reflecting the sensitivity of metro project financing to macroeconomic conditions such as interest rates, inflation, and exchange rate fluctuations. Social and technological factors, while comparatively lower in weight, still contribute meaningfully to overall risk, particularly through their impact on project implementation and operational efficiency.

After integrating entropy-based adjustments, the final combined weights demonstrate a more balanced distribution across the four dimensions. The entropy method slightly moderates the dominance of political factors while increasing the relative importance of economic and technological indicators, indicating that data variability introduces additional nuance into the weighting structure. This confirms that relying solely on subjective judgment may overemphasize certain dimensions, whereas the hybrid approach ensures a more comprehensive and objective evaluation.

Overall, the results highlight that financing risks in CPEC metro projects are primarily driven by political and economic uncertainties, but are also significantly influenced by market dynamics and technological conditions. The application of the AHP–Entropy hybrid model provides a rigorous and adaptable framework for capturing these multidimensional interactions, thereby offering valuable support for decision-making in infrastructure financing.

5. Financing Risk Mitigation Strategies under the PEST Framework

In response to the identified financing risks, this study proposes a set of targeted strategies aligned with the PEST framework to enhance the resilience and sustainability of metro project financing under CPEC.

5.1 Political Strategies

To mitigate political and policy-related risks, strengthening institutional coordination between China and Pakistan is essential. A stable and transparent regulatory environment can reduce uncertainty and improve investor confidence. Governments should ensure policy consistency in areas such as taxation, subsidies, and financing mechanisms. In addition, improving governance, reducing bureaucratic delays, and enhancing transparency in project approvals can help minimize cost overruns and financial inefficiencies.

5.2 Economic Strategies

Given that economic factors particularly exchange rate volatility and inflation—are the dominant drivers of financing risk, appropriate financial risk management strategies are critical. The implementation of currency hedging mechanisms can help mitigate exchange rate exposure, especially for projects financed through foreign-denominated loans. Similarly, the use of financial instruments such as interest rate swaps can reduce the impact of fluctuating borrowing costs.

Furthermore, diversifying financing sources is essential to reduce reliance on external debt. Greater participation of multilateral development banks, international financial institutions, and private investors can distribute financial risk and enhance funding stability. Continuous monitoring of macroeconomic indicators such as inflation, exchange rates, and interest rates through early warning systems can enable proactive risk management.

5.3 Social Strategies

To address social risks related to ridership and demand uncertainty, improving demand forecasting and service planning is crucial. Accurate estimation of passenger flow can enhance revenue predictability and reduce dependence on government subsidies. Additionally, improving accessibility, service quality, and affordability can increase public acceptance and ridership levels, thereby strengthening financial sustainability.

Exploring alternative revenue sources—such as

commercial development around metro stations and transit-oriented development (TOD) can further enhance income generation and reduce financial pressure.

5.4 Technological Strategies

Technological strategies should focus on improving operational efficiency and reducing long-term maintenance costs. The adoption of advanced technologies for system monitoring, predictive maintenance, and energy efficiency can lower operational expenditures and improve service reliability.

Efficient project management practices, including better planning, cost control, and performance monitoring, can also contribute to reducing financial risk. Enhancing technical capacity and ensuring proper maintenance of infrastructure can prevent unexpected breakdowns and associated financial losses.

5.5 Integrated Risk Management Approach

Since PEST factors are highly interdependent, an integrated risk management approach is necessary. For instance, economic instability may reduce fiscal capacity (political), while technological inefficiencies may affect service quality and ridership (social). Therefore, policymakers should adopt a holistic framework that simultaneously addresses political, economic, social, and technological risks.

The hybrid PEST–AHP–Entropy framework used in this study can serve as a practical tool for identifying, prioritizing, and managing financing risks in metro projects under CPEC.

6. Conclusion

This study demonstrates that financing risks in metro projects under the China–Pakistan Economic Corridor are inherently multidimensional, involving complex interactions among political, economic, and market factors. Political stability and policy continuity emerge as primary determinants of financing outcomes, while economic fluctuations and market uncertainties pose significant challenges to long-term project sustainability. The integration of quantitative and qualitative assessment methods provides a comprehensive framework for evaluating these risks and supports more informed decision-making.

The findings underscore the necessity of adopting diversified financing strategies, strengthening bilateral cooperation, and enhancing risk management capabilities to ensure the successful implementation and sustainable operation of metro projects under CPEC. By offering both theoretical insights and practical recommendations, this research contributes to the broader discourse on infrastructure financing and provides a valuable reference for future cross-border projects.

References

Hussain, E. (2017). China-Pakistan Economic Corridor: Will it sustain itself?

Ali, Y., Sabir, M., & Hassan, M. (2024). Risk management in railway construction investments: CPEC ML-1 project.

Khan, M. A., & Chang, Y. (2021). The political economy of CPEC.

World Bank. (2023). World Development Indicators.

Zou, P., Zhang, G., & Wang, J. (2007). Risk management in construction projects.

Hwang, B. G., et al. (2017). Risk management in infrastructure projects.

Saaty, T. L. (1980). The Analytic Hierarchy Process.

Shannon, C. E. (1948). A mathematical theory of communication.