Causes of Construction Delays in Countries with High Geopolitical Risks

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Abstract: International construction contractors are increasingly expanding their business into emerging markets that are often characterized by high geopolitical risk. Working in these regions poses unique challenges that lead to unconventional causes for construction delay. As such, this research aims to (1) develop a better understanding of the causes of delays that may be encountered in countries with high geopolitical risks, (2) gauge the relative impact these delay causes are expected to have on project completion, and (3) capture how delay causes are influenced by project and country characteristics. Research findings are based on two distinct data sources: quantitative and qualitative data. First, a window delay analysis is conducted of six project schedules and narratives with extensive quantitative data informed of the probability and impact of various delay causes in countries with high geopolitical risks. This quantitative source was then complemented with qualitative data based on interviewing 18 experts who were involved in 36 projects, which spanned 16 countries with high geopolitical risks. Results of the quantitative and qualitative data analysis were merged to create an integrated delay cause database. This merging helps to leverage the advantages of both approaches, i.e., accuracy of data and breadth of coverage, and enables construction companies to better anticipate the future causes of delay on their international construction projects. For an upcoming project in a country with high geopolitical risk, the database can be used to suggest or predict the most likely causes of delay based on matching the similarity (location and project type) with existing cases. Comparison of results with the literature on construction delay causes in developing countries suggests that there are several delay causes that are unique, and also substantial, in countries with high geopolitical risks. The benefits of this research are broad. The capacity to predict delay causes in future projects in which geopolitical risks are detectable can result in (1) the development of more effective risk response plans, (2) more reliable estimation of contingencies, and (3) establishment of more efficient project control procedures. **DOI: 10.1061/(ASCE)CO.1943-7862.0001222.**

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Introduction

Construction companies are increasingly looking to global markets as opportunities to expand and mitigate risks associated with local market fluctuations. The growth of international construction has been well documented over the past decade. *Engineering News-Record* (ENR) published its first list of top international contractors in 2002. The list ranks contractors based on revenue generated by projects outside of the company's home country. International revenue of the top 225 contractors grew from $106.5 billion in 2001 to $453.02 in 2011 (ENR 2003, 2013). A closer look at this growth reveals that it is fuelled both by international revenue increases of long-standing international contractors from Europe and the United States, as well as entry of several new players into the market from Asia and South America. International construction is attracting more players from emerging markets, with Chinese contractors making inroads in Africa and Brazilian contractors expanding to neighboring nations in South America.

Construction companies that expand to global markets expose themselves to a larger number of risks. Diversification into new markets comes with a hefty price. Companies have to learn how to deal with a different set of uncertainties and risks that are not common in the company's home market (Artidi and Gutierrez 1991; Ramcharran 1998; Hastak and Shaked 2000; Shore and Cross 2005; Gunhan and Arditi 2005; Ozorhon et al. 2007). Expanding to growing construction markets in Africa, Asia, and South America is a double-edged sword with high profit margins and less competition being balanced with geopolitical risks. A closer look into the African construction market (a region with well-known geopolitical risks) reveals that more than $222 billion was invested in 322 infrastructure projects with energy and transportation construction projects making up 61% of projects by value (Deloitte 2014). International construction companies play a significant role in these projects, with European and U.S. firms delivering 37% and Chinese firms delivering 12% of this work (Deloitte 2014).

Unmitigated geopolitical risks can cascade into project schedule delays, cost overruns, and lost profits for international contractors. Operating in countries with high geopolitical risks is generally characterized by distinctive circumstances that translate into unique reasons for project delays. As such, this study aims to (1) develop a better understanding of the causes of delays that may be encountered in countries with high geopolitical risks, (2) gauge the relative impact these delay causes are expected to have on project completion, and (3) capture how delay causes are influenced by project and country characteristics. While the majority of research into

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construction delays has relied on the use of qualitative assessments and expert opinion, this study relies on a triangulation approach that merges quantitative assessments using forensic analysis of project schedules with traditional qualitative assessments based on surveying individuals with construction expertise in countries with high geopolitical risks. As such, the novelty of this work relates both to the unique scope of the study (construction in countries of high geopolitical risks), as well as the research methodology that enables a better understanding of how project and country attributes influence the extent of construction delays.

Background

Construction Delays

Analysis of delay causes on construction projects is one of the more comprehensively investigated areas in construction research. This can be attributed to both the prevalence of construction delays on projects as well as the effects delays have on project profitability, stakeholder relationships, and the overall image of the construction industry within the public eye. One of the earliest studies carried out was that by Baldwin et al. (1971), who identified 17 delay causes on construction projects in the United States. From that point onward, studies were conducted in various developed as well as developing countries. Recent studies were particularly undertaken in developing countries as illustrated in Table 1. Similar to what has earlier been reported by Toor and Ogunlana (2008), research findings in these different countries revealed a similar overall trend of construction delays that typically propagate from inadequate procurement systems, lack of resources, discrepancies between design and construction, lack of project management practices, variation orders, communication lapses, cultural issues, and different interests of a project's stakeholders.

Table 1. Studies on Delay Causes in Developing Countries

Country	Study
Benin	Akogbe et al. (2013)
Egypt	Abd El-Razek et al. (2008) and Ezeldin and Abdel-Ghany (2013)
Ghana	Frimpong et al. (2003) and Fugar and Agyakwah-Baah (2010)
Hong Kong	Kumaraswamy and Chan (1998) and Lo et al. (2006)
India	Doloi et al. (2012, 2013) and Chaphalkar and Iyer (2014)
Iran	Khoshgoftar et al. (2010) and Pourrostam and Ismail (2010)
Jordan	Sweis et al. (2008)
Kuwait	Koushki et al. (2005)
Lebanon	Mezher and Tawil (1998)
Libya	Shebob et al. (2012)
Malaysia	Othman et al. (2006), Alaghbari et al. (2007), Sambasivan and Soon (2007), and Tawil et al. (2014)
Nigeria	Mansfield et al. (1994)
Pakistan	Gardezi et al. (2014)
Saudi Arabia	Al-Khalil and Al-Ghafly (1999), Al-Kharashi and Skitmore (2009), Assaf et al. (2013), and Mahamid et al. (2015)
Singapore	Wang et al. (2004)
Taiwan	Yang et al. (2013)
Thailand	Toor and Ogunlana (2008)
Turkey	Kazaz et al. (2012)
United Arab Emirates	Faridi and El-Sayegh (2006)
Vietnam	Long et al. (2004) and Le-Hoai et al. (2008)
Zambia	Kaliba et al. (2009)

While these studies addressed the construction industry at large or its residential sector, some went further to investigate delay causes in certain types of specialized construction works. For instance, Kamanga and Steyn (2013) conducted a study to identify the causes of delay in completing road construction projects in the African country of Malawi. Likewise, Kaliba et al. (2009) examined road construction project delays in another African country, Zambia. Moreover, a risk matrix for factors affecting time delays in road construction projects was developed by Mahamid et al. (2015). Delay causes in Benin's development projects, such as community health care centers and community markets, were also investigated by Akogbe et al. (2013). Meanwhile, Frimpong et al. (2003) researched the causes of delay in construction of groundwater projects in Ghana. Al-Kharashi and Skitmore (2009) focused their study of the delay causes in Saudi Arabia on public projects that are part of the government's national development plan. Further, the time delays in Iran's dam construction projects were examined by Ghoddosi et al. (2008), whereas Fallahnejad (2013) studied the same for Iran's gas pipeline projects. In Singapore, Hwang et al. (2013) studied the delay causes and critical schedule success factors of public housing projects managed by the country's Housing and Development Board (HDB). The focus of Pham and Hadikusumo's (2014) study was on the petrochemical projects in Vietnam under the engineer, procure, and construct (EPC) delivery system. The causes of delay in oil and gas projects in the Gulf region were also researched by Ruqaishi and Bashir (2015).

Undoubtedly, there is quite a large body of knowledge on delay causes in the construction industry and its various sectors. Yet the comparison of delay causes among this plethora of published research is impeded by the lack of standardization in delay cause classification and terminology as shown in Table 2 (Toor and Ogunlana 2008). One of the impediments to comparing construction delay causes across the literature is this lack of standardization in delay cause classification and semantics. As such, this research synthesized construction delay causes that were reported in the literature and developed a construction delay taxonomy of 30 grouped delay causes that were indicated to be most prevalent in areas of high geopolitical risk. The taxonomy groups the causes into three distinct categories as shown in Fig. 1. Individual differences in contractual conditions may lead to shifting some delay causes across categories. As such, the categorization in Fig. 1 is generic and may change depending on specific contractual risk allocations.

Geopolitical Risk and Construction

The unique nature of construction projects in countries with high geopolitical risks is expected to translate into unique reasons for construction delays (Toor and Ogunlana 2008; Akogbe et al. 2013; Mahamid et al. 2012). A recent study by Xiaopeng and Pheng (2013) compiled the opinions of 138 subject matter experts and found that the (1) degree of government stability, (2) project desirability to the host country, (3) policy uncertainty, (4) racism and xenophobia, and (5) unfavorable attitude toward foreign business to be the top five variables that impact the degree of political risk for international construction projects. In their study they define political risks as those risks that are attributed to political events, discriminatory actions, or inactions taken by government or power groups in the host country, and would result in unexpected changes or discontinuities in the business environment and unwanted potential effect on the profits or other goals of an enterprise.

This research relies on the Political Risk Index developed by Maplecroft (2014) as a basis for defining political risk. The

Table 2. Sample of Delay Causes in Countries with High Geopolitical Risk (Adapted from Toor and Ogunlana 2008)

Reference	Project type	Country	Cause 1	Cause 2	Cause 3	Cause 4	Cause 5	Cause 6	Cause 7	Cause 8	Cause 9	Cause 10
Frimpong et al. (2003)	Public sector projects	Nigeria	Contractors' difficulties in receiving interim payments from public agencies	Contractors' financial difficulties	Inadequate public agencies' budgets	Deficiencies in contractors' organizations	Deficiencies in planning and scheduling	Frequent variation or changed orders	Difficulties in obtaining construction materials	Deficiencies in public agencies' organizations	Contractors' unrealistic tenders	Unrealistic contract durations imposed by public agencies
Akogbe et al. (2013)	Nonresidential building construction	Benin	Financial capability	Financial difficulties	Poor subcontractor performance	Materials procurement	Changes in drawings	Inadequate planning and scheduling	Slow inspection of completed works	Equipment availability	Preparation and approval of drawing	Accepting inadequate design drawings
Mahamid et al. (2012)	Roadway construction	Palestine (West Bank)	Political situation	Segmentation of the West Bank and limited movement between areas	Award project to lowest bid price	Progress payments delay by owner	Shortage of equipment	Delays in decision making by owner	Low productivity of laborers	Delay in approving sample materials	Poor communication by owner with other construction parties	Conflict between contractor and other parties
Long et al. (2004)	Various large construction projects	Vietnam	Slow site clearance	Slow government permits	Inaccurate time estimating	Lack of capable representatives	Contractors' financial difficulties	Improper planning and scheduling	Unsatisfactory site compensation	Inadequate experience	Obsolete technology	Lack of responsibility

index combines 30 political risk indexes under the four themes of governance framework, political violence, business and macroeconomic risk, and societal forced regime change risk. The index shows a fairly large concentration of countries with high political risk in Africa, the Middle East, and Asia, followed by South America. A closer look at these regions reveals that international contractors play a significant role in delivering work in these regions. In total, international contractors delivered a total of \$294.5 billion of revenue in 2012 from these regions (ENR 2013). Table 3—adapted from ENR (2013)—shows the countries from which the top 10 contractors in each region hail. In Africa, Chinese and historical colonial influences are evident, with Chinese and European contractors taking the sixth and third spots, respectively, in the top 10 list. A similar pattern can be seen in the Middle East, with four Korean contractors on the top 10 list. The Asian market shows a more leveled playing field with contractors from six countries and four continents making the top 10 list. In Latin America, Spanish contractors tend to dominate the international construction market landscape, with Brazilian firms expanding regionally to serve their growing neighboring markets.

Analysis of the international construction landscape (Table 3) demonstrates that (1) international contractors play a significant role in delivering projects in areas of high geopolitical risks, (2) international contractors' involvement in these areas is a global phenomenon and more and more contractors are willing to take risks in these countries, and (3) international construction markets in Africa, the Middle East, and Latin America show signs of specialization, with Chinese, Korean, and Spanish contractors playing a significant role in these respective markets.

Construction booms in countries with high geopolitical risks can be attributed to several factors and can be grouped into the following categories (Deloitte 2014; KPMG 2014):

1. Resource-driven growth: Construction activities linked to the need to expand facilities associated with natural resource extraction and subsequent investments in core infrastructure from resource extraction windfalls (e.g., Libya, Angola, and Iran);
2. Postwar-driven growth: Construction activities linked to the need to rebuild core infrastructure after being destroyed by war (e.g., Iraq, Afghanistan); and
3. International development–driven growth: Construction activities linked to international development agencies that fund projects in countries with significant gaps in their core infrastructure (e.g., Sub-Saharan Africa).

Research Methodology

The research approach is based on two parallel yet complementary streams of data collection and analysis. First there is the quantitative stream. Quantitative data analysis is based on a detailed analysis of project schedules using the window delay analysis method. The analysis was complemented with a review of project update narratives to capture the root cause of various delay events. The quantitative analysis allows a clear quantification of the actual extent of delay each delay cause had on the project and is a key strength of this research compared with the majority of previous work, which relied on qualitative assessment of the impact of delay causes. A parallel qualitative analysis stream is based on semistructured interviews with 18 experts that were involved in 36 projects that spanned 16 countries with high geopolitical risk indexes. The qualitative and quantitative differentiation is intended to reflect the method used to quantify the impact of each delay cause on the project rather than the actual number of projects used. For both streams, data were populated in a database, analyzed, and

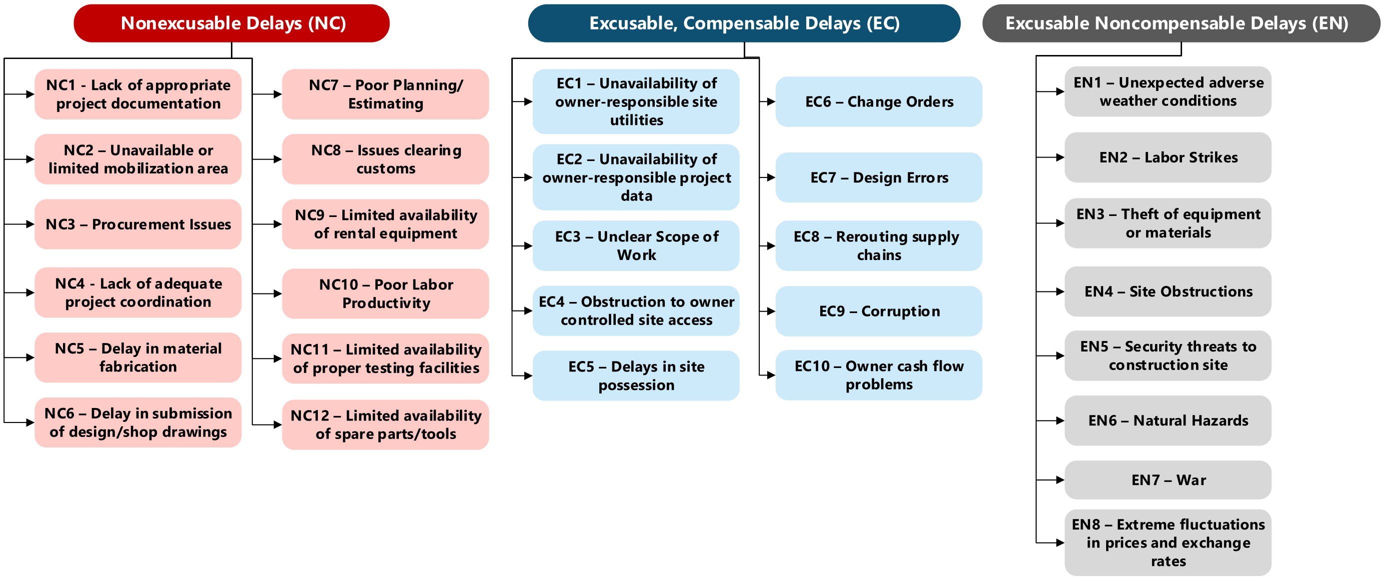

Fig. 1. Taxonomy of delay causes in construction projects

Table 3. Landscape of International Construction in Regions with High Political Risk (Adapted from ENR 2013)

Aspect	Item or rank	Asia	Africa	Latin America and Caribbean	Middle East
Revenue	Market revenue ($ billion)	112.2	58.1	41.1	83.1
	Top 10 revenue ($ billion)	58.3	24.4	24.1	31.2
	Top 10% of market share	52.0%	42.0%	58.6%	37.5%
Top 225 contractors ranking	1	Germany	Italy	Brazil	United States
	2	Spain	China	Spain	Greece
	3	United States	France	Spain	Korea
	4	China	China	Spain	Korea
	5	United States	China	United States	Korea
	6	Australia	China	Argentina	United States
	7	Italy	United States	Spain	Italy
	8	China	France	United States	United States
	9	China	China	Italy	United Kingdom
	10	United States	China	France	Korea

categorized based on salient features of the project (project type and size) and location of work (region and country). The result of this analysis is a measure of the delay's likelihood of occurrence, i.e., probability, and the extent of delay, i.e., impact. The riskiest delays are those that have the highest probability of occurrence and greatest impact on project completion.

Validation is based on using a test case from the sampled data. Finally, data from the qualitative and quantitative streams were merged to create an integrated delay cause database as shown in Fig. 2. The following sections describe the methodology in further detail.

Quantitative Delay Analysis Approach

The database created for this research was based on a detailed review of 36 projects that were undertaken in the period 2009–2012 by a major U.S. international contractor. The quality of the data needed to facilitate a proper quantitative assessment was evaluated and ranked into six quality levels as follows:

1. Level A: Full project documents with update and narrative reports—including detailed reasoning of delays and time-impact analysis—were available;
2. Level B: Full project documents with update and narrative reports were available;
3. Level C: Full project documents with update but no narrative reports were available;
4. Level D: Full project documents with some update and narrative reports were available;
5. Level E: Some project documents with some update and narrative reports were available; and
6. Level F: Some project documents with update but no narrative reports were available.

Nineteen projects that fell under Quality Level A and four projects under Quality Level B were included in the quantitative analysis. Projects that fell under Quality Levels C–E were excluded due to lack of sufficient data to facilitate the analysis. These 23 projects were subsequently filtered by removing projects that were not undertaken in high political risk countries and still underway during the time of analysis. The remaining eight projects, shown in Table 4, underwent a detailed window analysis of the causes of delays as documented in the monthly schedule update and narrative reports. As seen, the majority of projects were undertaken in Afghanistan in addition to one project in Iraq.

Via tracking the activities that were critically delayed, the window analysis technique helps to determine the amount of delay that had occurred on a project and when the delay(s) took place, thus allowing a more focused investigation of the causes and

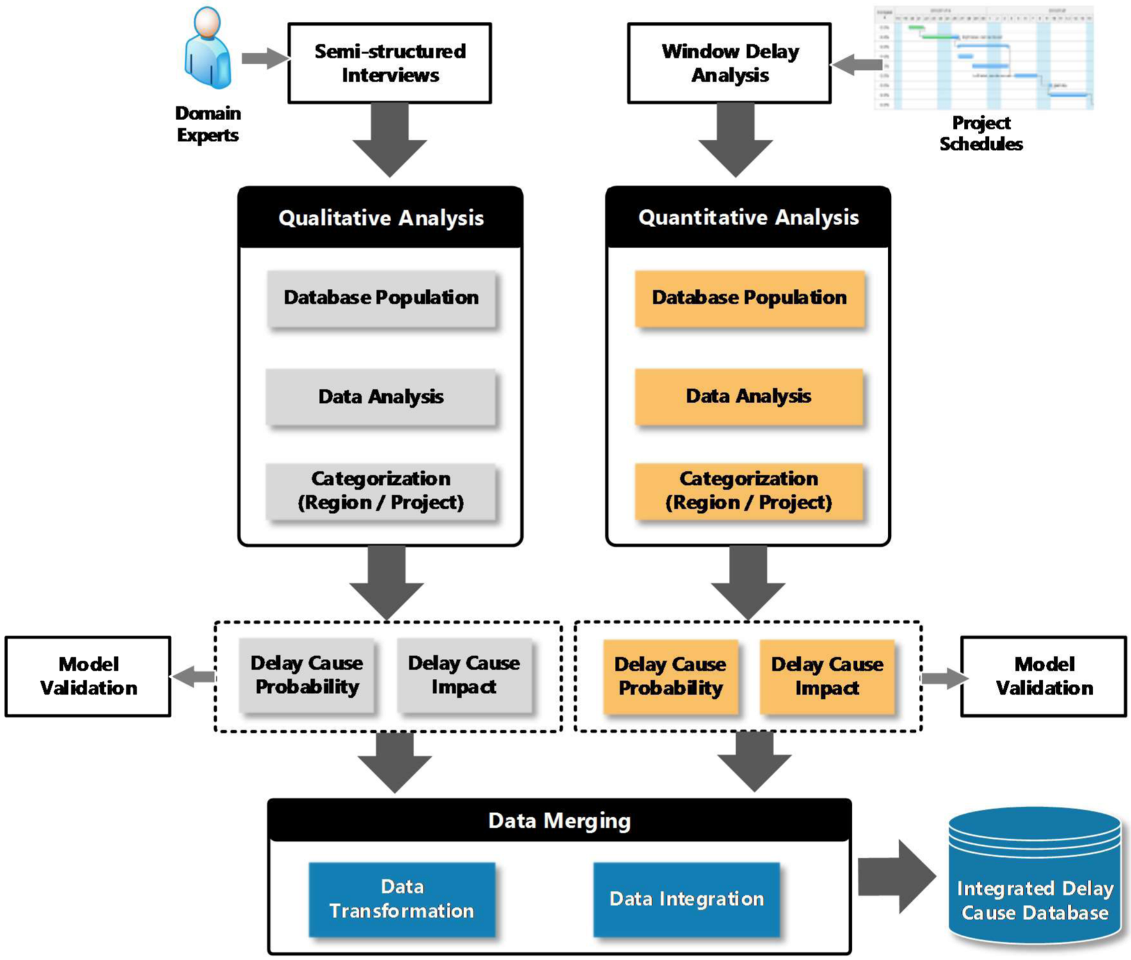

Fig. 2. Research methodology

Table 4. Listing of Projects Investigated in Quantitative Analysis

Project number	Scope	Type of project	Location
1	Fuel tanks construction	Industrial	Afghanistan
2	Fuel tanks construction	Industrial	Afghanistan
3	Aprons, ramps, and runways	Roads and airports	Afghanistan
4	Aprons, ramps, and runways	Roads and airports	Afghanistan
5	Munitions storage area and ammunition storage area	Military	Afghanistan
6	Ramps, shelters, and airports	Roads, airports, and military	Afghanistan
7	Refueling points	Industrial	Afghanistan
8	Building and utilities on military air base	Military	Iraq

responsibility for the delays to be undertaken. The basis of the window analysis technique is that the total life of a project is divided into a number of fragments or windows. The effects of delays within each window can then be sequentially analyzed. This was the method adopted in the process of updating the as-planned program at the monthly project meetings of the examined projects.

The accuracy of this technique is a function of the size and number of windows used. In this research, for instance, analysis was done at 1-month intervals because of the update cycle in place. This approach generally allows a better understanding of not only which delays were encountered on a project, but which delays had an overall impact on project completion date, thus facilitating a deeper level of understanding for the impact of delays on project as discussed in Alkass et al. (1996), Gothand (2003), and Hegazy and Zhang (2005).

Qualitative Delay Analysis Approach

Qualitative assessments involved face-to-face semistructured interviews with experts who were involved in a large number of construction projects that encountered delays. A total of 18 experts who participated in 36 projects that took place in countries with high geopolitical risk were involved in these interviews. Projects included power stations, overhead power transmission, utility infrastructure, and roadways. The qualitative approach allowed the analysis of a much more diverse group of projects in Africa, the Middle East, and Asia. Table 5 lists the countries in which these projects were undertaken ranked by their Political Risk Index (Maplecroft 2014). During the interviews, experts were asked to prioritize the causes of delay in each project in which they participated. Results were compiled and delay causes reconciled using the taxonomy shown in Fig. 1.

Quantitative Assessment of Delay Causes

Within the context of this study, the quantitative assessment involves estimating measures of the probability and impact of each delay cause based on a detailed review of project schedules and the

Table 5. Project Background of Experts Participating in the Qualitative Survey

Region	Country	Number of projects	Political risk index
Africa	Libya	9	Extreme
	Sudan	1	Extreme
	Algeria	7	High
	Chad	2	High
	Nigeria	1	High
	Mauritania	1	High
	Benin	4	Moderate
	Botswana	1	Moderate
	Morocco	1	Moderate
Asia	Yemen	1	Extreme
	India	2	High
	Iran	2	High
	Vietnam	1	High
	Pakistan	1	High
	China	1	High
Latin America	Nicaragua	1	High

subsequent window analysis of the schedule update and narrative reports. This helps define and categorize the causes of delay within the projects under investigation. The quantitative assessment was conducted using the window analysis technique. The technique determines the amount of delay that has occurred on a project and when the delay(s) occurred by identifying the activities that were critically delayed through the monthly updates conducted for each project.

A duration impact factor (DIF) is calculated for each documented delay cause i in project j that falls under project category k. The DIF, which measures the magnitude or amount of a delay, takes into account both the duration of the delay as well as the overall duration of the project. The DIF_{ijk} value is calculated according to Eq. (1)

$$\mathrm{DIF}_{ijk} = D_{ijk}/T_{jk} \tag{1}$$

where D_{ijk} = delay duration resulting from delay cause i in project j that falls under project category k; and T_{jk} = total time or duration of project j that falls under project category k. Values of the total delay duration and number of encounters for each delay cause i are shown in Table 6.

For each project category k, tracking the DIFs allows contractors to utilize the existing project database to forecast both the likelihood and impact of a particular delay cause on an upcoming project under the same category. Accordingly, appropriate risk response and contracting strategies can be adopted.

A combined list of delay causes for each project category k can be developed to showcase the various delay causes identified in projects under that category. For each delay cause i within project category k, the DIF_{ijk} values can then be summed up to measure the collective impact of this delay cause, or in other words to estimate a collective impact factor (CIF_{ik}) for this delay cause, under this project category. Considering m projects in a given category k, CIF_{ik} can be represented as shown in Eq. (2)

$$\mathrm{CIF}_{ik} = \sum_{j=1}^{m} \mathrm{DIF}_{ijk} \tag{2}$$

Meanwhile, the likelihood or probability of occurrence, P_{ik}, for each delay cause i under project category k, is calculated according to Eq. (3)

Table 6. Duration in Days and Number of Encounters of Each Delay Type

Delay cause	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
EC1	—	—	−48 (1)	—	—	—
EC2	—	−37 (1)	−74 (1)	—	—	—
EC3	—	—	−135 (1)	—	—	—
EC4	−67 (1)	—	—	−28 (1)	−12 (1)	−75 (1)
EC5	−652 (4)	−66 (2)	−256 (3)	−491 (2)	−12 (1)	—
EC6	−524 (5)	—	−168 (1)	−545 (1)	−94 (1)	−285 (1)
EN1	−108 (1)	−2 (1)	—	−5 (1)	—	—
EN2	—	—	—	−10 (1)	—	—
EN3	—	—	−270 (1)	—	—	—
EN4	—	—	—	−165 (1)	—	—
EN5	—	—	—	—	—	−113 (2)
NC1	—	—	—	−49 (1)	—	−99 (1)
NC2	—	−322 (4)	−90 (1)	−174 (2)	—	—
NC3	—	—	—	—	−45 (1)	—
NC5	−104 (1)	—	—	—	—	—
NC6	−31 (1)	—	—	—	−168 (1)	—
NC7	—	−36 (1)	—	—	−32 (1)	—
NC8	—	—	—	−11 (1)	−40 (1)	—
NC9	—	—	—	—	—	−75 (1)
NC10	—	—	—	—	−52 (1)	−109 (1)

Note: The number of encounters is given in parentheses.

$$P_{ik} = Q_{ik}/N_k \tag{3}$$

where P_{ik} = probability of delay cause i under project category k; Q_{ik} = frequency or number of projects under category k, where delay cause i occurred; and N_k = total number of projects under category k.

Given Eqs. (2) and (3), an expected value index, EV_{ik}, for each delay cause i under project category k can be estimated as the multiplication product of P_{ik} and CIF_{ik}, according to Eq. (4)

$$\mathrm{EV}_{ik} = P_{ik} \times \mathrm{CIF}_{ik} \tag{4}$$

The outcome of this methodology is a prioritized list of schedule delay causes for each project category. Methodology was implemented using the set of projects whose quantitative data were available to the authors. The analysis, shown in Tables 6 and 7, reveals the following:

1. The top cause of delay in projects is EC5, delays in site possession, which reflects the nature of the projects, which were mostly construction jobs supporting Army bases in Afghanistan. The root cause for this particular delay was found to be the need to conduct a comprehensive scanning of land mines in the construction area prior to the commencement of any construction work on site. Also, debris resulting from demining activities is usually an obstruction to work commencement. These along

Table 7. Prioritized List of Causes of Delay in Afghanistan Projects

Ranking	Causes of delay	Expected value EV_{ik}
1	EC5: Delays in site possession	−2.91
2	EC6: Change orders	−2.85
3	EN1: Unexpected adverse weather conditions	−0.25
4	NC4: Obstruction to owner-controlled site access	−0.21
5	EN3: Theft	−0.2
6	NC2: Unavailable or limited mobilization area	−0.19
7	NC7: Poor planning	−0.05
8	NC4: Lack of adequate project coordination	−0.05
9	NC8: Issues clearing customs	−0.05
10	NC5: Delay in material fabrication	−0.04

with the owner's occupation of the construction site usually lead to late access or hand over of the construction sites to the nominated contractors.
2. The second highest delay cause is EC6, change orders. The root cause for this delay was found to be the changes in owner requirements. This cause has been widely reported by previous studies as discussed in "Background."
3. The third highest cause of delay is EN1, unexpected adverse weather conditions. Although this factor differs from one place to another within Afghanistan, areas such as Bagram, Bastion, and other mountainous areas are usually subject to a high level of snowfall, leading to site closure lasting more than three continuous months in some cases.
4. Obstruction to owner-controlled site access (NC4) is the fourth highest cause of delay in Afghanistan. This is usually due to the intense security checks being conducted by the Army for safety reasons.

In comparison with the literature published on construction delays, some delay causes were found to be more significant to projects in countries with high geopolitical risks like EC5, delays in site possession; NC4, obstruction to owner-controlled site access; EN3, theft; and NC8, issues clearing customs. However, the comparison with the said literature also revealed that some delay causes were found to be common and as significant to projects in countries with high geopolitical risk like EN1, unexpected adverse weather conditions; NC4, lack of adequate project coordination; NC5, delay in material fabrication; and EC6, change orders.

As seen, the novelty of this research is that, unlike many previous studies, the measurement of delay duration and frequency made extensive use and comparisons of actual project plans and baselines, critical paths, update reports, and project narratives. This high level of data scrutiny translated into a relatively small number of projects that could be analyzed. As such, the analysis was complemented with a qualitative assessment of delay causes based on the opinion of subject-matter experts familiar with construction in countries with high geopolitical risks.

Qualitative Assessment of Delay Causes

In order to prioritize the causes of delay, the expected value method is again used. Similar to the quantitative approach, the expected value is calculated by multiplying the probability and impact of the delay. The expected value for each delay cause i in category or region k (EV_{ik}) is determined according to Eq. (5)

$$\mathrm{EV}_{ik} = P_{ik} \times \mathrm{CIF}_{ik} \tag{5}$$

where P_{ik} = probability of occurrence of delay cause i under category or region k; and CIF_{ik} = collective or relative impact of delay cause i under category or region k. While Eq. (5) looks similar to Eq. (4), which was previously used in the quantitative approach, the means for estimating the probability and impact values are quite different. P_{ik} is calculated based on the number of times the delay cause i was highlighted by interviewees as being encountered on a project. Accordingly, the probability is calculated according to Eq. (6)

$$P_{ik} = Q_{ik}/N_k \tag{6}$$

where Q_{ik} = number of times the delay cause i was repeated under category or region k; and N_k = total number of projects under category or region k.

On the other hand, the collective or relative impact of delay cause i on a project in category or region k, i.e., CIF_{ik}, is calculated based on the reciprocal of the average rank of delay cause i within the same project category or region k. As such, the collective or relative impact is calculated using Eq. (7)

$$\mathrm{CIF}_{ik} = 1/R_{ik} \tag{7}$$

where R_{ik} = average rank of for each delay cause i under category or region k and is calculated according to Eq. (8)

$$R_{ik} = \sum_{j=1}^{N_k} R_{ij} \bigg/ Q_{ik} \tag{8}$$

where R_{ij} = rank for delay cause i in project j. In this context, $R = 1$ for the top-ranked delay cause, $R = 2$ for the second highest delay cause, and so forth.

As cited previously, this methodology was implemented by interviewing 18 experts who have worked on international projects in countries with high geopolitical risks. As a result, ranked lists of delay causes for different countries were prepared. Samples are shown in Table 8. The analysis of trends for delay causes in Table 8 reveals the following:

- EC10, owner cash flow problems, was a common cause of delay with the highest rank among Sub-Saharan African countries.

Table 8. Top 10 Ranked Causes of Delays in African Countries

Rank	Libya	Algeria	Chad	Benin
1	EC9: Corruption	NC8: Issues clearing customs	EC10: Owner cash flow problems	EC10: Owner cash flow problems
2	EN4: Site obstructions	EC5: Delays in site possession	EC3: Unclear scope of work	NC8: Issues clearing customs
3	NC4: Lack of adequate project coordination	NC10: Poor labor productivity	NC8: Issues clearing customs	NC9: Limited availability of rental equipment
4	EN7: War	EN5: Security threats to construction site	NC9: Limited availability of rental equipment	EC6: Change orders
5	EC8: Rerouting supply chains	EN1: Unexpected adverse weather conditions	EC5: Delays in site possession	NC5: Delay in material fabrication
6	NC10: Poor labor productivity	EN2: Labor strikes	NC6: Change orders	NC3: Procurement issues
7	NC8: Issues clearing customs	NC5: Delay in material fabrication	EC8: Rerouting supply chains	EC3: Unclear scope of work
8	EC6: Change orders	NC6: Delay in submission of design or shop drawings	EN5: Security threats to construction site	EC5: Delays in site possession
9	EC1: Unavailability of owner-responsible site utilities	EC1: Unavailability of owner-responsible site utilities	EC9: Corruption	EC8: Rerouting supply chains
10	EC5: Delays in site possession	EN4: Site obstructions	EN8: Extreme fluctuations in prices and exchange rates	EC9: Corruption

Also, EC3, unclear scope of work, was a more common problem within Sub-Saharan African countries than North African countries. Financial problems are the most common cause of delay of Sub-Saharan African projects due to instability of owner or client funding for major projects. Project cancellation by the owner due to insufficient funding is a common occurrence on projects in these countries.

- NC8, issues clearing customs, was a common delay cause with a relatively high rank within both North African and Sub-Saharan African countries with an average rank of 1.5. Most of these countries suffer from the retention of equipment at customs extending up to months due to regulatory issues or even due to refusal to be involved in bribery or corruption issues.
- NC9, limited availability of rental equipment, was another common cause of delay in Sub-Saharan African countries, thus making it an important cause of delay to monitor. Due to the developing nature of these countries, finding equipment in an acceptable condition and at a reasonable price was a common issue facing contractors, leading to delays. In many cases contractors need to import their equipment in order to execute the project, which subsequently increases their exposure to the NC8 delay cause mentioned previously.
- EN5, security threats to construction site, and NC6, change orders, are other issues both regions share as a highly ranked cause of delay. Politically unstable areas and underdeveloped countries, whether in North Africa or Sub-Saharan Africa, both suffer from security issues such as kidnapping of engineers, obstructions created by the local residents to the work, and even war and terrorism.
- EC9, corruption, was revealed to be a cause of delay in both North African and Sub-Saharan countries. This is consistent with several reports on conducting business in this region (Maplecroft 2014; Deloitte 2014).
- NC10, poor labor productivity, was one of the top 10 causes of delay in North African countries. This delay cause is somewhat unique to this region and may be influenced by cultural and training factors within these courtiers. Contractors can mitigate this risk by making more realistic assumptions regarding local labor availability and productivity or relocate their own labor, which is found to be a common practice among Chinese contractors working in the region.

In comparison with the literature published on construction delays, some delay causes were found to be more significant to projects in African countries with high geopolitical risks. These include EC9, corruption; NC8, issues clearing customs; NC9, limited availability of rental equipment; and EN4, site obstructions. However, the comparison with the literature also revealed that some delay causes were common and as significant to projects in African countries with high geopolitical risks. These include NC10, poor labor productivity; NC4, lack of adequate project coordination; EC10, owner cash flow problems; and EC6, change orders.

The methodology used in this study allows mining the data in different dimensions. In addition to determining delay causes by country or region, analyzing the data by project type was possible as shown in Table 9. Results of the analysis of trends for delay causes by project type in Table 9 reveal the following:

- EN4, site obstructions, and EC5, delays in site possession, were common causes of delay for overhead transmission lines, roads, and utilities projects. This is due to the linear nature of these projects and their spread over vast areas of land which subject contractors to various obstructions like local residents and communities, unidentified utilities, Army-controlled territories, and in some cases unexploded ordnances.
- NC5, delay in fabrication, was the highest cause of delay within power station projects. Unavailability of materials ranging from minor items like small valves and strainers up to the main components such as turbine generators could delay vital activities within the project.
- NC8, issues clearing customs, were a common cause of delay across all projects ranking anywhere from first to sixth place. This indicates that this delay cause is endemic to countries with high geopolitical risks. The NC8 cause of delay, however, ranked highest within industrial or power projects, which can be explained by the reliance of these projects on large quantities of imported materials and equipment, making them more susceptible to any delays clearing customs.
- EN1, unexpected adverse weather, was ranked relatively high for power transmission and utilities projects. This can be explained by the fact that these projects span relatively large and remote areas with construction operations taking place with no protection from the weather.
- NC10, poor labor productivity, was further revealed as a common cause of delay across all project types. This indicates that, similar to NC8, this delay cause is endemic to countries with high geopolitical risks. The same result was also confirmed by the quantitative analysis. This cause of delay was particularly

Table 9. Top 10 Ranked Causes of Delays by Project Type

Rank	Power transmission lines	Power stations	Infrastructure (utilities)	Roadway construction
1	EN1: Unexpected adverse weather conditions	NC5: Delay in material fabrication	EC3: Unclear scope of work	NC8: Issues clearing customs
2	EN4: Site obstructions	EN7: War	EC10: Owner cash flow problems	EC10: Owner cash flow problems
3	EC9: Corruption	NC8: Issues clearing customs	EN1: Unexpected adverse weather conditions	NC10: Poor labor productivity
4	EN7: War	NC10: Poor labor productivity	NC9: Limited availability of rental equipment	EN2: Labor strikes
5	NC10: Poor labor productivity	EN6: Natural hazards	NC8: Issues clearing customs	EC9: Corruption
6	NC8: Issues clearing customs	NC6: Delay in submission of design or shop drawings	EC5: Delays in site possession	EC5: Delays in site possession
7	EC8: Rerouting supply chains	EC6: Change orders	EC9: Corruption	EC1: Unavailability of owner-responsible site utilities
8	EN5: Security threats to construction site	NC3: Procurement issues	EC1: Unavailability of owner-responsible site utilities	NC4: Lack of adequate project coordination
9	EC5: Delays in site possession	EN4: Site obstructions	EC8: Rerouting supply chains	NC5: Delay in material fabrication
10	EN3: Theft of equipment or materials	EC7: Design errors	NC10: Poor labor productivity	EN5: Security threats to construction site

ranked higher in power station projects because these projects typically require more skilled labor which may not be readily available in countries with high geopolitical risks.
- Finally, NC6, delay in submission of design drawings, was another common cause of delay within power station projects. On the other hand, NC6 was not found to be a common cause of delay within infrastructure and overhead transmission lines projects. This may be attributed to the complexity of these types of projects.

Triangulation Approach

The merit of merging qualitative and quantitative approaches for risk analysis and assessment has recently been recognized. Some researches of late have promoted the synergistic integration of qualitative and quantitative techniques to better assess project risks (Fung et al. 2012; Nieto-Morote and Ruz-Vila 2011; Yoon et al. 2013). The integration would allow strengths known in each, i.e., the breadth of knowledge in qualitative approaches and the quality and accuracy of data in quantitative approaches, to be amalgamated. In this study, a triangulation approach was also pursued to enable knowledge on delay causes in countries with high geopolitical risks to be leveraged from both qualitative and quantitative approaches, thereby enhancing the accuracy and coverage of the prediction.

For implementation, projects are first categorized according to project region or country (R) and type of work (W). This is in line with some of the earlier studies on delay analysis and risk classification, such as Hastak and Shaked (2000) and Wang et al. (2004). According to this categorization and based on the outcomes of the quantitative and qualitative analyses, a common or global index, GEV_{iRW}, for delay causes under category k is developed. When considering only one of the two sources of data, e.g., the qualitative data set, this index can be calculated according to Eq. (9)

$$\text{GEV}_{\text{iRW}} = \frac{\text{EV}_{iR} + \text{EV}_{iW}}{2} \tag{9}$$

where EV_{iR} = expected value index for delay cause i in region R (in this case, category k is equivalent to region R); and EV_{iW} = expected value index for delay cause i in work type W (in this case, category k is equivalent to work type W).

In the case of qualitative sources, EV_{ik} (which applies to either region R or work type W) is calculated based on the reciprocal of the delay cause rank according to Eqs. (5) and (7). However, in case of quantitative sources along with the qualitative sources, a modified version of the expected value index previously presented in Eq. (1) has to be calculated in order to be able to merge the two sets of analysis results. This index, which is called QEV_{ik}, is calculated according to Eq. (10)

$$\text{QEV}_{ik} = P_{ik} \times \text{CIF}_{ik} \tag{10}$$

where QEV_{ik} = modified version of the expected value index; P_{ik} = probability of occurrence of delay cause i under category k; and CIF_{ik} = collective or relative impact of the delay cause i under category k. Hence, the common or global index, GEV_{iRW}, for delay causes under category k takes the form

$$\text{GEV}_{\text{iRW}} = \frac{\text{QEV}_{iR} + \text{QEV}_{iW}}{2} \tag{11}$$

In order to demonstrate the applicability of the triangulation approach, a hypothetical scenario involving a power station project in Afghanistan was considered. As seen previously, the quantitative data set had comprehensive information on delay causes in projects in Afghanistan; however, all of these projects involved construction activities in Army camps. None concerned power stations. The qualitative data set, on the other hand, had information on several power station projects, none of which were in Afghanistan. Based on the information in Tables 7 and 9 and using Eqs. (10) and (11), the qualitative and quantitative data analysis results could be merged as shown in Table 10.

Eqs. (9) and (11) can be altered in a number of ways. Quantitative data are known to be more reliable than qualitative data. Therefore, a multiplier can be used to factor in the relative weight between quantitative and qualitative sources. Also, the domain experts being interviewed in the qualitative approach have different backgrounds and industry experiences. Some may provide qualitative information that is more sophisticated than others. A different multiplier can be utilized to reflect this scenario as well.

Summary and Conclusions

Delay causes in construction projects have been researched for years. Recent studies in particular tried to better understand why projects get delayed in developing countries. This information is useful to contractors willing to expand their business in such countries; however, it has further been noticed that some of the international contractors are also being attracted to countries with high geopolitical risks. While performing work in these countries can be challenging, there are rewards due to the limited competition and the big investments made in development and infrastructure projects. Examples include Chinese contractors in African countries and Spanish contractors in South America. The research at hand attempted to investigate and shed more light on this particular space.

From an early stage of this research, it became apparent that some data sources were more reliable than others. For a few projects undertaken in countries with high geopolitical risks, complete project data sets were accessible, while for many this was not the case. With such recognition, it was critical to devise a methodology

Table 10. Top Causes of Delay List in Afghanistan Power Plants Using the Triangulation Approach

	Qualitative (power station)		Quantitative (Afghanistan)		Merged sources (power station in Afghanistan)	
Delay cause	EV_{ik}	Rank	QEV_{ik}	Rank	GEV_{ik}	Rank
Delays in site possession or demining	—	—	1	1	0.5	1
Change orders	0.1	7	0.4	2	0.25	2
Delay in fabrication	0.234	1	0.05	8	0.14	3
Regulatory issues at the customs	0.231	3	0.04	5	0.14	4
War	0.231	2	—	—	0.12	5
Bad weather	—	—	0.2	4	0.1	6

that can accommodate for all possible scenarios; that is, (1) when only quantitative data are available, (2) when only qualitative data are available, and finally (3) when a mix of qualitative and qualitative data sources are accessible. This is one of the novel aspects of this research. The paper presented three distinct yet complementary approaches to quantify the expected delay causes on construction projects in countries with high geopolitical risks. The same concepts can still be applied for analyzing delay causes in developing or developed countries at large.

The quantitative approach was based on actual delay analysis and an in-depth assessment of delay causes from construction schedules and update and narrative reports. This approach can be used when the company has a complete set of construction schedules and reports. The qualitative approach, on the other hand, was based on interviewing experts who had worked on projects in these countries. In the actual implementation of this study, 18 experts who were involved in 36 projects in Africa, the Middle East, and the Far East were interviewed. This approach is effective for construction companies that do not keep high-quality records for their updated schedules but have access to knowledgeable experts in the area of delay causes. In cases where companies have access to both types of knowledge resources (qualitative and quantitative data), a merging approach is proposed. This technique benefits from the accuracy of quantitative data and coverage of qualitative data. This enhanced prediction can result in (1) the development of more effective risk response plans, (2) more reliable estimation of contingencies, and (3) establishment of more efficient project control procedures.

Having said that, there are two fundamental limitations that should be accounted for when employing the herein presented principles. First, the capacity to predict delay causes in a particular context in largely contingent on the quality and also the breadth of information and knowledge captured by the qualitative and/or quantitative approaches. In case of poor or limited information and knowledge available, accurate prediction of delay causes in a new project scenario will be hard, if not impossible, to undertake. This emphasizes the criticality of information and knowledge sharing among industry practitioners for the sake of a better understanding of overseas business environments where geopolitical risks are influential. Second, the prediction approach itself did not account for the relative quality of information and accumulated experience of experts involved. As cited previously, this can be enhanced via manipulating the equations used. That has not been done in this study; however, it is worth investigating in further research.

Results of analyzing delay causes in countries with high geopolitical risks, through the information that became available in this particular study, revealed some interesting findings nonetheless. Some unique delay causes were found to have a significant impact on projects in these countries that were not commonly reported in the vast number of previous studies on construction delay causes. Examples include corruption of government officials (EC9), issues clearing imported material and equipment from customs (NC8), poor labor productivity (NC9), security threats to construction sites (EN5), and theft of equipment (EN3). Delay causes that were found to be common across the literature and still apply to countries with geopolitical risks include owner cash flow problems (EC10), change orders (EC6), and unexpected adverse weather conditions (EN1).

These findings can help support international contractors working on projects in countries with high geopolitical risks develop more effective risk mitigation and treatment strategies. Indeed, the ultimate goal of any study on delay analysis and risk management is to be proactive and have the capacity to better handle risky events in future projects. The scope of the current research did not cover this particular stage of risk management; however, this is a logical step in future research. It would be useful to examine real-life case studies and analyze how risks were handled and which strategies turned out to be successful. Capturing that knowledge across multiple case studies in countries with high geopolitical risks will help establish common themes for successful and unsuccessful practices. It will also be useful to understand how the mitigation and treatment strategies work under different contractual and delivery approaches. It has long been recognized that risks are contextual and as a result the response strategies are contextual as well. Such knowledge can help create a proper environment so the risk mitigation and treatment actions can deliver the intended results.

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