The Moderating Effect of Project Risk Mitigation Strategies on the Relationship Between Delay Factors and Construction Project Performance

Abstract

Purpose – This study aims to explore the relationship between delay factors and construction project performance with respect to project risk mitigation strategies as moderators.

Design/methodology/approach – Random sampling was used to select the sample of the study. Data were gathered through a survey of 204 Malaysian construction companies. The data were analysed using the partial least squares technique.

Findings – The results indicate that environmental, resource, and coordination issues negatively affect construction project performance. Project visibility and flexibility can mitigate the negative effects of both resource and coordination issues on project performance. Furthermore, supplier development can mitigate the negative effects of coordination issues.

Practical implications – The findings of the study will be useful for construction firms to complete construction projects timely, within a scheduled budget, and with only minor defects if adopted.

Originality/value – This study is amongst the first to empirically test the moderating role of risk mitigation strategies on the relationship between delay factors and project performance in the construction industry.

Keywords: Delay Factors, Project Performance, Project Risk Mitigation, Construction, Malaysia

Introduction

The global construction industry, including that in Malaysia, faces delays that halt many projects, or even cause total abandonment. For example, the second Pulau Pinang Bridge (the longest bridge in Malaysia and Southeast Asia) was supposed to be completed in 2011, but the bridge was only completed in 2013 because of the significant delays experienced. The project delay had generated a cost increment from USD 1 billion for the initial plan, (Rosni & Nor Zainah, 2008) to USD 1.5 billion (Roslan, 2014). Kuala Lumpur Airport Terminal 2 (KLIA 2) has also suffered significant delays because of the frequent design changes,
suffering huge cost overruns. Beckers et al. (2013) have reported that the estimated total value lost versus the plan for the KLIA 2 project is USD 2 billion.

Construction project delays have been investigated for decades. Research in this area is broadly divided into two streams: one is related to the factors that cause project delays (e.g., Lo et al., 2006; Doloi et al., 2011; Eboreime, 2013; and González et al., 2014), and another is related to the effects of the delay (e.g., Abinu and Jagboro, 2002; Sambasivan and Sonn, 2007; and Amoatey et al., 2014). Various delay causes have been identified. Assaf et al. (1995) have identified 56 delay causes under 9 major groups. In a separate study, Assaf and Al-Hejji (2006) have identified 73 delay causes, which are categorised as external-, project-, owner-, contractor-, design-, materials-, and equipment-related factors. Construction project delays cause cost overruns (Manavazhia and Adhikari, 2002), project abandonment (Sambasivan and Soon, 2007), and the dissatisfaction of all parties. Therefore, mitigation efforts are necessary to minimise losses (Bramble and Callahan, 2010).

Numerous researchers have recommended a wide range of mitigation strategies to decrease delay causes (Gunduz et al., 2013; Haseeb et al., 2011; and Sambasivan and Soon, 2007). To the best of our knowledge, the effectiveness of such suggested mitigation strategies in reducing the effect of delay factors on the construction project performance has not been empirically investigated. The moderating effect of risk mitigation strategies, namely, project visibility, project flexibility, and supplier development on the relationship between delay factors and project performance has been investigated to address this gap. Theoretically, the findings of the present study contribute to the knowledge in the construction field by establishing the moderating effects of risk mitigation strategies on the relationship between delay causes and project performance. The research results contribute to minimising the effect of the delay factors on the performance of construction projects. The findings provide useful input to all construction sector players in managing delay risks with proper mitigation strategies. The empirical study aims to address the following research questions:

1) To what extent do delays causes affect construction project performance?

2) Do risk mitigation strategies moderate the relationship between delay causes and project performance?

This paper is organised as follows. After the Introduction, a literature review on delay causes, effects of delays, and risk mitigation strategies is provided. A conceptual model is
then proposed to determine the relationships between delay causes and project performance, and to test the moderating effect of risk mitigation strategies. Subsequently, an empirical study is developed to validate the proposed conceptual model. The findings and contributions are discussed afterwards. Finally, the limitations of this study are presented.

**Literature review**

**Delay causes**

Determining construction project delay causes has been widely performed. Different findings on the most critical construction project delay causes have been documented by researchers from various countries, including Malaysia. Assaf *et al.* (1995) conducted a survey in Saudi Arabia and found 56 delay causes in Saudi construction projects (Assaf *et al.*, 1995). Based on the survey feedback from the contractors, the most important delay factors were the preparation and approval of drawings, delay in the progress of contractors, payment from owners, and design changes. Architects and engineers regard cash problems during the construction, the relationship amongst subcontractors, and the slow decision-making process of owners as the main delay causes. Meanwhile, owners consider the design errors, labour shortages, and inadequate labour skills as important delay factors.

Ogunlana and Promkuntong (1996) have studied the delay causes of Thailand’s construction projects. The authors have summarised these delay causes into three major areas: (i) shortage problems or inadequacies in the industry infrastructures (largely on resource supplies), (ii) factors caused by clients and consultants, and (iii) factors caused by the incompetency/inadequacy of contractors. In another study, Chan and Kumaraswamy (1997) have determined and assessed the relative importance of delay factors in Hong Kong from the viewpoints of contractors, consultants, and clients. The study result shows that the five most significant factors that caused delays were poor site management and supervision, unforeseen ground conditions, slow decision-making involving all project teams, client-initiated variations, and necessary variations of the work.

Al-Momani (2000) has investigated delay causes by quantitatively analysing 130 public projects in Jordan. The results show that the main delay causes in Jordan were contributed to designers, user changes, weather, site conditions, late deliveries, economic conditions, and an increase in quantity. Subsequently, a similar research was conducted in Jordan to identify the most important construction project delay causes (Odeh and Battaineh, 2002). Odeh and
Battaineh (2002) have assessed construction project delay causes with traditional types of contracts from the perspectives of contractors and consultants. The results obtained indicate that owner interference, inadequate contractor experience, financing and payments, labour productivity, slow decision-making, improper planning, and subcontractors’ problems were amongst the top 10 important factors, as agreed on by both contractors and consultants.

Frimpong et al. (2003) have conducted a survey to identify and evaluate the relative importance of the significant factors that contribute to delay and cost overruns in Ghana’s groundwater construction projects. The survey targeted a wide range of personnel involved in projects, ranging from owners, consultants, and contractors. Twenty-six factors were designed in the questionnaire based on a preliminary investigation conducted in groundwater drilling projects in Ghana between 1970 and 1999. The study reveals that the main causes of delay and cost overruns in the construction of groundwater projects in Ghana included monthly payment difficulties from agencies, poor contractor management, material procurement, poor technical performance, and increase in material prices.

In another similar study in Ghana, Fugar and Agyakwah-Baah (2010) have categorised delay factors into nine major groups in a questionnaire subjected to the following key project participants: clients, consultants, and contractors. The overall results obtained from the study indicate that the respondents generally agreed that financial group factors ranked the highest amongst the major factors that caused delays in construction projects in Ghana. Financial group factors caused delays in terms of honoring payment certificates, difficulty in accessing credit, and fluctuation in prices; material group factors were ranked second, followed by scheduling and controlling factors (Fugar and Agyakwah-Baah, 2010).

Assaf and Al-Hejji (2006) have conducted a survey on the time performance of different types of Saudi Arabian construction projects, aiming to determine delay causes and the importance of these causes according to the viewpoint of each project participant, including the owner, consultant, and contractor. The questionnaire comprised 73 delay causes identified through the literature review and discussion with certain parties involved in the construction industry. The study indicates that the most common delay cause agreed on by all three personnel was “change order”.

Aziz (2013) identified relative importance indices and determined the influence ranks of ninety-nine factors causing delays in construction projects in Egypt. It addressed the most
significant factors and groups causing delays, especially after the Egyptian revolution. The explored factors were classified under the following nine (9) primary classifications: (1) Consultant related delay factors, (2) Contractor related delay factors, (3) Design related delay factors, (4) Equipment related delay factors, (5) External related delay factors, (6) Labour related delay factors, (7) Material related delay factors, (8) Owner related delay factors, and (9) Project related delay factors.

In the Malaysian construction industry, Alaghbari and Abdulmoghi (2005) have studied the factors that cause delays in Malaysian building constructions from the viewpoints of a wide range of construction industry players: developers, government boards, main contractors, consultants, and manufacturers. The results reveal that financial problems, poor management, consultant’s supervision problems, consultant’s incompetency, and lack of materials in the market were the main delay causes in projects. In another study, from a list of 31 factors included in a survey questionnaire, clients, consultants, and contractors all agreed that financial problems were the main factors, followed by coordination problems as the second most important factor that caused delays in Malaysian construction projects (Alaghbari et al., 2007). In an extended study by Sambasivan and Soon (2007), the 10 most important delay causes in the Malaysian construction industry were presented to identify both delay factors and the effect of these factors on the project completion, namely, contractor’s improper planning, contractor’s poor site management, inadequate contractor’s experience, client’s inadequate finance and payments for completed work, problems with subcontractors, shortage in the material, labour supply, equipment availability and failure, lack of communication amongst parties, and mistakes made during construction.

Abd El-Razek et al. (2008) have studied the critical delay factors in Egyptian construction projects from the viewpoints of contractors, consultants, and owners. The overall results show that the most important causes were contractor’s financing during construction, delays in owner’s payment to contractor, design changes by owner or an owner’s agent during construction, partial payments during construction, and the utilisation of non-professional construction/contractual management.

Meanwhile, Haseeb et al. (2011) have indicated the time performance of a construction project in Pakistan, and that the most common delay factors were natural disasters, such as floods and earthquakes. The study also acknowledges other factors, such as financial and
payment problems, improper planning, poor site management, insufficient experience, and the shortage of materials and equipment.

Desai and Bhatt (2013) have recently identified the delay causes in residential construction projects in India. The survey was directed to developers, contractors and architects, comprising 59 delay causes as questionnaire items. The results show that all parties involved in the survey agreed that labour-related factors were the most important delay causes. Moreover, the study also reveals that 5 out of 10 most critical factors had common rankings: original contract duration proved to be too short, also there were labour shortages, delays in material delivery, low productivity level of labourers, and delays in progress payments by owner (Desai and Bhatt, 2013). Another recent study on the effects of delays on Turkish construction projects concludes that out of 83 different factors studied, the planning and scheduling, fluctuation of prices, rework caused by errors, late delivery of materials, owner’s demand, poor site management, and project complexity were the major delay causes (Gunduz et al., 2013).

Effects of delays

Aibinu and Jagboro (2002) have evaluated the effects of delays in the Nigerian construction industry from the viewpoints of quantity surveyors, engineers, and architects, as well as contractors. This study reveals that the six effects of construction delays were time overruns, cost overruns, disputes, total abandonment, arbitration, and litigation. Sambasivan and Soon (2007) have also disclosed the same effects of delays in the Malaysian industry.

Haseeb et al. (2011) have highlighted the effect of delays in the Pakistan construction industry, including clashes, claims, total desertion and reduced growth of the construction industry. Moreover, Manavazhia and Adhikari (2002) have found that the actual effect of delays on project costs was only about 0.5% of the total budgeted project cost. This study investigates the material and equipment procurement delays in highway projects in Nepal, which were supposedly related to cost overruns because such delays always occur in the construction projects of developing countries (Manavazhia and Adhikari, 2002).

Most of the studies investigating the delay factors in construction projects focus on either the causes or effects. However, some studies discuss the probable link between the causes and effects of delays. Assaf and Al-Hejjii (2006) have associated contractor- and labour-related causes to probable time overruns in Saudi Arabian construction projects. Odeh and
Battaineh (2002) have discussed the probable link between contract-related causes to disputes in Jordanian construction projects. Chan and Kumaraswamy (1997) have emphasized the link between consultant- and client-related causes to probable time overruns in construction projects in Hong Kong.

The systematic analysis conducted by Sambasivan and Soon (2007) on both the causes and effects of delays in Malaysian construction projects shows an interesting association between the causes and effects on construction projects. Time overruns are majorly contributed to client- and contractor-related factors. Contractor-related factors, such as change orders and discrepancies in the contract document, were linked to the cost overruns of projects. Client-, contract-, contract relationship- and external-related factors were found to significantly affect probable disputes that occur during projects. Client- and contract relationship-related factors have caused disputes to be settled through an arbitration process. Client-, labour-, contract-, contract relationship-, and external-related factors have sent disputes to be settled through a litigation process. Additionally, client-, consultant-, labour-, contract-, and external-related factors have contributed to the total abandonment of projects.

Based on the above selected review of previous studies, most studies evidently emphasised the critical delay causes in different countries from the perceptions of various parties involved in construction. Few studies have also investigated the effects of delays on project performance. However, the effect of mitigation strategies in minimising the influence of recognised delay factors on project performance has not been studied widely, which the present study addresses. Risk mitigation strategies are defined and discussed in the next section.

Risk mitigation strategies

Certain researchers claim that construction project risks can be defined as anything that influences the construction projects during the planning and execution phases (Akintoye and MacLeod, 1997; Edwards and Bowen 1998; and Smith et al., 2006). Typical risks or changes in construction include delays at the start and end of tasks, the deletion and addition of tasks, and the variation in resource inputs (Sun and Meng, 2009). These changes and risks emerge from impulsive decisions and intractable actions with obscure information shared amongst project stakeholders.
Wang et al. (2004) have emphasised a systematic risk management approach in the construction industry, which consists of three main steps: risk identification, risk analysis and evaluation, and risk response or treatment. Ropponen and Lyytinen (1997), and McGrew and Bilotta (2000) have argued that risk mitigation strategies positively affect a timely project delivery through a better estimation of resources required to perform a task, and by decreasing the number of task failures. Given that risk mitigation aims to implement an appropriate method to mitigate risks, a project management team should decide and formulate various risk mitigation strategies (Wang et al., 2004).

A typical technique used to mitigate scheduling issues is crashing project activities. Crashing activities entail allocating more resources (such as materials, labour, and equipment) rather than planning to hasten the completion of a project (Kessler and Chakrabarti, 1999). However, crashing or the vertical integration approach may be considered as a contradictory solution for delay issues because of the increasing inventory and high investment risk. Vertical integration refers to producing a required product in-house by acquiring suppliers or setting up manufacturing capacities internally (Wagner, 2006).

Project visibility is an alternative solution to the management of scheduling pressures and dependencies. Project visibility can be performed through computer-based tracking systems, which facilitate the monitoring of certain status information about all other activities and the dependencies of these projects (Malone and Crowston, 1994). Chapman and Ward (1997) assume that better and observable information leads to better and accurate estimation of the amount of time and money required to complete a project, and information visibility helps further comprehend the expected deliverability of a project. Project flexibility (Geraldi, 2008; Guo et al., 2014) and supplier development (Wagner, 2006; Meng, 2012) are another two mitigation strategies proposed in the literature. Project organisations should be flexible to changes and challenges to manage the uniqueness, uncertainty, and complexity of projects (Geraldi, 2008). Supplier development is important because alternative suppliers might be unavailable and supplier switching is costly (Wagner, 2006).

In summary, given that the most damaging effects of delays are attributed to poor systematic overview and early identification of project delays, project management teams can proactively manage potential delays through a precautionary set of risk mitigation strategies. Such strategies include visibility, flexibility, and supplier development schemes that may initiate coping with unexpected variations (including both controllable and uncontrollable)
and risk mitigation. The present study investigates the ability of these mitigation strategies to minimise the effect of delay factors.

**Model conceptualisation**

The risky and unstable environment in the construction industry usually triggers the potential of changes occurring during a project’s life cycle. Assaf *et al.* (1995) have declared changes that include delays as a result of omissions, errors and change of scope by owners. Given the declaration of the authors, Ibbs *et al.* (2011) have stated that “change is normally defined as any event that results in a modification of the original scope, execution time, cost, and/or quality of work” in construction projects.

Thus, delay factors in construction projects emanate from modifications and omissions, errors, and changes in different areas of a project. Antill and Woodhead (2013) consider delays as changes and categorised these delays into two groups based on controllability, namely, “controllable” and “uncontrollable”. Controllable delays are those involving the sources under the control of a contractor, such as workmanship, labour productivity, clerical errors and material procurement. Uncontrollable delays include delays that cause a contractor to have less or ineffective control. Weather conditions, inflation, and unforeseen ground conditions are examples of this type of delays (Antill and Woodhead, 2013).

The present study indicates resource and coordination issues as two groups of delay factors that can reflect all controllable delays, as discussed by Antill and Woodhead (2013). In addition, these two groups can reflect the intra- and inter-organisational delay causes proposed in this study. Moreover, environmental or external issues are the third group considered as uncontrollable delays. Consequently, delay factors have been divided into resource, environmental and coordination groups because these factors can ensure all causes studied by previous scholars and consider these factors in terms of functionality, controllability, and intra- and inter-organisational.

Figure 1 shows the proposed framework to investigate the effects of potential delay causes on project performance. This study also examines the moderating effect of three project risk mitigation strategies, namely, project visibility, project flexibility, and supplier development on the relationships between delay factors and project performance.
Nagaraju _et al._ (2012) have defined resource as an entity that contributes to the accomplishment of project activities, such as materials, manpower, equipment, and financing. Materials include delay causes related to shortages, material changes, delivery, damage, and the manufacturing of the materials. Manpower includes shortages of labour, labour skills, and the nationalities of the labourers. Equipment includes any cause of delay related to failure, shortage, and delivery of equipment, or the productivity or skill of the equipment operator. Financing includes contractors’ financing requirements and progress payments paid by owners. Atkinson (1999) has identified human error whilst Love and Li (2000) have described poor workmanship as resource issues that cause project delays and poor project performance. Available resources should be allocated in timely manner; otherwise, the overall project progress and completion duration may be adversely affected (Nagaraju _et al._, 2012). Consequently, the results of these issues can negatively affect project performance. Therefore, the following hypothesis is developed:

\[ H1: \text{Resource issues negatively affect the construction project performance.} \]
Environmental issues in the construction business can be referred to as external factors, such as adverse weather conditions, unforeseen site conditions and problems with neighbours, market fluctuation, and regulatory changes, which are usually beyond the control of project teams and can cause poor project performance (Assaf and Al-Hejji, 2006; Chan and Kumaraswamy, 1997; Odeh and Battaineh, 2002; and Sambasivan and Soon, 2007). Regarding adverse weather conditions, Enshassi et al. (2003) and Enshassi et al. (2009) have studied the contributing factors of the construction delays from the perspectives of three parties in Palestine and the Gaza Strip. The authors have noted that because of excellent climatic conditions (including the inexperience to any hurricanes or great increases in temperature or snow fall) in the Gaza Strip, weather does not affect the execution of construction projects and it does not contribute to any damages in these projects. Conversely, weather conditions might negatively affect the project performance in Malaysia because the regional climate is categorised as equatorial, and rainfall occurs throughout the year, which is even heavier during the rainy season. Sudden rain and the rainy season itself often cause delays in construction works, and improper drainage at construction sites may cause flooding in these sites.

Enshassi et al. (2009) have revealed the importance of poor site locations and market conditions in the Gaza Strip, given that these factors may determine the speed of a project and may, consequently, affect project performance. Moreover, previous scholars have indicated that site locations and market conditions are less important delay factors in Saudi Arabia and Hong Kong, respectively (Assaf and Al-Hejji, 2006; Fong et al., 2006). This finding may be because of the existence of international and open markets in these countries, which provide freely available construction materials compared to the developing countries. Therefore, environmental issues, such as bad climatic conditions, poor site locations, and market conditions, can negatively affect project performance. Therefore, the following hypothesis is formulated:

H2: Environmental issues negatively affect construction project performance.

Coordination issues

Malone and Crowston (1994) have defined coordination as managing dependencies or the joint efforts of members towards mutual objectives. Coordination in construction project management can be defined as a process of managing resources orderly to achieve a higher
degree of operational efficiency in a given project (Hossain, 2009). Gue et al. (2014) have broadly specified coordination as synchronising different resources and stakeholder activities throughout the entire project’s life cycle to govern risk management.

Roloff et al. (2015) have observed that coordination issues result from frequent changes to contractually agreed terms of payment, quantities, and delivery times between clients and suppliers. Coordination issues in construction project management are contract relationship-related factors, such as major disagreements and negotiations about the replacement and addition of new work to a project; changes in specifications, inappropriate overall organisational structure and site management related to a project, and the lack of communication amongst parties, which delays and slows down the supervision in decision making (Odeh and Battaineh, 2002). Larson (1995) has stated that project performance is influenced by the cooperation between the owner and contractor. Next, Meng (2012) has revealed that insufficient coordination with contractors and the deterioration of the relationship amongst the project parties may increase the likelihood of poor project performance. Odeh and Battaineh (2002) have considered the contractual relationship as one of the causes of poor performance. Factors such as inadequate planning by contractors, improper site management by contractors, inadequate project handling experience of contractors, and payment delays for work completed directly can all lead to time overruns and affect project completion (Sambasivan and Soon, 2007). Given the above reason, the following hypothesis is formulated:

H3: Coordination issues negatively affect construction project performance.

Project visibility

As one of the operational attributes of a project’s portfolio performance, project visibility can be referred to as the degree of exposure of a project to the stakeholders (Patanakul, 2015). The visibility and transparency of a project can facilitate stakeholders to verify the presence of all critical success factors through synchronised information, knowledge sharing, communication, and collaboration with all stakeholders. The visibility strategy may also help identify project sponsors and the sponsors’ responsibility, identify a project manager with a successful track record on similar projects, the certification of key resources available, as required by the project plan, and the guarantee that major functional deliverables arrive at suitable intervals. From the stakeholders’ perspective, project visibility can improve the
support from project stakeholders, especially executive sponsors (Patanakul, 2015). From the customers' perspectives, project visibility is positively correlated with the level of effort and commitment of a project team (Thamhain, 2004). Bendoly and Swink (2007) have suggested that project information visibility can facilitate effective resource-sharing at the project level, which can benefit both project (local) and portfolio (global) performance. Hence, increased project visibility may reduce project delays by enabling robust resources, communication management, and relationship synchronisation, positively affecting project performance. Accordingly, this research formulates the following hypothesis:

H4: Project visibility positively moderates the effect of (a) resource issues, (b) environmental issues, and (c) coordination issues on project performance.

Project flexibility

Project flexibility refers to the elasticity and adaptability in terms of the various societies and organisations which are relevant to projects and multi-project firms (Geraldi, 2008). Flexibility is related to parties involved in a project, how a project is organised, and when information is communicated (Geraldi, 2008). Businesses have a universal notion that global interdependencies are becoming more critical, the pace of change is accelerating, and creating organisations that are more flexible and adaptive is required (Malone and Crowston, 1994). Therefore, flexible contractual arrangements, and technical and financial capabilities across a project are identified as the key success factors in risk mitigation (Guo et al., 2014).

Flexibility is one of the basic mechanisms that can be incorporated into the project risk mitigation design to eliminate uncertainty and complexity, both organisationally and environmentally (de Man and Roijakkers, 2009; Osipova and Eriksson, 2013). Bettis and Hitt (1995) have discussed the organisations operating in changing environments, and stressed the increasing level of uncertainty and decreasing predictability that such environments present. The authors have highlighted flexibility as a mitigation strategy that protects an organisation from uncontrollable changes. According to Geraldi (2008), project organisations that face a high uncertainty level should strive for a high flexibility level. Therefore, this research develops the following hypothesis:

H5: Project flexibility positively moderates the effect of (a) resource issues, (b) environmental issues, and (c) coordination issues on a construction firm’s performance.
Supplier development

Supplier development refers to the act of supporting certain suppliers in enhancing the performance of a supplier’s products and services or improving a supplier’s capabilities (Wagner, 2006) to benefit the buying organisation. Basically, supplier development concerns providing regular feedback on a supplier’s performance, as experienced by a buyer’s organisation, together with any customer complaints. This information can provide a strong incentive to improve supplier performance, particularly in areas such as delivery reliability and lead times.

Changes in the legislation, regulation, systems, or procedures typically affect all project suppliers. Given these circumstances, a buying organisation in a construction project would have to adopt a suitable supplier development programme that targets all key suppliers uniformly. Wagner (2006) has indicated that supplier development is becoming increasingly important because other approaches, such as supplier switching, might not be viable because of the unavailability of alternative suppliers, or excessively high switching costs, and vertical integration might require substantial investment and may contradict a firm’s intentions to focus on its core competencies. In terms of effectiveness and efficiency, Handfield et al. (2000) believe that supplier development is best viewed as a long-term business strategy that serves as a basis for an integrated supply chain.

Poor project performance can be effectively reduced by adopting supplier development and partnering whilst improving certain aspects of the relationship and coordinating with project partners, which help address project performance problems (Meng, 2012). Moreover, the supply chain relationship would more significantly affect the extent of time delays (Meng, 2012). Accordingly, this study formulates the following hypothesis:

H6: Supplier development positively moderates the effect of (a) resource issues, (b) environmental issues, and (c) coordination issues on the construction project performance.

Research methodology

Measure of constructs

This study conducted a survey on four sections: firms’ basic information, delay causes (resource, environmental, and coordination issues), project performance, and risk mitigation.
strategies (project visibility, project flexibility, and supplier development). The survey items were derived from those used in the previous studies to ensure content validity. The delay causes were adapted from Assaf and Al-Hejji’s study (2006). The project performance items were derived from Meng’s research (2012). Project visibility, project flexibility, and supplier development were adapted from Patanakul’s (2015), Geraldí’s (2008), and Wagner’s studies (2011), respectively. Each item in this scale was measured using the five-point Likert scale. Table 1 presents these items.

Sample and data collection

The sampling frame of this study consisted of all construction contractor companies in the Malaysian construction industry. The sample was selected randomly from the list provided by the Real Estate and Housing Developers’ Association Malaysia’s website. Malaysia has 1322 registered construction contractor companies. The study set its target on the owners, contractors, and consultants in Malaysian construction contractor companies. These members were selected as respondents for being directly involved in construction projects, which provided these parties with the knowledge and experience in all project activities. The survey was conducted using a structured questionnaire mailed to the corresponding respondents in each firm.

“As a general rule, the minimum is to have at least five times as many observations as the number of variables to be analysed” (Hair et al., 2010, p. 101). Therefore, for this study 45 items multiplied by 5 gave a sample size of 225, which was deemed appropriate for this study. The number of questionnaires to be distributed was determined by using previous studies’ response rate. Le-Hoai et al. (2008) reported a 33.3% response rate for their research survey on construction contractor companies in Malaysia. According to this, 675 questionnaires needed to be distributed in order to obtain 225 responses. To compensate for any shortfalls in the 225 responses that may have occurred due to undelivered or partially completed responses, the number of distributed questionnaires was increased further from 675 to 700 as suggested by Dwivedi et al. (2010). Out of the 700 questionnaires sent to the firms, 212 were collected. A return rate of 30.3% was obtained. Eight of the questionnaires returned were invalid because the questionnaires were incomplete. The usable response percentage was approximately 29.1%.
The power test is generally defined as the probability of rejecting a false null hypothesis (H0), that is, the probability of obtaining a valid result (Cohen, 1988). The power analysis (1-β) was conducted in this study to validate the empirical findings of the analysis. The power in the 204 samples was measured using G*Power version 3.1.9.2 (Faul et al., 2009). Using G*Power with a statistical significance (α level) of 0.05 yielded a power of 0.993, which was above 0.80 and signified a satisfactory degree of sample power in the present study (Chin, 2001). These results indicated that the proposed sample size was large enough to reject the null hypotheses and detect significant effects (Faul et al., 2009).

Analysis

This study used the partial least squares Structural Equation Modelling (PLS-SEM) technique using SmartPLS Version 3.0 to test the research model. This technique was selected as it has the ability to analyse a complicated model (Hair et al., 2011). In addition, Hair et al. (2011) suggested that the PLS-SEM is the preferable approach compared to the covariance-based SEM (CB-SEM) when the theory is less developed and the objective of the study is prediction. As the main objective of this study was to test the moderating effects of risk mitigation strategies which are exploratory in nature, the PLS-SEM was selected. A two-step data analysis approach was applied based on the recommendation of Hair et al. (2013). The first step analysed the model to be measured; whereas, the second step evaluated the relationships amongst the structures of the underlying constructs (see Zailani et al., 2015; Yusof et al., 2016; Fathi et al., 2016). The two-step approach was aimed to establish the reliability and validity of the measures prior to assessing the structural relationship of the model.

Results

Measurement model results

The reflective constructs were examined in terms of reliability and validity. The composite reliability (CR) was equivalent to the Cronbach’s alpha and was measured in relation to the internal reliability. Table 1 shows that the CR of all the constructs was above 0.7, which satisfied the rule in Hair et al.’s study (2013). Hair et al. (2010) recommended the acceptance of items with a minimum loading of 0.6. The reliability of individual items was reasonably
judged, given that all the scales reported loadings that exceeded 0.7. The average variance extracted (AVE) was used to evaluate the convergent validity; this value exceeded 0.5 in all the constructs. This finding indicated the satisfactory convergent validity of these constructs (Fornell and Larcker, 1981).

Table 1: Measurement Model Evaluation

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>Factor Loadings</th>
<th>CR</th>
<th>AVE</th>
</tr>
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<tbody>
<tr>
<td>Resource Issues (RI)</td>
<td>In the last project my firm faced resource issues in terms of …</td>
<td></td>
<td>0.924</td>
<td>0.527</td>
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<td></td>
<td>Shortage of materials on site</td>
<td>0.627</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Shortage of site labor</td>
<td>0.674</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Poor skilled and experience labor</td>
<td>0.695</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Financial problems</td>
<td>0.635</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Equipment and tool shortage on site</td>
<td>0.728</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Poor site conditions (location, ground, etc.)</td>
<td>0.780</td>
<td></td>
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<td></td>
<td>Low productivity of labor</td>
<td>0.768</td>
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<tr>
<td></td>
<td>Lack of experience on the part of the consultant’s site staff</td>
<td>0.690</td>
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<td></td>
<td>Lack of subcontractor’s skills</td>
<td>0.798</td>
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<tr>
<td></td>
<td>Lack of equipment and tools on the market</td>
<td>0.838</td>
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</tr>
<tr>
<td></td>
<td>Lack of site contractor’s staff</td>
<td>0.722</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Issues (EI)</td>
<td>In the last project my firm faced environmental issues in terms of …</td>
<td></td>
<td>0.940</td>
<td>0.757</td>
</tr>
<tr>
<td></td>
<td>Changes in laws and regulations</td>
<td>0.843</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor weather conditions</td>
<td>0.878</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor economic conditions (currency, inflation rate, etc.)</td>
<td>0.874</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>External work due to public agencies (roads, utilities and public services)</td>
<td>0.856</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor site conditions (location, ground, etc.)</td>
<td>0.898</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination Issues (CI)</td>
<td>In the last project my firm faced coordination issues in terms of …</td>
<td></td>
<td>0.801</td>
<td>0.597</td>
</tr>
<tr>
<td></td>
<td>Construction mistakes and defective work</td>
<td>0.922</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor site management</td>
<td>0.797</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presence of consultant’s site staff</td>
<td>0.713</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incomplete documents</td>
<td>0.749</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of coordination with contractors</td>
<td>0.772</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delayed and slow supervision in making decisions</td>
<td>0.819</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delay in delivery of materials to site</td>
<td>0.813</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract modifications (replacement and addition of new work to the project and change in specifications)</td>
<td>0.813</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Visibility (PV)</td>
<td>We and our partners inform in advance any changing needs</td>
<td>0.658</td>
<td></td>
<td>0.556</td>
</tr>
<tr>
<td></td>
<td>We and our partners share knowledge of core business process</td>
<td>0.758</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We and our partners keep each other informed about customer’s future needs</td>
<td>0.703</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We and our partners communicate future strategic needs</td>
<td>0.798</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The exchange of information is frequent and informal</td>
<td>0.802</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We and our partners collaborate to monitor the progress of the project</td>
<td>0.682</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We always search for new ways to integrate the process</td>
<td>0.804</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Flexibility (PF)</td>
<td>It is possible to switch the contract from one supplier to another</td>
<td>0.783</td>
<td></td>
<td>0.610</td>
</tr>
<tr>
<td></td>
<td>It is possible to change the specifications of the suppliers’ projects</td>
<td>0.832</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>It is both economically easy and economical to mix different specifications and materials.</td>
<td>0.720</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>There is an alternative capacity to accommodate an increase in specifications</td>
<td>0.785</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overtime or temporary worker is possible to cope with changes in specifications</td>
<td>0.782</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier Development (SD)</td>
<td>Conducted training and education</td>
<td>0.757</td>
<td>0.909</td>
<td>0.626</td>
</tr>
<tr>
<td></td>
<td>Consideration to enhance business relationships in the future</td>
<td>0.862</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Development of targeted quality and other improvement benchmarks within the suppliers</td>
<td>0.768</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We share ideas on information with our key suppliers through cross functional teams</td>
<td>0.795</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We have a continuous quality improvement program that includes our key suppliers</td>
<td>0.773</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Performance (PP)</td>
<td>The last project was completed on time</td>
<td>0.872</td>
<td>0.907</td>
<td>0.764</td>
</tr>
<tr>
<td></td>
<td>The last project was completed within the scheduled budget.</td>
<td>0.871</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The last project was completed with minor defects.</td>
<td>0.880</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CR= Composite Reliability; AVE= Average Variance Extracted
Two techniques were employed to evaluate the discriminant validity in the constructs (see Abdullah et al., 2015; Nikbin et al., 2015; Zailani et al., 2014). Firstly, the indicator cross-loadings were investigated. Each opposing construct did not exceed any indicator load (Hair et al., 2012). Secondly, the value of the intercorrelations between the construct and the other model constructs should be surpassed by the square root of the AVE of a single construct (Table 2). Both analyses confirmed the discriminant validity of all the constructs.

Table 2 shows that amongst the three proposed delay causes, coordination was the main issue that Malaysian construction companies faced (mean = 3.45). Risk mitigation strategies were practiced satisfactorily. The project performance was also found to be satisfactory (mean = 3.93).

Table 2: Discriminant Validity Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>RI</th>
<th>EI</th>
<th>CI</th>
<th>PV</th>
<th>PF</th>
<th>SD</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>2.96</td>
<td>0.770</td>
<td>0.726</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EI</td>
<td>2.84</td>
<td>0.781</td>
<td>0.687</td>
<td>0.870</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI</td>
<td>3.45</td>
<td>0.906</td>
<td>0.659</td>
<td>0.638</td>
<td>0.773</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>3.74</td>
<td>0.927</td>
<td>-0.685</td>
<td>-0.617</td>
<td>-0.657</td>
<td>0.746</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PF</td>
<td>3.72</td>
<td>0.838</td>
<td>-0.536</td>
<td>-0.541</td>
<td>-0.535</td>
<td>0.724</td>
<td>0.781</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>3.32</td>
<td>0.553</td>
<td>-0.518</td>
<td>-0.447</td>
<td>-0.552</td>
<td>0.588</td>
<td>0.732</td>
<td>0.791</td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>3.93</td>
<td>0.698</td>
<td>-0.691</td>
<td>-0.759</td>
<td>-0.659</td>
<td>0.689</td>
<td>0.567</td>
<td>0.456</td>
<td>0.874</td>
</tr>
</tbody>
</table>

Assessment of the structural model

The measurement model generated satisfactory results. Thereafter, the structural model was assessed. The accuracy of the predictions from using this model was determined through the variance portion, explained. The model was able to consider 65.6% of the project performance variances. In addition to estimating the $R^2$ magnitude, the predictive relevance evaluation measure developed by Stone (1974) and Geisser (1975) was incorporated as another tool to determine the model fit (see Nikbin et al., 2014; Kamal et al., 2016). Thus, the ability of the model to estimate clear indicators of underlying constructs was able to be assessed. The Stone–Geisser $Q^2$ (cross-validated redundancy) value was calculated to measure the predictive relevance according to a blindfolding process performed in the PLS. Chin (2010) indicated that the model displays a predictive relevance if the value of $Q^2$ is greater than zero. The current research obtained a cross-validated redundancy of 0.529, which was considerably higher than zero. Thus, the model exhibited an acceptable fit and high predictive relevance.
Non-parametric bootstrapping was applied to test the structural model (Wetzels et al., 2009) with 2,000 replications. Table 3 presents the structural model that results from the PLS analysis. All the delay factors negatively affected the project performance significantly. Therefore, H1, H2, and H3 were supported. The strength of the effect of the delay factors on project performance was examined according to the effect size ($f^2$) (Hair et al., 2013). Notably, environmental issues had the highest effect on project performance ($f^2 = 0.168$), followed by resource issues ($f^2 = 0.084$), and coordination issues ($f^2 = 0.054$).

The product indicator approach (mean-centred) was employed to create an interaction construct (Hair et al., 2013). The CR and AVE of the interaction constructs met the criteria for reliability and convergent validity. The results indicated that the interaction of resource issues and project visibility ($\beta = 0.102$, $p < 0.05$), coordination issues and project visibility ($\beta = 0.126$, $p < 0.01$), resource issues and project flexibility ($\beta = 0.072$, $p < 0.05$), coordination issues and project flexibility ($\beta = 0.090$, $p < 0.05$), and coordination issues and supplier development ($\beta = 0.068$, $p < 0.05$) positively affected the project performance significantly. Hence, H4a, H4c, H5a, H5c, and H6c were supported; whereas, H4b, H5b, H6a, and H6b were unsupported. These findings indicated that project visibility and project flexibility minimised the negative effect of resource issues and coordination issues on the project performance. In addition, supplier development minimised the negative effect of coordination issues.

Table 3: Path coefficient and hypothesis testing.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Relationship</th>
<th>Path Coefficient</th>
<th>Effect Size</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1</td>
<td>RI -&gt; PP</td>
<td>-0.302***</td>
<td>0.084</td>
<td>Supported</td>
</tr>
<tr>
<td>H2</td>
<td>EI -&gt; PP</td>
<td>-0.397***</td>
<td>0.168</td>
<td>Supported</td>
</tr>
<tr>
<td>H3</td>
<td>CI -&gt; PP</td>
<td>-0.194**</td>
<td>0.054</td>
<td>Supported</td>
</tr>
<tr>
<td>Moderating Effect of Project Visibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H4a</td>
<td>PV*RI -&gt; PP</td>
<td>0.170*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H4b</td>
<td>PV*EI -&gt; PP</td>
<td>0.015</td>
<td>0.001</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H4c</td>
<td>PV*CI -&gt; PP</td>
<td>0.126**</td>
<td>0.088</td>
<td>Supported</td>
</tr>
<tr>
<td>Moderating Effect of Project Flexibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H5a</td>
<td>PF*RI -&gt; PP</td>
<td>0.072*</td>
<td>0.032</td>
<td>Supported</td>
</tr>
<tr>
<td>H5b</td>
<td>PF*EI -&gt; PP</td>
<td>-0.003</td>
<td>0.000</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H5c</td>
<td>PF*CI -&gt; PP</td>
<td>0.090*</td>
<td>0.047</td>
<td>Supported</td>
</tr>
<tr>
<td>Moderating Effect of Supplier Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H6a</td>
<td>SD*RI -&gt; PP</td>
<td>0.005</td>
<td>0.000</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H6b</td>
<td>SD*EI -&gt; PP</td>
<td>0.032</td>
<td>0.004</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H6c</td>
<td>SD*CI -&gt; PP</td>
<td>0.068*</td>
<td>0.026</td>
<td>Not Supported</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01, ***p<0.001 (one tail)
Discussion

The structural model tested provides evidence that delay factors have a negative effect on project performance. The negative effects of resource, environmental, and coordination issues on project performance were parallel to the studies of Alaghbari and Abdulmoghi (2005), Assaf and Al-Hejji (2006), and Desai and Bhatt (2013). The results of the effect size show that environmental issues negatively affected project performance the most followed by resource and coordination issues. The mean value shows that coordination issues were the main weaknesses that Malaysian construction contractor companies faced (mean = 3.45); whereas, resource (mean = 2.96) and environmental issues (mean = 2.84) were minor concerns in Malaysia. Although the occurrence of environmental issues can lead to severe project delays, Malaysian construction firms were less concerned about these issues because regulations and economic conditions were stable in Malaysia at the time of this study; whilst, the roads and public services were satisfactory. Heavy rainfall in Malaysia also minimally affected project performance, according to the information on the average rainy days provided by the Malaysian Meteorological Department, and construction companies considered rainy days by pre-scheduling. Therefore, Malaysian construction companies should value risk mitigation strategies more to lessen the negative effects of coordination and resource issues on project performance.

The results of the moderating effect of the three risk mitigation strategies on the relationships between delay causes and project performance show that both project visibility and flexibility can reduce the negative effect of resource and coordination issues on project performance. In addition, supplier development can reduce the negative effect of coordination issues on project performance. Given that coordination issues are the main challenges faced by Malaysian construction companies, adopting the three risk mitigation strategies is essential to mitigate the effect of coordination issues and, consequently, enhance project performance. However, project visibility and project flexibility strategies are also useful in counteracting the negative effect of resource issues (as the second cause of delay) on project performance.

Conclusion and implications

Many construction projects experience extensive delays thereby exceeding initial times and cost estimates. Construction projects involve more factors and uncertainties than the product lines. These factors increase the probability of delays in construction projects and make risk
mitigation strategies important to reduce diversions from the original programme. Hence, the ability of three risk mitigation strategies, namely, project visibility, project flexibility, and supplier development, in minimising the effects of delay causes on project performance has been investigated in this study. The findings suggest that environmental, resource, and coordination issues negatively affect construction project performance. Moreover, although project visibility and project flexibility can mitigate the negative effects of both resource and coordination issues on project performance, supplier development can only mitigate the negative effect of coordination issues. Notably, the findings show that the tested mitigation strategies cannot cushion the negative effect of environmental issues on project performance.

The moderating effects of project visibility and flexibility on the impacts of resource and coordination issues on project performance suggest that the construction contractor companies can minimise and control delays in construction projects caused by resource and coordination issues by sharing knowledge on the core business process with partners, informing partners about customers’ future needs, communicating with partners regarding future strategic needs, exchanging information frequently, collaborating with partners in monitoring the project progress, searching permanently for new ways to integrate processes, considering the right of switching suppliers if the agreed on duties in the contract are not accomplished as agreed upon, considering the right of changing the specifications of suppliers’ projects, and distinguishing alternative capacities and temporary workers to be assigned when necessary.

The moderating effect of supplier development on the relationship between the coordination issue and project performance suggests to the contractor companies that in addition to the above mentioned practices, conducting training and educating suppliers, enhancing business relationships with suppliers, developing the targeted quality and other improvement benchmarks within suppliers, sharing ideas with key suppliers through cross-functional teams, and practicing a continuous quality improvement programme that includes key suppliers are effective practices for minimising delays caused by coordination issues.

In terms of the theoretical contribution, the present study is the first to investigate the ability of risk mitigation strategies to minimise the negative effect of delay causes on project performance. From the practical viewpoint, the results of this research should be of great significance to construction companies and policy makers in the field of construction management. This study illustrates appropriate risk mitigation strategies, which enable
construction firms and governments to complete construction projects on time, within a scheduled budget, and with minor defects if they are adopted.

Although the objective of the study was successfully accomplished, its limitations should be considered before presenting a generalisation of the study. First, this study has performed a survey limited to Malaysian construction companies. However, the extent of certain causes of delay and effects on project performance might differ amongst countries. Thus, future research could test the research model of this study in different countries. Second, the three tested risk mitigation strategies cannot minimise the negative effect of environmental issues on project performance. Future studies can test other risk mitigation strategies to determine proper strategies to mitigate the effects of environmental issues. Third, this study has been conducted using a questionnaire survey and has a cross-sectional nature. Therefore, the survey results will be affected by the fact that the dynamic changes in the project performance cannot be observed by this study. Hence, a longitudinal study that examines the relationships for an extended period must be conducted to provide more precise results. Furthermore, another study can be performed for specific types of construction projects, such as utility, highway construction and dam construction projects.

References


Chin, W.W. (2001. “PLS-Graph user’s guide”, CT Bauer College of Business, University of Houston, USA.


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