

Short Communication

EVALUATING SUPPLY CHAIN RISK MANAGEMENT IN PAKISTAN'S MINING SECTOR: A CASE STUDY OF THE SAINDAK COPPER-GOLD PROJECT, BALOCHISTAN

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Abstract: This study evaluates the efficacy of Supply Chain Risk Management (SCRM) procedures in Pakistan's mining sector, utilizing the Saindak Copper-Gold Project (SCGP) in Balochistan as a case study. The research employs a qualitative, single-case study design, drawing on secondary data and semi-structured interviews with key informants from procurement, logistics, production, and distribution departments. The findings reveal that the SCGP supply chain is heavily dependent on specialized Chinese suppliers for high-technology equipment and spare parts, with only low-value raw materials sourced locally. A qualitative risk assessment identifies supply-side dependencies, geopolitical vulnerabilities, logistical bottlenecks, skill gaps, and infrastructural deficiencies as critical risks ($REV \geq 12$) threatening cost-efficiency, operational continuity, and safety. Current mitigation strategies are predominantly reactive and tactical, lacking a formal, proactive SCRM framework. The study concludes that a structured SCRM process — aligned with ISO 31000 — is urgently needed, alongside strategic policy interventions to diversify supplier bases, localize skills, and develop regional industrial infrastructure. Recommendations include establishing a "Mining Technology Park" in Balochistan and mandating local content requirements for mining concessions.

Keywords: Supply chain risk management, mining sector, Saindak Copper-Gold Project, Balochistan.

Introduction

Globally interconnected supply chains offer substantial advantages, yet they have also increased systemic vulnerabilities due to supplier consolidation and just-in-time manufacturing practices (Lee, 2008). Historical disruptions—such as the 2011 Tohoku earthquake and the 2000 Philips plant fire — highlight the devastating consequences of supply chain failures (Tang, 2006; Lee and Pierson, 2011). Consequently, Supply Chain Risk Management (SCRM) has become indispensable for building resilient operations, particularly in high-risk sectors like mining. This imperative is especially pronounced in Pakistan, where Balochistan hosts the majority of the country's mining industry.

Despite possessing vast reserves of copper, gold, chromite, and other minerals, the region faces unique challenges including rugged terrain, security threats, water scarcity, sociopolitical tensions, regulatory ambiguities, and inadequate infrastructure (Shah, 2018; Yin, 2014). As the sector develops, robust SCRM is essential for navigating these compounded risks and ensuring sustainable economic growth (Board of Investment, Government of Pakistan, 2017).

This research focuses on the Saindak Copper-Gold Project (SCGP), located in the Chagai District of Balochistan, Pakistan. The project is one of the largest copper-gold deposits in the country and operates in a geographically remote and arid environment. The operational context is characterized by significant logistical challenges, security concerns, and a heavy reliance on imported technology and expertise, making it an ideal case for studying SCRM in a high-risk setting.

Although, SCRM is widely acknowledged as essential for mitigating supply chain uncertainties (Kleindorfer and Saad, 2005), its systematic implementation in Pakistan's mining industry remains poorly understood. The combination of geographical remoteness, inadequate infrastructure, security threats, and complex stakeholder interactions creates a unique risk profile in Balochistan (Shah, 2018). Existing generic SCRM frameworks may inadequately address these localized challenges, potentially leading to costly disruptions, project delays, and safety incidents.

A systematic review of the literature reveals a significant empirical gap, while foundational SCRM frameworks have been established (Lee, 2004; Jüttner *et al.*, 2005). Recent studies have explored risk management in international

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mining contexts (Kumar *et al.*, 2017; Govindan *et al.*, 2020), and there is a notable deficiency in context-specific SCRM research within Pakistan's mining sector. The specific objectives of this study are: (i) to map the supply chain network of the Saindak project and identify key internal and external risks; (ii) to analyze the potential impact of these risks on the mine's core objectives; and (iii) to investigate the mitigation strategies and mechanisms employed by the Saindak project.

Materials and Methods

Research Design and Strategy

A qualitative, single-case study design was adopted for this research, deemed most suitable for exploring the "how" and "why" inquiries concerning SCRM procedures in a relatively unexplored context. The case study approach enables comprehensive, contextual examination of the SCGP, facilitating data triangulation through interviews, documents, and secondary sources. This design addresses practical limitations, such as challenging access to multiple sites, by facilitating an in-depth examination of a singular, information-dense case.

Collection and Analysis

Primary data were collected through semi-structured interviews and questionnaires administered to 30 managers working in the production, logistics, distribution, and procurement departments of the SCGP. Participants were selected using a purposive sampling technique based on their direct involvement in supply chain operations. Secondary data were gathered from project reports, academic journals, books, government publications, and online sources. All interviews were conducted on-site at the Saindak project in Chagai, Balochistan. Qualitative data were analyzed using thematic analysis to identify key risk categories and patterns in mitigation strategies. Quantitative data from the questionnaires were analyzed using descriptive statistics and a qualitative risk assessment matrix.

Risk Assessment Framework

The risk assessment was conducted using a qualitative approach where the Probability of each risk occurring (scaled 1 to 4) and the Impact on operational objectives (scaled 1 to 4) were evaluated. The Risk Exposure Value (REV) was calculated as Probability $\times$ Impact. Risks with a REV of 12 or higher were classified as critical, requiring immediate attention. This framework allowed for the prioritization of risks based on their potential to disrupt cost-efficiency, operational continuity, and safety.

Results and Discussion

Supply Chain Mapping and Risk Identification

The SCGP supply chain is characterized by a high degree of import dependency. More than 95% of high-technology

equipment, machinery, and specialized spare parts are sourced from a network of Chinese suppliers, including Changsha Research Institute of Mining and Metallurgy, Nanchang Mining Machinery Group, Jiangsu Seagull Cooling Tower, and People's Electric Appliance Group. Only low-value raw bulk minerals (such as limestone and quartz) are procured locally. This unbalanced structure introduces several serious risks:

- **Geopolitical and Trade Policy Risks:** Over-reliance on a single nation exposes the project to international sanctions, shifts in Chinese trade policy, and geopolitical conflicts.
- **Logistics and Lead Time Risks:** The lengthy sea and land route from China to Balochistan is susceptible to port congestion, bad weather, and security incidents.
- **Single Sourcing and Information Failure:** Specialized equipment often has no alternative supplier, creating a bottleneck. Language barriers and geographical distance increase the risk of miscommunication regarding specifications.
- **Defective Supplies:** Remote quality control makes it difficult to verify equipment standards before shipment, leading to major production delays when faulty parts are received.

Internally, the crushing, grinding, flotation, and smelting processes face risks including machine breakdown (requiring specialized spare parts and technicians), utility service failure (water and electricity), workplace accidents, and a significant skills gap due to reliance on expatriate technicians.

Downstream, the transportation of finished copper-gold concentrates to Karachi port faces infrastructure inadequacies (poor road and rail networks), transportation breakdowns, cargo theft, and funds flow risks related to currency exchange and foreign customer payments.

Risk Assessment and Analysis

A qualitative assessment of probability and impact was conducted, with the results summarized in Table 1. The analysis revealed that the most critical risks ($REV \geq 12$) are primarily external and stem from the project's import dependency and the underdeveloped local infrastructure.

The risks with the highest REV scores are all interconnected. Geopolitical dependency and a lack of local industrial backup amplify operational risks like machine breakdowns (due to unavailability of spare parts and skilled technicians) and logistical failures (due to poor infrastructure). The skills gap, rated with high probability and significant impact, directly undermines the project's ability to maintain equipment independently, perpetuating a costly "fly-in, fly-out" model for Chinese technicians. This finding aligns with the work of

Table 1. Risk evaluation for SCGP.

Risk Category	Specific Risk	Probability	Impact	REV
Supply Risks	Geopolitical/Trade Policy	3	4	12
	Long Lead Times	4	3	12
	Defective Supplies	3	4	12
	Single Sourcing	4	3	12
	Information Failure	3	3	9
Operational Risks	Machine Breakdown	3	4	12
	Utility Service Failure	3	4	12
	Skills Gap	4	3	12
	Workplace Accidents	2	4	8
	Absenteeism	2	2	4
Demand Risks	Infrastructure Unavailability	4	4	16
	Transportation Breakdown	4	4	16
	Cargo Theft/Damage	3	3	9

Khan *et al.* (2018) and Hussain and Haseeb (2020), who highlighted infrastructure and geopolitical instability as major supply chain vulnerabilities in Pakistan.

Current Risk Mitigation Strategies

The current mitigation strategies observed at the SCGP are predominantly tactical and reactive rather than strategic (Table 2). For supply risks, the primary tactic is maintaining large safety stockpiles of critical spare parts, which is costly and inefficient. For operational risks, the project relies heavily on expatriate technicians to manage machine failures, with limited formalized local skill transfer. Demand and logistical risks are managed through reactive maintenance of infrastructure and the use of private security escorts.

The analysis reveals a disjointed, reactive approach to risk management. There is no evidence of an organization-wide, standardized process for systematic risk identification, formal risk assessment and resource allocation, documented risk treatment plans and tested contingency procedures, or continuous monitoring and periodic review of the risk landscape. Instead of implementing a comprehensive SCRM procedure as outlined by ISO 31000, the project focuses on immediate hazard control.

This reactive stance leaves the project highly vulnerable to systemic shocks in its complex international supply chain, echoing the findings of Jüttner (2005) who argued that reactive strategies are insufficient for managing complex risk environments.

This study set out to evaluate Supply Chain Risk Management (SCRM) practices in Pakistan's mining sector, utilizing the Saindak Copper-Gold Project (SCGP) in Balochistan as a case study. Through a comprehensive mixed-methods investigation incorporating quantitative risk assessment, qualitative interviews, and documentary analysis, the research has generated empirical insights that both confirm and extend existing understanding of supply chain vulnerability in emerging economy mining contexts.

The study confirms that while the SCGP is technically sophisticated, with modern extraction and processing capabilities that position it as one of Pakistan's premier mining operations, its supply chain is highly vulnerable. The excessive reliance on a single-country supplier base with more than 95% of high-tech equipment, machinery, and spare parts sourced from Chinese suppliers creates dangerous concentration risk that exposes the project to geopolitical tensions, trade policy shifts, and supplier-specific disruptions (Christopher and Lee, 2004). This dependency is compounded by underdeveloped local industrial and infrastructure ecosystems in Balochistan, which provide neither alternative supply sources for sophisticated inputs nor the institutional capacity to support supply chain resilience. The combination of external dependency and internal deficiency poses significant threats to cost-efficiency, operational continuity, and long-term sustainability—the core objectives around which the project's economic viability depends.

The risk assessment identified seven critical risks (REV ≥ 12): geopolitical dependency, long lead times, defective supplies, machine breakdown, utility failures, skills gap, and infrastructure unavailability. These risks are not independent but interconnected, forming a systemic vulnerability pattern where geopolitical dependency amplifies the impact of long lead times, skills gaps increase the likelihood of machine breakdowns, and infrastructure deficiencies compound the effects of utility failures (Ivanov & Dolgui, 2020). The interconnected nature of these risks means that isolated mitigation efforts — such as maintaining inventory buffers — cannot adequately address the underlying vulnerability; systemic vulnerabilities require systemic responses that address root causes rather than symptoms.

For federal and provincial governments, strategic interventions should focus on addressing the structural vulnerabilities identified in this study. The establishment of a Mining Technology Park in Balochistan — a Special Economic Zone dedicated to mining services and equipment

Table 2. Observed vs. recommended risk mitigations.

Risk	Observed Mitigation	Gap Identified
Geopolitical/Sourcing	Large safety stockpiles	No local supplier development
Machine Breakdown	Expatriate technicians; large spares inventory	Limited local skill transfer program
Infrastructure	Reactive maintenance; private security	No strategic government partnership

offering tax incentives, utility subsidies, and simplified regulations — could attract OEM assembly facilities, local manufacturing workshops, and international certification bodies, catalysing industrial development and local content creation. Investment in critical infrastructure through public-private partnerships should prioritize road and rail connections between Gwadar and Karachi ports and Balochistan's mining belts, alongside ensuring reliable water and electricity supply to industrial areas. Implementation and enforcement of international quality management and HSE standards (ISO 9001, ISO 45001) across the mining sector would build international confidence in Pakistani mining products and services. Finally, mandating technology transfer, skills development, and local content requirements in operating licenses for international contractors would ensure that foreign investment contributes to building indigenous capabilities.

Conclusion

Based on these findings, several strategic recommendations emerge for key stakeholders. For SCGP operators, the immediate priority should be establishing a formal SCRM framework aligned with international standards such as ISO 31000:2018, incorporating systematic risk identification, assessment, treatment, and continuous monitoring. This should be accompanied by active supplier diversification efforts to reduce geopolitical dependency, seeking qualified suppliers from alternative countries including South Korea, Turkey, and European nations for non-proprietary equipment. Additionally, a strategic localization program should be implemented comprising structured technical training for Pakistani engineers and technicians to progressively reduce reliance on expatriate staff, and systematic identification and support of capable Pakistani businesses to provide consumables, spare parts, and eventually sub-assemblies. The study has limitations that should be acknowledged, including the single-case design limiting generalizability, sample size constraints for statistical analysis, and reliance on interview data with potential for respondent bias. These limitations suggest directions for future research, including quantitative validation of risk assessment findings across multiple mining sites in Balochistan, evaluation of the effectiveness of localization interventions, investigation of the role of digital technologies (IoT, AI) in enhancing SCRM in remote mining operations, and exploration of the political economy dimensions of supply chain risk in Pakistan's mining sector.

In conclusion, starting with the enormous potential of Balochistan, Pakistan can turn its mining industry from a consumer of imported technology and a source of raw materials into a technologically sophisticated, self-sufficient sector that creates long-term jobs, supports domestic manufacturing, and makes a substantial contribution to the national economy. The path forward requires coordinated action by project operators and government authorities, guided by strategic vision and sustained commitment to systematic risk management and capability development.

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