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Analyzing Spatial Differences in Construction Risk Management: A Comparative Study of Regional Perception

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The Arctic region is often assessed as having high uncertainty and risk in construction projects owing to its extreme environmental conditions. However, it is emerging as a new frontier for future energy development, given its abundant resources. We aim to establish a risk management framework by identifying country risk factors that arise from spatial differences when Korean construction companies, with extensive experience in Middle Eastern and Asian construction projects, enter the less familiar Arctic market. Through a comprehensive literature review, 21 country risk factors were identified. Subsequently, a survey was conducted among Korean experts involved in overseas construction projects to assess these risks. The results indicate that in the Middle East, "political" and "legal" risks are perceived as relatively severe, attributed to the instability of political institutions and legal frameworks. In contrast, in the Arctic, "environmental" and "cultural" risks are identified as the most critical, primarily owing to the extreme climate and stringent environmental protection regulations. In this study, we utilized human sensing methodologies through expert surveys to capture spatially informed risk data. This study contributes to understanding the regional characteristics of country risks driven by spatial differences and provides foundational data for Korean construction companies in formulating strategies for international project entry. However, the study is limited by a lack of comprehensive data on the Arctic region, necessitating future research to develop adaptive strategies through long-term data collection on environmental changes.

1. Introduction

As global resource depletion accelerates, the demand for construction projects aimed at resource development has been increasing. Korean construction companies have also been actively securing overseas construction projects, with plant construction projects accounting for the highest proportion at 42% of their total contracts.(1) Historically, these companies have predominantly focused on plant construction projects in the Middle East and Asia.(2) However,

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owing to the decline in international oil prices, the construction market in the Middle East has contracted, leading to increased uncertainty in securing new contracts since 2017.[3] From a long-term perspective on the global oil market, energy demand is expected to rise by approximately 25% by 2030, with the demand for oil anticipated to continue growing until 2040.[4] This has led to an increased global emphasis on developing new markets for resource exploitation to meet future energy needs.

The Arctic region, encompassing territories such as Russia, Alaska (USA), Canada, and Norway, among others, is recognized as holding 13% of the world's undiscovered oil and 30% of its undiscovered natural gas reserves.[5] Recently, resource development activities in the Arctic have gained significant momentum. Countries within the Arctic region have already begun resource extraction and secured economically viable reserves through exploration and drilling activities. The Korean government is also actively pursuing policies to increase opportunities for Korean construction companies to participate in Arctic development projects. However, the Arctic region is characterized by extreme challenges, including severe cold, instability in permafrost due to global warming, and isolation from external resources, all of which contribute to a highly adverse construction environment.[6] Additionally, Korean construction companies face difficulties in entering the Arctic market owing to unique country risks associated with spatial differences from their previous experiences in the Middle East and Asia.

The International Organization for Standardization defines risk as the "effect of uncertainty on objectives, which can result in both loss and opportunity".[7] Overseas construction projects are particularly susceptible to country risks due to spatial differences (e.g., political, economic, social, and cultural) between the host and home countries, which may negatively impact the financial viability of such projects.[8] Plant construction projects, in particular, are characterized by large-scale operations, significant initial investments, and irreversible decision making processes.[9] To ensure profitability in the Arctic region, it is imperative that Korean construction companies assess the country risks arising from these spatial differences and develop strategic risk management approaches. In this study, experts function as "human sensors", providing critical insights into regional risks, thereby enabling the identification and quantification of risks that may otherwise be difficult to assess.

In this study, we aimed to evaluate the country risks associated with plant construction projects in the Middle East, Asia, and the Arctic from the perspective of Korean construction companies and to analyze regional differences in risk perception. The methodology of this study is as follows: First, in Sect. 2, the concept of risk as defined for this study will be explained, and a literature review of risk factors considered in overseas construction projects will be conducted. Second, in Sect. 3, a framework for evaluating country risks will be proposed, and the key risk factors for plant construction projects in the Middle East, Asia, and the Arctic will be assessed from the perspective of Korean construction companies. Third, in Sect. 4, the regional differences in risk perception across the Middle East, Asia, and the Arctic will be analyzed on the basis of the same risk factors. This study is expected to contribute to the development of risk management strategies by analyzing the perception differences driven by spatial differences for the same risk factors.

2. Theoretical Consideration

2.1 Risk management

Overseas construction projects, while offering opportunities for market expansion and profit generation, also carry a high degree of uncertainty owing to the substantial capital investments required and the long-term nature of the return on investment. Consequently, these projects face significantly higher risks than domestic projects. To ensure the financial stability and profitability of overseas projects, it is essential to implement advanced risk management strategies and make strategic decision making.

The concept of risk management began in 1955, initially focusing on risk assessment in the financial sector during the 1960s. The idea of financial risk management started to emerge in the early 1970s. Initially, risk management was limited to insurance and finance; however, from the mid-1980s, leading global construction companies began to formally adopt risk management concepts, which have since expanded to encompass all sectors.(10) In particular, risk management has been addressed from a corporate management perspective, with the concept becoming established in the Korean construction industry in the early 2000s. As the number of overseas construction projects has increased recently, the establishment and application of risk management strategies have become more critical than ever. Risks associated with overseas construction projects not only reduce profitability and extend construction periods but can also lead to the overall failure of a project. Therefore, it is essential to develop tailored risk management strategies that consider the specific characteristics of each project when undertaking overseas construction endeavors.

Numerous studies have proposed a standardized process for risk management, which typically involves three key stages: (1) risk classification and identification, (2) risk analysis and evaluation, and (3) risk response and monitoring. In this study, we followed these stages to conduct a comprehensive risk assessment, identify key risk factors, and analyze spatial differences in risk perception.

2.2 Risk identification

To successfully execute a project, it is essential to consider and manage a wide range of risk factors. Internally, factors such as the company's environment, capabilities, planning, schedule, and costs must be considered. Externally, country risks stemming from spatial differences, including political, economic, social, and cultural factors, must be considered. Numerous studies have been conducted to identify and manage both internal and external risk factors.

Pinto and Mantel identified key risk factors that contribute to construction project failure through a comprehensive literature review.(11) The key factors identified include project scope, management objectives, schedule management and planning, and communication with stakeholders, among a total of 10 critical factors. Zhi identified 60 risk factors specific to overseas construction projects.(12) Bing *et al.*, through a case study in China, presented 25 critical factors affecting the execution of overseas construction projects, categorized into internal, project-specific, and external risk factors.(13) Hastak and Shaked classified the international construction market into three levels (country, market, and project) and identified risk factors while proposing an evaluation framework.(14) Baloi and Price further subdivided risks in international construction projects into seven categories, including estimation, design, and competition level, providing a more detailed analysis of specific risks.(15)

In Korea, several studies have also focused on identifying risk factors and proposing management strategies for construction projects. Han *et al.* used construction indicators to identify factors affecting profitability in the construction industry, particularly in overseas projects.(16) Kim identified risk factors that impact the profitability of overseas construction projects and developed a profitability prediction model.(17) Cha and Shin defined the relationship between project costs and risk factors, identifying key risks.(18) Bae identified risk factors associated with the construction phases of LNG plant projects in the Middle East.(19) Park identified and proposed management strategies for risk factors in overseas power plant EPC projects.(20) Hyun identified risk factors in South African independent power projects and proposed mitigation strategies.(21) Wee identified risk factors and assessed their relative importance in Russian LNG liquefaction plant construction projects.(22) Lee identified risk factors in Indian power projects and used the Analytic Hierarchy Process (AHP) method to develop a risk matrix.(23) Choi proposed a risk management model for independent power projects in Myanmar.(24) Table 1 shows a summary of both domestic and international studies on identifying and managing risk factors in construction projects.

Despite extensive research on risk factors and management strategies in various regions, studies on the Arctic region are limited. In this study, we identified key risk factors in the Arctic construction market and analyzed differences in risk perception compared with those in the Middle East and Asia construction markets to establish strategies for entering new markets.

Table 1
Literature review on risk identification.

Author	Key research contents
Pinto (1990)	Identification of key factors leading to project failure, deriving 10 major influencing factors
Zhi (1995)	Derivation of 60 risk factors based on four major classifications of construction project characteristics
Bing (1999)	Presentation of risk management factors based on a case study in China, deriving 25 influencing factors grouped into three categories
Hastak (2000)	Risk identification and evaluation system for international construction projects categorized at national, market, and project levels
Baloi (2003)	Derivation of risk factors by subdividing construction risks into seven categories
Han (2001)	Derivation of profitability influencing factors related to construction works by utilizing construction-related indicators
Kim (2005)	Identification of factors affecting profitability in international construction projects and development of a profitability prediction model
Cha (2006)	Derivation of risks through the relationship between project costs and risk factors
Bae (2010)	Identification of feasibility factors at each stage of a Middle East LNG plant project
Park (2011)	Risk identification and management plan presentation through risk analysis in power EPC projects
Hyun (2016)	Risk identification and prioritization in South Africa's IPP power projects for EPC execution, with suggested countermeasures
Wee (2016)	Derivation and prioritization of risk factors for Russian LNG liquefaction plant projects
Lee (2018)	Risk identification for Indian power projects using the AHP method
Choi (2020)	Presentation of a risk management model for Myanmar's independent power projects

2.3 Country risk

Country risk is a critical factor in international business and overseas construction projects, encompassing the uncertainties and risks arising from a country's political, economic, social, and environmental conditions. Numerous studies have defined and analyzed the concept of country risk. In this study, we seek to review these existing definitions and, building upon this review, propose a refined definition of country risk.

Kobrin primarily considers country risk as political risk, emphasizing the impact of governmental policy changes, civil unrest, and political instability on corporate operations.(25) His study particularly highlights the significant effect of political risk on corporate success in developing countries. Meldrum defines country risk as the political and economic uncertainties that affect foreign direct investment.(26) He analyzed how political stability, economic growth rates, and exchange rate fluctuations significantly affect investment decisions. Howell provided a more comprehensive definition of country risk, integrating not only political risk but also economic, social, and environmental risks.(27) He argued that these factors collectively form a country-specific risk profile. Bekaert *et al.* defined country risk in relation to economic development in emerging markets, emphasizing that economic growth and market openness are key elements in reducing risk.(28)

In this study, we define country risk as the risks stemming from differences in national characteristics owing to spatial differences. We emphasized that political, economic, environmental, and cultural factors in specific regions can create distinct risk profiles even for similar industrial activities. We aim to systematically analyze these risk factors to provide a strategic foundation for Korean construction companies when entering various international markets.

3. Country Risk Assessment Framework

3.1 Risk identification

In this study, we aimed to propose a framework for identifying key risk factors in overseas construction projects and analyzing the spatial differences in risk perception (Middle East, Asia, amd Arctic regions). First, a literature review was conducted to identify risk factors that should be considered in plant construction projects, and a risk breakdown structure (RBS) was established through expert consultation. Second, the identified risk factors were evaluated by a group of Korean experts with experience in overseas plant construction projects, and the collected survey data were then subjected to a reliability assessment to ensure their accuracy and trustworthiness. Third, individual risks were evaluated using data on risk occurrence probability and impact intensity, and key risk factors were identified for each region (Middle East, Asia, or Arctic region). Finally, the spatial differences in the perception of the same risk factors were analyzed, and tailored risk management strategies were proposed accordingly.

RBS is a tool used in project management, which systematically categorizes and organizes potential risks in a hierarchical structure. By classifying and organizing risks, RBS enables risk assessment and management.(29) In this study, a literature review was conducted to establish a mid-level RBS framework specifically for evaluating overseas construction projects from the perspective of Korean construction companies, and the findings are summarized in Table 2.(30–39) The mid-level risk factors for overseas construction projects can be broadly divided into two categories: project environment risk factors and construction project phase risk factors. To analyze spatial differences across regions (Middle East, Asia, and Arctic regions), the project environment risk factors were further classified into six subcategories: political, economic, cultural, environmental, market, and legal.

The 39 country risk factors corresponding to six mid-level categories were identified on the basis of theoretical considerations. These 39 country risk factors were validated through interviews with experts who have experience in executing overseas construction projects, resulting in the final identification of 21 key country risk factors, as summarized in Table 3.

3.2 Questionnaire development and reliability assessment

In this study, a survey was conducted on the basis of the established RBS with Korean construction experts who have experience in construction projects across different regions (Middle East, Asia, and Arctic regions). These experts served as “human sensors”, detecting and evaluating regional risks through their experiences, allowing the study to gather spatially informed risk data that would be difficult to quantify otherwise. The survey served as a tool to quantify the qualitative experiences of these experts, with the Likert scale being utilized in many studies owing to its convenience in measurement. The Likert scale, represented by discrete numbers, allows experts to express their opinions and easily demonstrates the relative magnitude

Table 2
Literature review for mid-level RBS classification.

Author	Number of risks	Key research contents
Kim (2005)	14	Contractor Capability, Project Characteristics, Project Environment, Client/Supervisor, Members, Country Environment, Project Information, Design, Cost Management, Estimation, Joint Venture, Contract, Bidding, Dispute
Cha (2006)	7	Schedule, Cost, Quality, Safety, Legal/Environmental, Contractual and Interpersonal Relationships, Plan
Ahn (2008)	5	Client/Region, Business Environment, Contract/Scope of Work, Project Characteristics, Construction/Project Management
Park (2011)	4	Design, Procurement, Construction, Commissioning
Kim (2011)	3	Engineering, Procurement, Construction
Park (2011)	4	Design Review, Procurement Review, Manufacturing Review, Construction Review
Kim (2015)	6	Design, Procurement and Supply, Construction, Commissioning, Project Management, External
Ahn (2012)	6	Political, Economic, Social, Environment, Institutional, Regulatory
Jung (2017)	7	External: Political, Economic, Social and Infrastructure Internal: Organizational Management, Construction Management, Localization, Construction Technology
Choi (2020)	8	Country, Economic Environment, Client, Project Feasibility, Profitability, Construction, Fuel, Power Market

Table 3
Risk breakdown structure (RBS).

Primary	Mid-level	Country risks		
		Number	Risk	Description
Country Risk	Political	P-1	Interference and regulations of state and central government	Increased administrative requirements, public fees, protectionist measures
		P-2	Suspension of business due to chaos such as regime change and civil war	Temporary suspension of transactions with specific countries, delay in administrative approval processes
		P-3	Corruption practices in the country such as bribery and collusion	Unfair payment practices, collusion and underground transactions
	Economic	E-4	Deterioration of the economy and financial condition of the country	Financial deterioration or bankruptcy of project owners leading to reduced funding capacity
		E-5	Changes in wages or material price	Excessive wage increases or fluctuations in material costs
		E-6	Impact of international currency and exchange rate fluctuations	Financial burdens due to currency depreciation
	Culture	C-7	Language barriers and cultural heterogeneity	Reduced labor productivity due to communication issues
		C-8	Conflicts due to religious and cultural differences	Productivity declines due to religious factors in the country
		C-9	Conflicts with organizations related to the project	Public complaints and protests from environmental groups due to lack of social consensus
	Environment	E-10	Effects of climate and weather	Adverse construction conditions and productivity loss due to climatic factors
		E-11	Effects of force majeure and irresistible force	Construction delays caused by glaciers, freezing, or sandstorms
		E-12	Effects of the ground condition	Reduced productivity due to ground characteristics
		E-13	Environmental regulations due to environmental protection in the country	Environmental requirements and degree of regulation in the host country
	Market	M-14	Holding status (present condition of possession) of technicians in the country	Availability of foreign labor and the skill level of local workers
		M-15	Site conditions different from the design	Discrepancies in the quality of specifications and design documents
		M-16	Lack of infrastructure	Infrastructure challenges in the host country, such as road, electricity, telecommunication, water, and internet services
		M-17	Difficulty in securing locally procured materials and equipment	Availability of locally sourced materials, distribution structures, and import restrictions
		M-18	Project experience in the country	Productivity loss due to lack of experience
	Legal	L-19	Delays in licensing and construction administrative procedures	Delays in obtaining permits due to inefficient administrative processes
		L-20	Claims and litigation-related unreasonableness	Unfair dispute resolution methods and prolonged arbitration periods
		L-21	Imposition of unfair taxes and rates	Customs duties, taxes, value-added tax (VAT), technology taxes, personal income tax, corporate income tax

of individual evaluation indicators.[40] Accordingly, we developed a questionnaire for assessing country risks in overseas construction projects using the established RBS and a Likert scale. The survey was conducted with a total of 120 overseas construction experts. The impact of country risk factors on project construction costs was assessed using a 7-point Likert scale. Out of 120 questionnaires distributed, 93 valid responses were obtained, following the exclusion of incomplete and nonrelevant submissions

Among the survey respondents, the largest group consisted of those with 6 to 15 years of experience in overseas construction projects, totaling 48 respondents. This was followed by 33 respondents with less than 5 years of experience and 12 respondents with more than 15 years of experience. Regarding the role of the respondents, 66 were from construction companies, while 27 were from client organizations. The details are summarized in Table 4.

In this study, SPSS Statistics 16 was used to verify the reliability of the survey. To assess internal consistency, Cronbach's alpha coefficient was utilized for the reliability testing of the survey items. Cronbach's alpha values range from 0 to 1, with a result of 0.8 or higher indicating high reliability. A value of 0.6 or above generally suggests acceptable internal consistency and is considered to demonstrate reliability.[41] In this study, all measurement items achieved Cronbach's alpha values ranging from 0.6 to 0.9, indicating high internal consistency and reliability.

3.3 Risk assessment

In this study, a Risk Probability-Impact Evaluation (PI) assessment was conducted using survey data on the probability of occurrence (P) and impact intensity (I) of country risks, leading to the identification of key risk factors by region. The PI assessment is an analytical technique used in risk management to determine the importance and prioritization of risks. It quantitatively assesses the probability of a risk occurring and the severity of its impact. The PI value is calculated by multiplying the probability of occurrence (P) by the impact intensity (I), as shown in Eq. (1). The PI value represents the relative severity of a risk, with higher PI values typically indicating risks that should be prioritized for management.[42] The results of the PI assessment are crucial for developing risk mitigation strategies. The PI assessment results for country risks in different regions (Middle East, Asia, and Arctic regions) conducted in this study are summarized in Table 5.

Table 4
Respondent demographic information.

Characteristic	Frequency	Percentage (%)	Cumulative percentage (%)
Experience (years)	–	–	–
0–5	33	35.5	35.5
6–15	48	32.7	88.2
> 15	12	11.8	100
Working position	–	–	–
Owner companies	27	29	29
Constructor	66	71	100

Table 5
Results of PI assessment.

Primary	Mid-level	Country risks	(a) Arctic region			(b) Middle East			(c) Asia		
		Number	P-I	Average	Rank	P-I	Average	Rank	P-I	Average	Rank
Country Risk	Political	P-1	3.16	2.34	18	4.31	3.50	10	3.66	3.34	15
		P-2	1.95		20	3.28		17	3.08		21
		P-3	1.93		21	2.89		20	3.29		18
	Economic	E-4	3.58	4.10	15	3.35	4.09	16	4.22	4.62	11
		E-5	4.76		7	4.69		6	4.75		4
		E-6	3.96		12	4.22		11	4.91		3
	Culture	C-7	3.39	3.53	17	3.74	3.18	13	3.18	3.24	20
		C-8	2.19		19	3.38		15	3.35		17
		C-9	5.02		5	2.42		21	3.18		19
	Environment	E-10	5.73	5.23	1	5.34	3.95	1	5.62	4.64	1
		E-11	4.62		8	3.44		14	4.14		13
		E-12	5.40		2	3.93		12	5.09		2
		E-13	5.16		4	3.09		19	3.70		14
	Market	M-14	4.50	4.51	10	4.67	4.66	7	4.62	4.39	5
		M-15	4.45		11	4.79		4	4.24		10
		M-16	3.44		16	4.54		8	4.25		9
		M-17	4.79		6	4.98		2	4.47		7
		M-18	5.38		3	4.33		9	4.37		8
	Legal	L-19	4.52	3.95	9	4.82	4.23	3	4.56	3.60	6
		L-20	3.68		13	4.77		5	3.37		16
		L-21	3.66		14	3.11		18	2.88		22

$$PI = P(Probabilty) \times I(Impact) \quad (1)$$

3.4 Analysis of spatial differences in risk perception

3.4.1 Analysis of spatial differences in "Arctic region" perception

Table 5(a) presents the results of the PI assessment for country risks in the Arctic region, showing that the "Environment" risk category has the highest severity, while the "Political" risk category has the lowest severity. This finding can be interpreted as reflecting the extremely harsh construction environment in the Arctic region owing to severe climatic conditions, despite the political stability provided by the presence of many advanced countries. The key country risk factors identified with the highest relative severity are "Influences of Climate and Weather (E-10)", "Influence of the Ground Condition (E-12)", "Project Experience in the Country (M-18)", and "Environmental Regulations due to Environmental Protection in the Country (E-13)". Corell highlighted that the irregular and extreme weather conditions in the Arctic region have significant impacts on working conditions and construction materials.[43] Several studies have pointed out the difficulties in construction processes due to extreme climatic and unstable geological conditions in the Arctic region, emphasizing the importance of developing strategies to manage these risks. A comparison with the Middle East, as shown in Table 5(b), reveals that the risks "Environmental Regulations due to Environmental Protection in the Country (E-13)" and "Conflict with Organizations related to the Project (C-9)" are rated as having a lower severity in the Middle East than in the Arctic region. This suggests that Korean construction companies with substantial experience in the Middle East need to develop management strategies for E-13 and C-9 risks when expanding into the Arctic region.

3.4.2 Analysis of spatial differences in "Middle East" perception

Table 5(b) presents the results of the PI assessment for country risks in the Middle East, indicating that the "Market" risk category has the highest severity, while the "Culture" risk category has the lowest severity. This finding suggests that construction projects in the Middle East often take place in environments with underdeveloped infrastructure, despite Korean construction companies having substantial experience in the region. The key country risk factors identified with the highest relative severity are "Influences of Climate and Weather (E-10)", "Difficulty in Securing Locally Procured Materials and Equipment (M-17)", "Delays in Licensing and Construction Administrative Procedures (L-19)", and "Site Conditions Different from the Design (M-15)". Extreme weather conditions in the Middle East, such as temperatures exceeding 50 °C during the summer, necessitate reduced working hours, while frequent sandstorms and high dust levels in desert areas can constrain project progress. Additionally, the geographical characteristics of the Middle East can create difficulties in equipment operation, leading to procurement and logistics challenges.

3.4.3 Analysis of spatial differences in "Asia" perception

Table 5(c) presents the results of the PI assessment for country risks in Asia, revealing that the "Environment" and "Economic" risk categories have the highest severity, while the "Culture" risk category has the lowest severity. This finding can be interpreted as reflecting the challenging construction environment in Southeast Asia, where many countries face poor financial conditions and experience high temperatures and rainfall due to tropical climates, leading to difficult construction conditions. Similar to the Middle East, Korean construction companies also have substantial experience in construction projects in Asia. The key country risk factors identified with the highest relative severity are "Influences of Climate and Weather (E-10)", "Influence of the Ground Condition (E-12)", "Impact of International Currency and Exchange Rate Fluctuations (E-6)", and "Changes in Wages or Materials Price (E-5)".

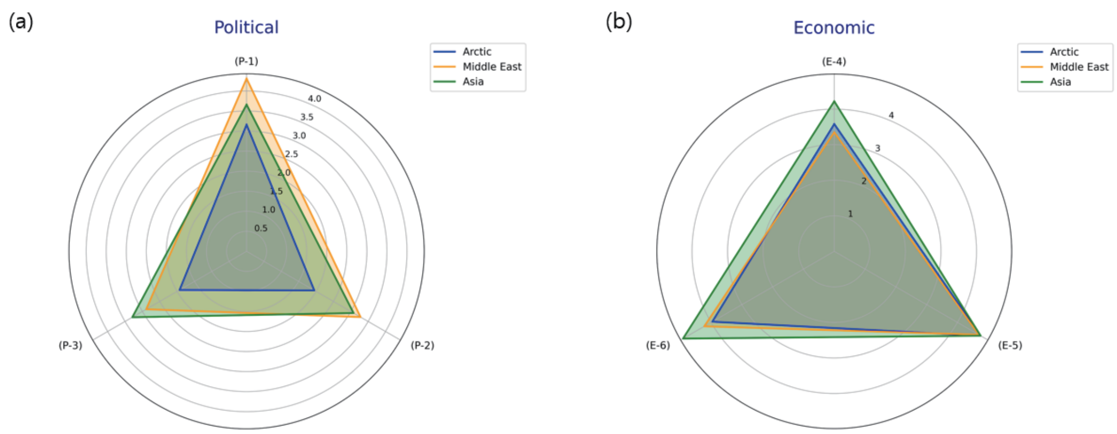
4. Discussion

4.1 Analysis of spatial differences in "Political Risk" perception

We aimed to analyze spatial differences in perceptions of "political" risks based on the intermediate classification of RBS, focusing on the Middle East, Asia, and Arctic regions. The risk prioritization of political risks was confirmed to be higher in the Middle East. This result indicates that emerging markets, such as the Middle East and Asia—key regions for Korean construction project contracts—are politically less stable than developed countries. The prioritization of country risks is higher in emerging markets (Middle East and Asia) due to unstable political and legal systems. The most effective way for Korean construction companies to address such country risks is to utilize international investment arbitration, specifically the investor-state dispute settlement ISDS mechanism, rather than litigation in domestic courts or the WTO dispute settlement system in these countries.(44) The spatial differences (Middle East, Asia, and Arctic regions) in perceptions of political risks are summarized in Fig. 1(a).

4.2 Analysis of spatial differences in "Economic Risk" perception

We aimed to analyze spatial differences in perceptions of "economic" risks based on the intermediate classification of RBS, focusing on the Middle East, Asia, and Arctic regions. The risk prioritization of the country risk "Changes in Wages or Material Price (E-5)" was confirmed to be high across all regions. This result indicates that this country risk must be effectively managed to ensure the financial stability of projects, as it directly affects both construction costs and project schedules. The risk prioritization of "Deterioration of the Economy and Financial Condition of the Country (E-4)" was found to be higher in Asia than in other regions. This can be interpreted as being due to the heavy reliance on foreign investment for infrastructure construction in the region and its significant exposure to global economic conditions.(45) The risk prioritization of the country risk "Impact of International Currency and Exchange Rate Fluctuations (E-6)" was confirmed to be higher in the Middle East and Asia than in the Arctic region. This is likely because the payment currency in international construction projects is primarily the U.S. dollar, leading to lower impacts from currency fluctuations in the Arctic region, which includes many developed countries. The spatial differences in perceptions of economic risks (Middle East, Asia, and Arctic regions) are summarized in Fig. 1(b).



	P-1	P-2	P-3
Arctic	3.16	1.95	1.93
Middle East	4.31	3.28	2.89
Asia	3.66	3.08	3.29

	E-4	E-5	E-6
Arctic	3.58	4.76	3.96
Middle East	3.35	4.69	4.22
Asia	4.22	4.75	4.91

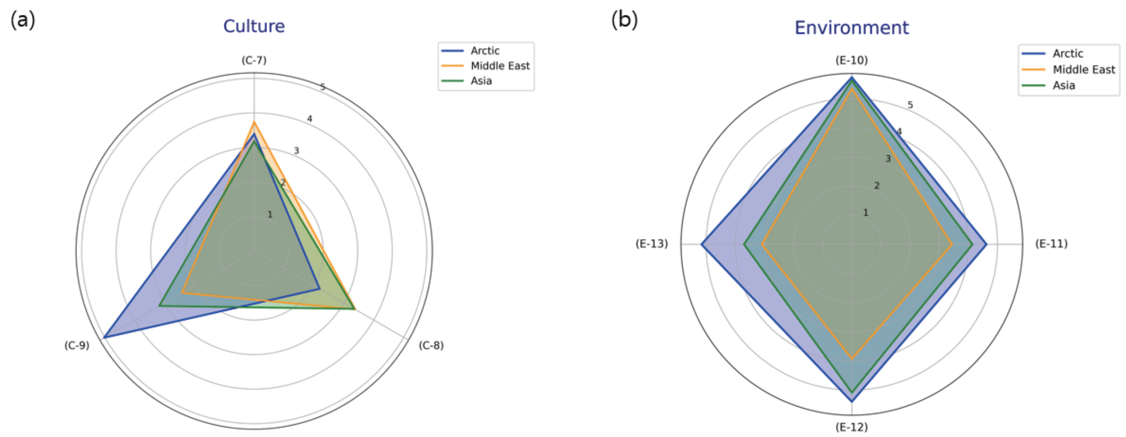
Fig. 1. (Color online) Spatial differences in "political" and "economic" risk perceptions.

4.3 Analysis of spatial differences in "Cultural Risk" perception

We aimed to analyze spatial differences in perceptions of "cultural" risks based on the intermediate classification of RBS, focusing on the Middle East, Asia, and Arctic regions. The country risk "Conflicts with Organizations related to the Project (C-9)" was confirmed to have a higher prioritization in the Arctic region than in other regions. This can be attributed to the strong opposition from environmental protection groups, leading to complaints and protests against development in the region.(46) The risk prioritization of the country risk "Conflicts due to Religious and Cultural Differences (C-8)" was found to be higher in the Middle East and Asia than in the Arctic region. This can be interpreted as being due to the decline in construction productivity caused by the religious characteristics of the Middle East and Asia. The country risk "Language Barriers and Cultural Heterogeneity" was shown to have similar levels of prioritization across all regions. The spatial differences (Middle East, Asia, and Arctic regions) in perceptions of culture risks are summarized in Fig. 2(a).

4.4 Analysis of spatial differences in "Environment Risk" perception

We aimed to analyze spatial differences in perceptions of "environmental" risks based on the intermediate classification of RBS, focusing on the Middle East, Asia, and the Arctic region. It was observed that environmental risks are perceived to be more prioritized in the Arctic region than in the Middle East and Asia. This may be due to Korean construction companies with less experience in executing construction projects in the Arctic region. As a result, they perceive environmental risks in the Arctic to be more significant than in the more familiar regions of the Middle East and Asia. Additionally, the Arctic region has stricter environmental regulations, including institutional safeguards designed to mitigate the risks of environmental pollution. The spatial differences (Middle East, Asia, and Arctic regions) in perceptions of environment risks are summarized in Fig. 2(b).



	C-7	C-8	C-9
Arctic	3.39	2.19	5.02
Middle East	3.74	3.38	2.42
Asia	3.18	3.35	3.18

	E-10	E-11	E-12	E-13
Arctic	5.73	4.62	5.40	5.16
Middle East	5.34	3.44	3.93	3.09
Asia	5.62	4.14	5.09	3.70

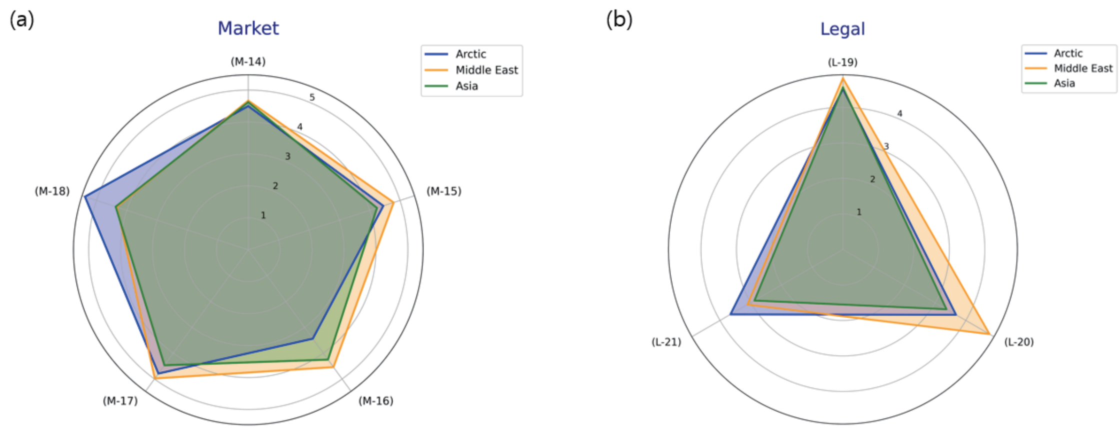
Fig. 2. (Color online) Spatial differences in "culture" and "environment" risk perceptions.

4.5 Analysis of spatial differences in "Market Risk" perception

We aimed to analyze spatial differences in perceptions of "market" risks based on the intermediate classification of RBS, focusing on the Middle East, Asia, and Arctic regions. The country risks "Holding Status of Technicians in the Country (M-14)", "Site Conditions Different from the Design (M-15)", and "Difficulty in Securing Locally Procured Materials and Equipment (M-17)" were confirmed to have high prioritization across all regions. The country risk "Project Experience in the Country (M-18)" showed the highest prioritization in the Arctic region. In contrast, the country risk "Lack of Infrastructure (M-16)" was confirmed to have the lowest prioritization in the Arctic region. This can be attributed to the Arctic region's extreme climatic conditions, which lead to the use of modular construction methods for many processes, thereby reducing the risk prioritization. On the other hand, this risk was found to be more prioritized in the Middle East and Asia than in the Arctic region. The spatial differences (Middle East, Asia, and Arctic regions) in perceptions of market risks are summarized in Fig. 3(a).

4.6 Analysis of spatial differences in "Legal Risk" perception

We aimed to analyze spatial differences in perceptions of "legal" risks based on the intermediate classification of RBS, focusing on the Middle East, Asia, and Arctic regions. The country risks "Delay in Licensing and Construction Administrative Procedures (L-19)" and "Claims and Litigation related to Unreasonableness (L-20)" were confirmed to have a higher prioritization in the Middle East. Middle Eastern countries each have their own unique legal systems, and in some cases, the legal and regulatory processes are considered highly complex and opaque. It is particularly advisable to manage these risks in the Middle East by executing projects through local partnerships. The spatial differences (Middle East, Asia, and Arctic regions) in perceptions of legal risks are summarized in Fig. 3(b).



	M-14	M-15	M-16	M-17	M-18
Arctic	4.50	4.45	3.44	4.79	5.38
Middle East	4.67	4.79	4.54	4.98	4.33
Asia	4.62	4.24	4.25	4.47	4.37

	L-19	L-20	L-21
Arctic	4.52	3.68	3.66
Middle East	4.82	4.77	3.11
Asia	4.56	3.37	2.88

Fig. 3. (Color online) Spatial differences in "market" and "legal" risk perceptions.

5. Conclusions

The Arctic region is emerging as a new market for energy supply development, owing to its abundant natural resources. However, its extreme environmental conditions pose significant challenges to construction activities, leading to heightened project uncertainty and considerable risks. For Korean construction companies seeking to secure project stability in Arctic plant construction projects, it is essential to assess the country risks associated with the spatial differences and to develop strategic risk management approaches. In this study, we evaluated the country risks encountered in plant construction projects across the Middle East, Asia, and Arctic regions from the perspective of Korean construction companies. Furthermore, we analyzed the differences in risk perception across these regions, providing insights into country risk management strategies.

We proposed a framework to identify key country risks by region and to analyze differences in risk perception. First, a literature review was conducted to identify 21 critical risk factors relevant to plant construction projects, leading to the development of RBS. Second, a survey was administered to experts involved in Korean overseas construction projects, followed by a reliability analysis of the collected data. Third, the data were used to assess individual risks and identify key country risk factors for each region, namely, the Middle East, Asia, or Arctic region. Finally, a comparative analysis of spatial differences in risk perception was conducted, and tailored risk management strategies were proposed.

The analysis of spatial differences in risk perception revealed the following findings. The political risk was found to be relatively more severe in the Middle East. This can be attributed to the political and institutional instabilities that are more prevalent in emerging markets (e.g., the Middle East and Asia) than in developed countries. Regarding economic risks, the "Changes in Wages or Material Prices (E-5)" risk was identified as having a high level of severity across all regions, owing to its direct impact on construction costs and duration. For cultural risks, the "Conflicts with Organizations related to the Project (C-9)" risk was particularly significant in the Arctic region, likely due to stringent environmental protection regulations. Furthermore, the severity of the "Conflicts due to Religious and Cultural Differences (C-8)" risk was higher in the Middle East and Asia than in the Arctic region, underscoring the need for effective risk management strategies to ensure construction productivity in these regions. In the environmental risk category, the Arctic region demonstrated a higher relative severity, which can be explained by the lack of experience that Korean construction companies have in this area. Conversely, the market risk, specifically "Lack of Infrastructure (M-16)", was found to be least severe in the Arctic region, likely owing to the prevalent use of modular construction techniques to overcome extreme environmental conditions. Finally, the legal risks were found to be relatively more severe in the Middle East than in other regions. This suggests that risk management in the Middle East should focus on leveraging local partnerships to effectively navigate these challenges.

This study provides valuable insights into the disparities in the perception of country risks, which arise from spatial differences between the Arctic region, where global experience in construction projects remains relatively limited, and the Middle East and Asia, where such experience is substantially more extensive. Additionally, the study provides value by identifying key country risk factors in the Middle East, Asia, and Arctic regions from the perspective of Korean construction companies, and by proposing corresponding risk management strategies. However, there are limitations due to the global lack of experience with construction projects in the Arctic region, which made it challenging to obtain sufficient data for a comprehensive analysis of certain risks. Future research should focus on the long-term collection of data from construction projects in the Arctic region to develop strategies for responding to environmental changes.

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