Kybernetes
Transaction costs in construction projects under uncertainty
Lei Guo Huimin Li Peng Li Chengyi Zhang

Transaction costs in construction projects under uncertainty

Lei Guo
North China University of Water Resources and Electric Power, Zhengzhou, China
Huimin Li
Department of Construction Engineering and Management, North China University of Water Resources and Electric Power, Zhengzhou, China
Peng Li
College of Ideological and Political Education, North China University of Water Resources and Electric Power, Zhengzhou, China, and
Chengyi Zhang
Department of Applied Engineering and Technology, Eastern Kentucky University, Richmond, Kentucky, USA

Abstract

Purpose – The purpose of this paper is to find how those uncertainty factors influence transaction costs generated and to identify ways to minimize the transaction costs borne by the construction owner.
Design/methodology/approach – The literature indicates that there is no consensus on a standard definition of transaction costs in the construction industry. A detailed literature review of research work on transaction costs in construction is conducted in order to identify the determinants of transaction costs in construction projects. A structural equation model is tested on data collected by means of a survey administered to construction owners.
Findings – The findings indicate that the transaction costs borne by the owner can be minimized if the owner minimizes the uncertainties inherent in the construction project by making sure the engineering design is as complete as possible before bids are sought from contractors; harmonious relationships between project participants; fair risk allocation; have experience in similar type projects; and contractor selection practices that routinely detect irregular behavior.
Research limitations/implications – The data used in this research are primarily based on the experiences of public owners and the markets in which they operate; a larger representation of private owners could make the conclusions more general. Another limitation of the study is that it relies on a survey of opinions rather than actual records of costs and other hard data.
Practical implications – No empirical study has ever been conducted of transaction-related issues in the construction industry because of the lack of a common understanding of transaction cost. This paper provides the groundwork for such a study.
Originality/value – This paper attempts to reconcile the many determinants of transaction costs in construction projects under uncertainty considered by different researchers in a multitude of research studies.

Keywords Structural equation modelling, Uncertainty, Construction project, Transaction costs, Construction management
Paper type Research paper

Kybernetes
Vol. 45 No. 6, 2016
pp. 866-883

0368-492X
DOI 10.1108/K-10-2014-0206

The authors thank the National Natural Science Foundation of China (Project No. 71302191), Department of Education of Henan Province, humanities and social science projects (Project No. 2013-QN-028) and Basic Science Research Project of Henan Province, China (Project No. 122300410029) for financially supporting this study.

1. Introduction

Construction projects are executed in a dynamic and uncertainties environment. The owners and contractors are facing challenges in this complex and uncertain factors. The uncertainty factors include human factors, environmental factors, and project factors. Contractors devote considerable time and energy to determining the costs of construction and then assessing the price they will quote to the owner. Price is the rate at which exchange may take place. Price to the contractor becomes a cost to the owner (Hillebrandt and Hughes, 2000). However, the actual cost of a construction project is not the only production cost. The costs of preparing a bidding document, estimating, drawing up a contract, administering the contract, and dealing with any deviations from contract conditions are also important. These costs are known as transaction costs in the study of economic organizations (Coase, 1937).

In transaction cost economics (TCE), a transaction occurs when a good or service is transferred across a technologically separable interface (Williamson, 1987). The main contention is that, in addition to the cost of production, there are also transaction costs between the parties (Winch, 1989). Transaction costs are referred to as "soft costs" by the Transportation Research Board (AECOM Consult Incorporated, 2010).

The value of this research is to identify the uncertainty factors that affect the transaction costs borne by the construction owner in uncertainty and find the way how to reduce the transaction costs in construction management, in order to improve the performance of construction project. This study makes three main contributions. First, this study enriches the literature by examining the linkage between uncertainty factors and transaction costs borne by the construction owner. The impacts of uncertainty factors on transaction costs are further developed. Second, this study uses structural equation model to advance the explanation of behavior and environment mechanism between uncertainty and transaction costs. Third, results advance the construction management research on how to reduce transaction costs in uncertainty perspective.

In the following section, we provide a review on the theoretical background of transaction costs in construction management, the relationship between uncertainty factors in construction projects and transaction costs. A research method section outlines the design of the research process, and a findings section reports the key results. The implications of the findings are discussed.

2. Literature review

The transaction paradigm has received considerable attention by academics and has been applied to a variety of construction-related topics including project delivery systems (Lynch, 1996; Whittington, 2008); construction contracts (Brokmann, 2001; Turner and Simister, 2001; Bajari and Tadelis, 2001); construction market and subcontracting (Eccles, 1981; Gunnarson and Levitt, 1982; Reve and Levitt, 1984; Winch, 1989; Constantino *et al.*, 2001; Bremer and Kok, 2000; Miller *et al.*, 2002; Lai, 2000); project organization and governance (Piertoforte, 1997; Turner and Keegan, 2001; Winch, 2001; Müller and Turner, 2005; Jobin, 2008); and the measurement of transaction costs (Antinori and Sathaye, 2007; Dudkin and Välilä, 2005; Ho and Tsui, 2009; Soliño and Gago de Santos, 2009; Farajian, 2010).

The majority of these studies on transaction costs in construction projects have focussed on the theoretical and qualitative aspects of this issue. In closer examination of this literature, it is also observed that there is a lack of standard terminology within and across research disciplines for defining transaction costs. While Williamson (1985) defines transaction costs to include the costs of drafting, negotiating and enforcing an

agreement, and also the costs of governance and bonding to secure commitments, Rahman and Kumaraswamy (2002) claim that transaction costs also include costs associated with breaches of contractual promises, and Joskow (1985) adds costs of acquiring and processing information, legal costs, organizational costs, and costs associated with inefficient pricing and production behavior. This inconsistency in definition and terminology results in inconsistency in data, and makes the analysis of the data almost impossible (Farajian, 2010).

There have been only a few studies, mainly in Europe attempting to quantify transaction costs in construction projects, but only for public/private partnership (PPP) projects. These studies report only the overall transaction costs (Soliño and Gago de Santos, 2009), or divide it into public agency transaction cost, winner-bidder transaction costs, and loser-bidder transaction costs (Dudkin and Välilä, 2005). Farajian (2010) develops a Bayesian network-based model to estimate the transaction costs of PPP projects.

Brokmann (2001) has suggested, contract goods prevail in the construction industry. These goods are highly complex and unique, take a dynamic process to complete, and involve change orders, claims, and sometimes legal disputes. Consequently the transaction costs in the construction phase are much higher than in the procurement phase. There appears to be a need in the construction industry to define transaction costs in a way that covers not only the pre-contract phase but also the construction phase of a project.

2.1 Category of transaction costs in construction projects

Most research is confined only to procurement-phase costs of bidding and contract negotiation, excluding costs related to contract monitoring and renegotiation in the construction and operational phases. Hughes *et al.* (2006) classify transaction costs by project phase, namely, pre-tendering costs (marketing, forming alliances, and establishing reputations), tendering costs (estimating, bidding, and negotiating), and post-tendering costs (monitoring performance, enforcement of contractual obligations, dispute resolution). Given that the objective of this study is to investigate the transaction costs borne by the owner, it is indeed appropriate that both pre-contract and post-contract transaction costs be considered in the study.

2.2 Pre-contract transaction costs

Pre-contract transaction costs are incurred before a transaction takes place. In this study, the pre-contract transaction costs are defined as the transaction costs borne by the owner before the construction contract is signed. At the pre-contract stage, Soliño and Gago de Santos (2009) conclude that pre-contract transaction costs include the costs of environmental impact assessment, feasibility study, preliminary design, and bidding including tender documentation preparation and negotiation. Whittington (2008) finds in six case studies that pre-contract transaction costs in the design-bid-build project delivery system range from 0.4 to 8.8 percent (average: 2.6 percent) of the value of the contract; the range for the design/build project delivery system is 0 to 5.7 percent (average: 2.2 percent).

2.3 Post-contract transaction costs

Post-contract transaction costs include the costs incurred after the contract has been signed but before the entire transaction has been completed. Post-contract transaction costs include the "setup and running costs of the governance structure to which monitoring is assigned and to which disputes are referred and settled: the

maladaptation costs that are incurred; the haggling costs that attend adjustments (or the lack thereof); and the bonding costs of effecting secure (credible) commitments" (Williamson, 1985).

Conflict and disputes in the construction industries of many countries (including Australia, USA, the UK, and Hong Kong) inflict a high cost to the industry (Yates, 1999). Whittington (2008) finds in six case studies that the post-contact transaction costs for the design-bid-build project delivery system range between 8.9 percent and 14.7 percent (average: 12.6 percent) of the contract value; the range for the design/build project delivery system is 3.4 percent to 14.3 percent (average: 9.5 percent).

3. Theoretical background and hypotheses

The transaction costs of any act of market exchange will depend on the interplay between different sets of human factors, environmental factors (Greenwood and Yates, 2007), and project factors. In a construction project the contractual problems include claims, change orders, and disputes. As Molenaar *et al.* (2000) suggest the factors that influence disputes include: people issues; process issues; and project issues. People issues involve organizations, relationships, roles, responsibilities, and expectations that affect these people. Process issues involve the manner in which the contract and construction are carried out. Project issues include those characteristics that define the technical nature of the work.

According to TCE, it is the inter-relationship between human and environmental factors that should ideally determine the eventual nature and governance structure of the transaction (Greenwood and Yates, 2007). The human factors are related to the owner's and contractor's behaviors. The environments factors involve the transaction environments and mechanism. In this study, the factors that affect transaction costs are extracted from the literature and are categorized under the headings of the uncertainty of the owner's behavior, the uncertainty of the contractor's behavior, uncertainty of the construction projects, and uncertainty of the transaction environment and mechanism.

3.1 Uncertainty of the owner's behavior

Owner behavior-related factors include experience, knowledge of construction project organization, financial stability, confidence in the project team, familiarity with construction methods, clarity of project scope, attitude toward risk, and competence in project management (Chan and Kumaraswamy, 1997; Songer and Molenaar, 1997; Dissanayaka and Kumaraswamy, 1999). The uncertainty of the owner's behavior can be measured by the following indicators.

Change orders are likely to be numerous if the owner's requirements are not clearly specified before the bidding stage. Onyango (1993) found that one of the largest contributors to claims was post-contract changes by owners. The preventive measures to reduce the frequency and magnitude of change orders and hence reduce transaction costs are discussed by Gunhan *et al.* (2007). Relationship with other parties focusses on whether the owner has a good relationship with designers, suppliers, and government agencies. This kind of stability in the owner's relationships reduces the likelihood of litigation (Arditi and Pulket, 2010) and is therefore likely to reduce transaction costs primarily in terms of legal fees.

Experience in similar type projects is highly related to the effectiveness of organizational learning. Experiences have value only if the lessons learned from

completed similar type projects are kept in the organizational memory and used in future projects (Kululanga and McCaffer, 2001). Experience in similar type projects is likely to generate fewer requests for information on the part of the contractor (Arditi *et al.*, 2010), and hence reduce transaction costs.

Payment on time concerns the timeliness of payments by the owner. Good relationships characterized by timely payments on the part of the owner are conducive to fewer claims on the part of the contractor, the absence of legal disputes (Ozorhon *et al.*, 2010), and hence a reduction in transaction costs.

Organizational efficiency involves the ability of a firm to produce maximum output given a set of inputs or to minimize input given a set of required outputs. Organizations try to combine inputs in their cost minimizing proportions, and aim to attain a cost minimizing scale of operation (Mosheim, 2002). To be effective, organizations need capabilities relevant to their missions and they must manage those capabilities efficiently. A stable and efficient organization is likely to reduce transaction costs.

If the owner issues a large number of change orders, has strained relationships with other parties (i.e. arbitrated or litigated cases), has little or no experience with similar projects, then the role of the owner affects transaction costs negatively (i.e. transaction costs will be higher). Building on these findings, it is expected that uncertainty of the owner's behavior would have a positive effect on transaction costs in construction projects:

H1. Transaction costs are higher if the owner's behavior is uncertainty.

3.2 Uncertainty of the contractor owner's behavior

Since a contract cannot cover all possible contingencies, may ask for additional payment due to inflation or other cost overruns, may threaten to deliberately file for bankruptcy, may fall behind schedule, and may either refuse to speed up or may demand extra payment due to the higher costs of overtime, and may pick out design errors and charge unreasonable rates for correcting them (Chang and Ive 2007). The uncertainty of the contractor's behavior can be measured by the following indicators.

Bidding behavior refers to the bidding behavior of a contractor relative to unbalanced pricing, claims games, and collusion. In competitive bidding, awarding a contract to an unbalanced bid may cause the owner's overall project cost to get higher, but it is hard to detect unbalancing (Arditi and Chotibhongs, 2009) and in some cases, it generates contentious change orders (Manzo, 1997). Collusion is an agreement among a group of firms whereby a bidder is allowed by the other bidders in the group to win a particular bid and obtain the greatest possible benefit from it (Chotibhongs and Arditi 2012). The failure to detect unbalanced bids, contractors who bid unreasonably low, and collusive bids is likely to cost the owner both in terms of transaction costs and production costs (Arditi and Chotibhongs, 2009; Chotibhongs and Arditi, 2012).

Qualifications of the contractor refers to how cognizant the owner is of the contractor's qualifications at the time the contract is signed. If the owner is not informed about the potential contractor's capabilities, the owner may face higher transaction costs due to bonding costs, and the contractor's likely deficiencies relative to the contractor's ability to schedule, coordinate, and control the work. Relationships with subcontractors concerns the quality and strength of the relationships between a general contractor and its subcontractors. As a general contractor and its subcontractors cooperate over the years, the relationships take the form of "relational" contracting (Constantino *et al.*, 2001). Maintaining relationships of high

quality with subcontractors is positively and strongly associated with general contractors' economic performance (Kale and Arditi, 2001), and the transaction costs incurred by the owner. The degree of partnering between a contractor and subcontractors can indicate the quality of these relationships.

Experience in similar type projects involves lessons learned from completed projects (Kululanga and McCaffer, 2001). A company may enjoy a good reputation if previous projects have been completed on schedule, within budget, in good quality and with minimal conflict (Molenaar *et al.*, 2000).

Relationships with previous owners concern the traditional rivalry between owners and contractors. Even though the importance of cooperation and trust between owners and contractors has been understood somewhat well, a strong relationship between owners and contractors is still difficult to achieve (Bresnen and Marshall, 2000). A smooth relationship is expected to lower transaction costs. The references provided by past owners can measure this indicator.

Material substitution refers to the replacement of one type of material for another. Closed specifications do not allow for substitution with a similar product. Since there is a suggestion of discrimination when only one supply source can be used, closed specifications are not common in public contracts. In open specifications, there is an opportunity for the contractor to ask more money due to the fluctuations in prices and uncertainty in the supply of the material. Frequent substitutions increase transaction costs. Frequency of claims is related to the contractor's policy relative to contract administration. Construction claims usually arise as assertions for extra money or time. The filing of a claim by a contractor, the evaluation of the claim by the owner, the resolution of the possible disagreements between the owner and the contractor generate substantial transaction costs. While such claims may be settled amicably, some can degenerate into unnecessary conflicts and disputes (Kumaraswamy, 1997), and in turn, increase transaction costs.

If the contractor displays ethical and lawful bidding behavior, is well qualified to do the job, has harmonious relationships with subcontractors, has constructed similar projects in the past, has had smooth relationships with previous owners, does not often file material substitution requests, and does not often file claims, then the contractor's impact on transaction costs is limited (i.e. transaction costs are low). Building on these findings, it is expected that uncertainty of the contractor's behavior would have a positive effect on transaction costs in construction projects:

H2. Transaction costs are higher if the contractor's behavior is uncertainty.

3.3 Uncertainty of the construction project

It is widely accepted that a construction project is subject to more risks than other business activities because of its complexity (Shen *et al.*, 2001). Technical plans/specifications should be subject to a complete review and be complete and clear (Diekmann and Girard, 1995). The uncertainty of the construction project can be measured by the following indicators.

Project complexity impacts the uncertainty in the transaction environment. The specific responses that different parties in construction manifest depend on the certainty of the environment. This environmental instability increases transaction costs (Farajian, 2010).

Uncertainty of project information indicates amount of information required to do the task and the amount of information already processed by the owner and contractor.

The amount of information needed depends on task complexity (the number of different factors that have to be coordinated); and performance requirements (such as time or budget constraints). When project uncertainty is high, initial drawings and specifications are likely to change, and the project members will have to solve many problems during construction.

Completeness of design is a measure of how well the owner or A/E have defined, documented, and specified the project. Unlike many other industries, construction is a complex blend of disparate needs, skills, and techniques that are difficult to coordinate. Inappropriately defined project scope may increase the number of change orders, disagreements, and disputes during the project (Diekmann and Girard, 1995), hence, increasing transaction costs.

Uncertainty of the construction project that is defined by project complexity, uncertainty in schedule and budget, incomplete design, is likely to generate higher transaction costs. Building on these findings, it is expected that uncertainty of the construction project itself would have a positive effect on transaction costs:

H3. Transaction costs are higher if the uncertainty of construction project is high.

3.4 Uncertainty of the transaction environment and mechanism

The contract between the owner and the contractor should define the rights and responsibilities of each party clearly. But the contract cannot predict all possible problem situations. Differences may exist in the parties' perception of risk allocation (Mitropoulos and Howell, 2001). A study of contract clauses found that there are significant disparities among owners and contractors with respect to the perception of risk allocation of contract clauses (Ibbs and Ashley, 1987). Uncertainty of transaction environment and mechanism can be measured by the following indicators.

Early contractor involvement is bound to have an effect on the many complex and uncertain processes owners face at the beginning of a construction project. It is also important to establish a trust-based cooperative relationship by facilitating contractors' contributions in the design stage (Korczynski, 1996; Eriksson and Pesämaa, 2007). The collateral effect of early contractor involvement in the design phase is a reduction in transaction costs as constructability problems are minimized in the construction phase.

Competition between bidders is the basic principle of project procurement. The absence of competition is associated with relatively low costs of bidding and contract negotiation (Dudkin and Välilä, 2005). Farajian (2010) also agrees with the idea that a lesser amount of competition can generate relatively low-transaction costs during the project initiation and procurement phases, but it is likely that total project costs will be higher due to the weaker competitive procurement process.

Integration of design and construction capitalizes on the close relationship between design and construction. These processes can best be viewed as an integrated system. Improved integration, collaboration, and communication in the interface between design and construction reduces transaction costs (Vrijhoef and Ridder, 2007), and can be achieved by project delivery systems such a design/build or integrated project delivery as opposed to the traditional design-bid-build system.

Bonding requirements refers to third party guarantees on contractor performance. Although the bonding fee is paid by the contractor, this is reflected in the contractor's overhead, which in turn is recovered from the owner. On the other hand, bonding requirements would discourage any opportunistic behavior on the part of the contractor (Mysen *et al.*, 2011), hence reducing transaction costs.

Incentive/disincentive clauses are important in construction contracts to encourage contractors to perform on schedule and/or within budget. The aim of this arrangement is to motivate the contractor and owner to work together to minimize project duration and/or actual costs; the contractor is able to maximize profits by capturing incentives, and the owner is motivated to minimize the total project duration and/or cost (Broome and Perry, 2002).

Fair risk allocation refers to the proper allocation of risks between the owner and the contractor. However, whenever risks are transferred to the contractor, contractors usually respond to these risks by increasing their contingency and markup, which ultimately increases the contract price to the owner (El-Sayegh, 2008). Fair risk allocation reduces conflicts and disputes, and consequently reduces transaction costs.

The transaction environment and mechanism that is defined by contractor early involvement, complete competition between bidders, connected design and construction activities, bonding requirements, contract incentives/disincentives, and fair risk allocation in the contract is likely to generate lower transaction costs. Building on these findings, it is expected that uncertainty of transaction environment and mechanism would have a positive effect on transaction costs:

H4. Transaction costs are higher if the uncertainty in the transaction environment and mechanism is high.

A model depicting the key theoretical relationship among the uncertainty of the owner's behavior, the uncertainty of the contractor's behavior, the uncertainty of the construction project, the uncertainty of the transaction environment and mechanism, and transaction costs is presented in Figure 1.

4. Research methodology

4.1 Sample and procedures

A questionnaire survey was conducted by e-mail to collect the required data on the variables and magnitude of transaction costs in construction projects. The potential respondents were selected from the list of Construction Owners Association of America

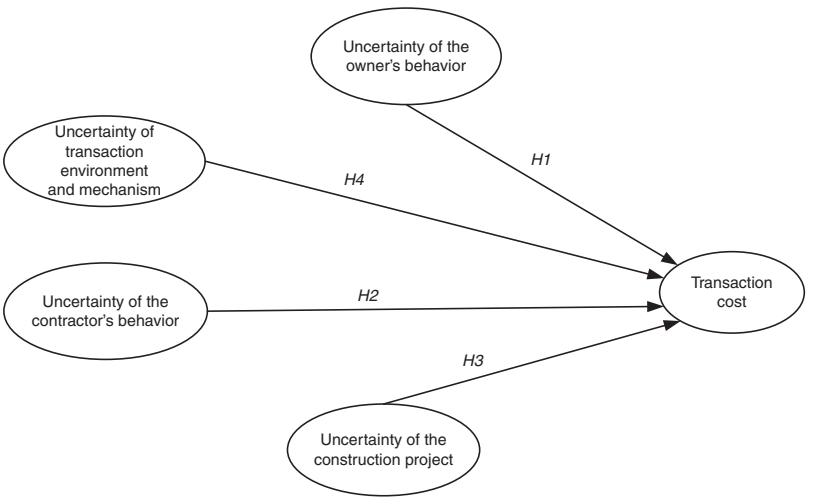

Figure 1.
Research framework

(COAA) 2011 Membership Directory, Federal Highway Administration (FHWA), 2010 members of American Association of State Highway and Transportation Officials Members (AASHTO), and the largest owners listed by The Top Owners list (Engineering News-Record, 2010). From March 2011 to April 2011, 2,628 e-mails were sent out. In total, 129 potential respondents were out of office, and 195 e-mails were not delivered. Finally, a total of 239 completed responses were returned for data analysis. The rate of response is 10.37 percent.

In total, 82 percent of the respondents are from the public sector and 18 percent from the private sector. This distribution is not surprising because most of the membership of COAA, AASHTO, and FHWA are public organizations. Concerning the respondents' status in their organization, 26 percent occupy executive positions, and 51 percent are project managers, and as such, they are expected to have adequate knowledge about construction project management. Also, 79 percent of the respondents have more than 15 years of work experience. Given the managerial level and the extensive experience of the respondents, the answers to the survey can be considered to be reliable.

The data collected from 239 questionnaires were analyzed using a software package called IBM® SPSS® Amos 7.0, a structural equation modeling (SEM) tool.

4.2 Measures

Respondents were required to rate the level of each determinant taking into account the characteristics of their organization's last construction project in which they were involved. They used a one to five point Likert scale, where 1 denoted "strongly agree" and 5 "strongly disagree."

Uncertainty of the owner's behavior. We measured uncertainty of the owner's behavior using five-item scale from the findings in Section 3 (1 strongly agree; 5 strongly disagree).

Uncertainty of the contractor's behavior. We measured uncertainty of the contractor's behavior using seven-item scale from the findings in Section 3 (1 strongly agree; 5 strongly disagree).

Uncertainty of the construction project. We measured uncertainty of the construction project using three-item scale from the findings in Section 3 (1 strongly agree; 5 strongly disagree).

Uncertainty of the transaction environment and mechanism. We measured uncertainty of the transaction environment and mechanism using six-item scale from the findings in Section 3 (1 strongly agree; 5 strongly disagree).

Transaction costs. We measured transaction costs using pre-contract and post-contract transaction costs. Pre-contract transaction costs include the cost of market research, the cost of exploring financing opportunities, the cost of conducting a feasibility study, the cost of bidding/negotiation, and the cost of day-to-day pre-contract project management. Also, respondents are asked to estimate the approximate cost of pre-contract transaction costs with respect to contract value in the last project they completed for their company/agency (1 for under 0.5 percent, 2 for 0.5-3.0 percent; 3 for 3.0-6.0 percent; 4 for 6.0-9.0 percent; 5 for higher 9.0 percent). Post-contract transaction costs include the cost of day-to-day contract administration, the cost of administering claims and change orders, the cost of dispute resolution, and incentive payments. Respondents are also asked to estimate the approximate cost of post-contract transaction costs with respect to contract value in the last project they completed for their company/agency (1 for under 4 percent; 2 for 4-8 percent; 3 for 8-12 percent; 4 for 12-16 percent; 5 for higher 16 percent).

4.3 Statistical analysis

The validity and reliability of the five constructs are presented in Table I. All Cronbach's α coefficients are satisfactory since they are all above 0.70. All the average variance extracted are above 0.50 and all composite reliability values are larger than 0.70. These results suggest that the internal consistencies of the construct are satisfactory. The factor loadings of the respective variables are presented in Table I. All factor loadings are above 0.50. In conclusion, it can be stated that all constructs on reliable.

Evaluating the measurement model. Confirmatory factor analysis was conducted by using IBM® SPSS® Amos 7.0. The unidimensionality, convergent validity, and discriminant validity of the measurement scales were examined. Table II shows the model fit indices.

Latent variables	Observed variables	Factor loading	Cronbach's α	Average variance extracted	Composite reliability
Uncertainty of the owner's behavior	Change orders	0.67	0.732	0.69	0.91
	Relationships with other parties	0.84			
	Experience in similar type projects	0.86			
	Payment on time	0.65			
	Organizational efficiency	0.67			
Uncertainty of the contractor's behavior	Bidding behavior	0.83	0.732	0.621	0.86
	Qualifications of the contractor	0.68			
	Relationships with subcontractors	0.78			
	Relationships with previous clients	0.79			
	Experience in similar type projects	0.86			
	Material substitution	0.58			
	Frequency of claim	0.72			
Uncertainty of the construction project	Project complexity	0.78	0.720	0.65	0.94
	Uncertainty of project information	0.82			
	Completeness of design	0.79			
Uncertainty in the transaction environment	Early contractor involvement	0.85	0.747	0.69	0.91
	Competition between bidders	0.89			
	Integration of design and construction	0.90			
	Bonding requirements	0.88			
	Incentive/disincentive clauses	0.81			
	Fair risk allocation	0.82			
Transaction costs	Pre-contract transaction costs	0.88	0.74	0.73	0.85
	Post-contract transaction costs	0.83			

Table I. Validity and reliability of constructs

The model fits the data well. As seen in Table II, all parameters are within recommended boundaries. Also, as seen in Table I, all the observed variables load highly and significantly onto their respective latent variables. In addition, all the constructs are positively and significantly correlated with each other.

Testing the structural model. The structural model presented in Figure 2 explains the relationships between the latent variables by means of the direction of the paths between the variable and the strength of the path coefficients. As seen in Table III, all parameters conform to recommended values. The model fits the data well.

Table II. Goodness-of-fit indices for the measurement model

Goodness-of-fit indices	Measurement model	Desired levels
Chi-square (χ^2)	812.8	Smaller
Degree of freedom (df)	356	–
χ^2/df	2.56	< 3.0
Root mean square residual (RMR)	0.043	< 0.05
Goodness-of-fit index (GFI)	0.912	> 0.90
Adjusted goodness-of-fit index (AGFI)	0.813	> 0.80
Parsimonious goodness-of-fit index (PGFI)	0.542	> 0.5
Comparative fit index (CFI)	0.905	> 0.90
Root mean squared error (RMSEA)	0.063	0.05-0.08

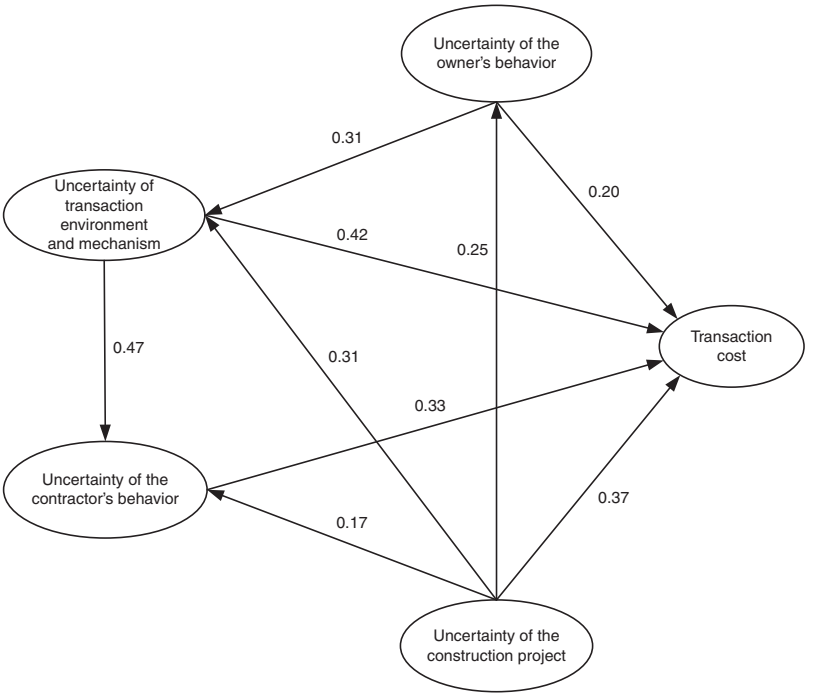

Figure 2. The structural equation model

Note: The path coefficients are significant at $p < 0.05$

5. Discussion of the findings

The reliability of the five constructs (Table I) and of the model (Table II) is satisfactory. The goodness-of-fit indices of the structural model (Table III) are also quite satisfactory. In this study, maximum likelihood was used to estimate hypothesized paths. All the path coefficients were statistically significant, shown in Figure 2.

5.1 Uncertainty of the owner's behavior

The first hypothesis that transaction costs raise up if the owner's behavior is uncertainty is verified by the data since the path coefficient is significant at $\alpha = 0.05$. On the other hand, the model indicates that a uncertainty behavior on the part of the owner increases the uncertainty in the transaction environment and increases the uncertainty behavior of the contractor since both path coefficients are significant at $\alpha = 0.05$. It appears that the uncertainty of the owner's behavior not only have a direct effect on transaction costs, but also has an indirect effect through "uncertainty in transaction environment and mechanism" and "uncertainty of the contractor's behavior."

According to the factor loadings presented in Table I, in order to reduce uncertainty of owner's behavior, the owner should have a good relationship with other parties such as contractors, designers, suppliers, and government agencies, pay the contractors on time, make an effort to improve organizational efficiency, and make sure plans and specifications are as complete as possible to reduce the frequency and severity of change orders. If the owner does not have experience in similar type projects, the owner should hire a professional project management firm.

5.2 Uncertainty of the contractor's behavior

The influence of the uncertainty of the contractor's behavior on transaction costs was found to be moderate, leading to the assertion that the second hypothesis holds. The more certainty the contractor's behavior, the less transaction costs are incurred. When a contractor is well-established and performs professionally and ethically, it is likely that it will not engage in opportunistic practice such as issuing unnecessary claims, hence reducing transaction costs.

The uncertainty of the contractor's behavior was also found to be affected by the proposed uncertainty of construction project positively. Given uncertainty of the construction project's effect on transaction costs (the higher uncertainty of the construction project, the higher transaction costs, significant at $\alpha = 0.05$), it can be stated that the uncertainty of the construction project affects transaction cost not only directly, but also indirectly through its effect on "uncertainty of the contractor's behavior."

Goodness-of-fit indices	Structural model	Desired levels
Chi-square (χ^2)	635.43	Smaller
Degree of freedom (df)	343	–
χ^2/df	2.431	< 3.0
Root mean square residual (RMR)	0.043	< 0.05
Goodness-of-fit index (GFI)	0.912	> 0.90
Adjusted goodness-of-fit index (AGFI)	0.835	> 0.80
Parsimonious goodness-of-fit index (PGFI)	0.543	> 0.5
Comparative fit index (CFI)	0.910	> 0.90
Root mean squared error (RMSEA)	0.056	0.05-0.08

Table III. Goodness-of-fit indices for the proposed structural model

According to the factor loadings presented in Figure 2, in order to reduce uncertainty of contractor's behavior and lower transaction costs, the contractor should stay away from bidding irregularities such as unbalanced pricing, cheating, and collusion; be qualified to do the jobs the contractor bids; have a good relationship with subcontractors and previous clients; and have experience in similar type projects.

5.3 Uncertainty in the transaction environment and mechanism

Certainty in the transaction environment means the scope of the project is well-defined, and the plans and specifications are clear and complete. The dominant influence of the transaction environment and mechanism on transaction costs observed in this study may be attributed not only to its direct influence on transaction costs, but also to its indirect influence through the contractor's behavior. The extensive effect of the transaction environment is also supported by other studies such as those by Diekmann and Girard (1995), Shen *et al.* (2001), Mitropoulos and Howell (2001), Ibbs and Ashley (1987), and Walker and Pryke (2009). As indicated by the high factor loadings in Table I, in order to reduce uncertainty in the transaction environment and hence transaction costs, the owner should make sure the design is as complete as possible, to secure the contractor's early involvement in the project, to encourage healthy competition between bidders, to integrate design and construction, and to assure a fair allocation of risks.

It was also found that the transaction environment and mechanism is affected by the owner's behavior and uncertainty of construction project. On the other hand, the transaction environment was found to affect the contractor's behavior. It is indeed the high level of uncertainty in the transaction environment that forces contractors to jack up their bids, file numerous claims, deal with substantial amounts of extra work, and in general have antagonistic relationships with owners that sometimes end up in disagreement, conflicts, and litigation. This finding makes sense since it is the owner who regulates all the factors mentioned in the preceding statement.

6. Conclusion

The construction project is performed in a complex and high risk environment. In such an environment, questionable decisions can be made in the planning and design phase; and disagreements, conflicts, disputes, change orders, and claims can occur in the construction phase. These problems contribute to an increase in transaction costs. In this study, a thorough compilation of the definitions of owner-borne transaction costs in construction projects was established by reconciling the views of different researchers and an empirical study was conducted to find the factors that affect transaction costs. The effects on transaction costs of the uncertainty of the owner's behavior; the uncertainty of the contractor's behavior; uncertainty of the construction project; and the uncertainty in the transaction environment and mechanism were investigated.

Data were collected by means of a questionnaire survey that was administered to the members of COAA, FHWA, AASHTO and the largest owners listed by *Engineering News-Record*. The collected data were analyzed using SEM. The reliability of the constructs used in the model is high, and the fit indices of the final structural model are satisfactory. The findings of the study are presented below:

Uncertainty in the transaction environment and mechanism appears to be the core construct of the model due to its strong linkages with transaction costs and the owner's behavior, the contractor's behavior, and construction project. The factor loadings of this construct (Table I) indicate that an integrated design and construction;

early contractor input to design; a healthy competition between bidders; and a fair allocation of risks through bonding and contract clauses that establish incentives/disincentives should reduce transaction costs.

Uncertainty of the construction project was found to moderately affect transaction costs through owner's behavior, the contractor's behavior and transaction environment and mechanism revealing the importance of project complexity; project information; and completeness of design in project. A design that is complete enough to deal with the high uncertainty and complexity inherent in modern projects should reduce transaction costs. Each construction project is unique and appropriate strategies should be developed to handle the particular uncertainties of the construction project.

The uncertainty of the contractor's behavior was found to be associated with transaction costs, which supports Williamson's (1979) view that uncertainty of behavior would increase transaction costs of economic exchange. Given the variables that control the "uncertainty of the contractor's behavior" construct (Table I), lower transaction costs can be achieved by procedures that make sure that the potential bidders do not unbalance their bids and do not collude with other bidders; have good relationships with former clients and subcontractors; and are qualified and experienced enough to perform the jobs they bid.

There is a significant relationship between the uncertainty of the owner's behavior and transaction costs. The owner's behavior not only affect transaction costs directly, it was found that it indirectly influences transaction costs through its impact on uncertainty of transaction environment and mechanism.

6.1 Implications

Based on the findings of this study, it can be concluded that the transaction costs borne by the owner can be minimized if the owner minimizes the uncertainties inherent in the transaction environment, understands well the behavior of the contractor, and pays attention to construction project information. Unlike most other research in this field, this study provides a complete picture of the transaction costs incurred by an owner in construction projects under uncertainty and concludes that an owner can minimize transaction costs by promoting constructable and timely design; harmonious relationships between project participants; fair risk allocation; completeness of design; and contractor selection practices that routinely detect irregular behavior.

6.2 Limitations and future research

The data used in this research are primarily based on the experiences of public owners and the markets in which they operate; a larger representation of private owners could make the conclusions more general. Another limitation of the study is that it relies on a survey of opinions rather than actual records of costs and other hard data. Finally, this research considered the total transaction costs borne by the owner; future research can look into the factors that affect transaction costs in the pre-contract and post-contract phases separately.

References

AECOM Consult Incorporated (2010), "Estimating soft costs for major public transportation fixed guide way projects", Transit Cooperative Research Program (TCRP) Report No. 138, Transportation Research Board, Washington, DC.

Antinori, C. and Sathaye, J. (2007), "Assessing transaction costs of project-based greenhouse gas emission trading", Formal Report No. LBNL-57315, Lawrence Berkeley National Laboratory, Berkeley.

Arditi, D. and Chotibhongs, R. (2009), "Detection and prevention of unbalanced bids", *Construction Management and Economics*, Vol. l27 No. 8, pp. 721-732.

Arditi, D. and Pulket, T. (2010), "Predicting the outcome of construction litigation using an integrated artificial intelligence model", *Journal of Computing in Civil Engineering*, Vol. 24 No. 1, pp. 73-80.

Arditi, D., Polat, G. and Akin, S. (2010), "Lessons learned system in construction management", *International Journal of Project Organization and Management*, Vol. 2 No. 1, pp. 61-83.

Bajari, P. and Tadelis, S. (2001), "Incentives versus transaction costs: a theory of procurement contracts", *RAND Journal of Economics*, Vol. 32 No. 3, pp. 387-407.

Bremer, W. and Kok, K. (2000), "The Dutch construction industry: a combination of competition and corporatism", *Building Research and Information*, Vol. 28 No. 2, pp. 98-108.

Bresnen, M. and Marshall, N. (2000), "Building partnerships: case studies of client-contractor collaboration in the UK construction industry", *Construction Management and Economics*, Vol. 18 No. 7, pp. 819-832.

Brokmann, C. (2001), "Transaction cost in relationship contracting", *AACE International Transactions*, pp. 1-7.

Broome, J. and Perry, J. (2002), "How practitioners share fractions in target cost contracts", *International Journal of Project Management*, Vol. 20 No. 1, pp. 59-66.

Chan, D.W.M. and Kumaraswamy, M.M. (1997), "A comparative study of the causes of time and cost overruns in Hong Kong construction projects", *International Journal of Project Management*, Vol. 15 No. 1, pp. 55-63.

Chang, C.Y. and Ive, G. (2007), "Reversal of bargaining power in construction projects: meaning, existence and implications", *Construction Management and Economics*, Vol. 25 No. 8, pp. 845-855.

Chotibhongs, R. and Arditi, D. (2012), "Analysis of collusive bidding behavior", *Construction Management and Economics*, Vol. 30 No. 3, pp. 221-231.

Coase, R. (1937), "The nature of the firm", *Economica*, Vol. 4 No. 16, pp. 386-405.

Constantino, N., Pietroforte, R. and Hamill, P. (2001), "Subcontracting in commercial and residential construction: an empirical investigation", *Construction Management and Economics*, Vol. 19 No. 4, pp. 439-447.

Diekmann, J.E. and Girard, M.J. (1995), "Are contract disputes predictable?", *Journal of Construction Engineering and Management*, Vol. 121 No. 4, pp. 355-363.

Dissanayaka, S.M. and Kumaraswamy, M.M. (1999), "Evaluation of factors affecting time and cost performance in Hong Kong building projects", *Engineering, Construction and Architectural Management*, Vol. 6 No. 3, pp. 287-298.

Dudkin, G. and Välilä, T. (2005), "Transaction costs in public-private partnerships: a first look at the evidence", economic and financial report, European Investment Bank, Luxembourg.

Eccles, R.G. (1981), "The quasi-firm in the construction industry", *Journal of Economic Behavior and Organization*, Vol. 2 No. 4, pp. 335-357.

El-Sayegh, S.M. (2008), "Risk assessment and allocation in the UAE construction industry", *International Journal of Project Management*, Vol. 26 No. 4, pp. 431-438.

Engineering News-Record (2010), "Top owners list", available at: http://enr.construction.com/toplists/ sourcebooks2010/Owners/topOwners/001-100.asp (accessed March 1, 2011).

Eriksson, P.E. and Pesämaa, O. (2007), "Modelling procurement effects on cooperation", *Construction Management and Economics*, Vol. 25 No. 8, pp. 893-901.

Farajian, M. (2010), "Transaction cost estimation model for us infrastructure public private partnerships", MS thesis, University of Maryland, College Park, MD.

Greenwood, D.J. and Yates, D.J. (2007), "The determinants of successful partnering: a transaction cost perspective", *Journal of Construction Procurement*, Vol. 12 No. 1, pp. 4-22.

Gunhan, S., Arditi, D. and Doyle, J. (2007), "Avoiding change orders in public school construction", *Journal of Professional Issues in Engineering Education and Practice*, Vol. 133 No. 1, pp. 67-73.

Gunnarson, S. and Levitt, R.E. (1982), "Is a building construction project a hierarchy or a market?", *Proceedings of the Seventh World Congress of Project Management*, *Copenhagen*.

Hillebrandt, P.M. and Hughes, W. (2000), "What are the costs of procurement and who bears them?", *Proceedings of 2nd International Conference on Construction in Developing Countries*, *Gaborone*.

Ho, P. and Tsui, C.-W. (2009), "The transaction cost of public private partnerships", *Proceedings of LEED Conference*, *CO*.

Hughes, W., Hillebrandt, P., Greenwood, D. and Kwawu, W. (2006), *Procurement in the Construction Industry: The Impact and Cost of Alternative Market and Supply Processes*, Taylor and Francis, London and New York, NY.

Ibbs, C.W. and Ashley, D.B. (1987), "Impact of construction contract clauses", *Journal of Construction Engineering and Management*, Vol. 113 No. 3, pp. 501-517.

Jobin, D. (2008), "A transaction cost-based approach to partnership performance evaluation", *Evaluation*, Vol. 14 No. 4, pp. 437-456.

Joskow, P.L. (1985), "Vertical integration and long-term contracts: the case of coal-burning electric generating plants", *Journal of Law, Economics, and Organization*, Vol. 1 No. 1, pp. 33-80.

Kale, S. and Arditi, D. (2001), "General contractors' relationships with subcontractors: a strategic asset", *Construction Management and Economics*, Vol. 19 No. 5, pp. 541-549.

Korczynski, M. (1996), "The low-trust route to economic development: inter-firm relations in the UK engineering construction industry in the 1980s and 1990s", *Journal of Management Studies*, Vol. 33 No. 6, pp. 787-808.

Kululanga, G.K. and McCaffer, R. (2001), "Measuring knowledge management for construction organizations", *Engineering, Construction and Architectural Management*, Vol. 8 Nos 5/6, pp. 346-354.

Kumaraswamy, M.M. (1997), "Conflicts, claims and disputes in construction", *Engineering, Construction and Architectural Management*, Vol. 4 No. 2, pp. 95-111.

Lai, L.W.C. (2000), "The Coasian market-firm dichotomy and subcontracting in the construction industry", *Construction Management and Economics*, Vol. 18 No. 3, pp. 355-362.

Lynch, T.D. (1996), "A transaction cost framework for evaluating construction project organization", doctoral dissertation, Pennsylvania State University, University Park, PA.

Manzo, F.A. (1997), "The impact of an unbalanced bid on the change order process", *Construction for News*, Vol. 7 No. 1, pp. 1-8.

Miller, C.J.M., Packham, G.A. and Thomas, B.C. (2002), "Harmonization between main contractors and subcontractors: a prerequisite for lean construction?", *Journal of Construction Research*, Vol. 3 No. 1, pp. 67-82.

Mitropoulos, P. and Howell, G. (2001), "Model for understanding, preventing, and resolving project disputes", *Journal of Construction Engineering and Management*, Vol. 127 No. 3, pp. 223-231.

Molenaar, K.R., Washington, S. and Diekmann, J. (2000), "Structural equation model of construction contract dispute potential", *Journal of Construction Engineering and Management*, Vol. 126 No. 4, pp. 268-277.

Mosheim, R. (2002), "Organizational type and efficiency in the Costa Rican coffee processing sector", *Journal of Comparative Economics*, Vol. 30 No. 2, pp. 296-316.

Müller, R. and Turner, J.R. (2005), "The impact of principal-agent relationship and contract type on communication between project owner and manager", *International Journal of Project Management*, Vol. 23 No. 5, pp. 398-403.

Mysen, T., Svensson, G. and Payan, J.M. (2011), "The key role of opportunism in business relationships", *Marketing Intelligence and Planning*, Vol. 29 No. 4, pp. 436-449.

Onyango, D. (1993), "Reduction in conflicts in construction", MSc report, Loughborough University of Technology, Loughborough.

Ozorhon, B., Arditi, D., Dikmen, I. and Birgonul, M.T. (2010), "The performance of international joint ventures in construction", *Journal of Management in Engineering*, Vol. 26 No. 4, pp. 209-222.

Piertoforte, R. (1997), "Communication and governance in the building process", *Construction Management and Economics*, Vol. 15 No. 1, pp. 71-82.

Rahman, M.M. and Kumaraswamy, M.M. (2002), "Minimising transaction costs, maximising relational benefits and optimizing risk management – through partnering in Hong Kong projects.", *International Journal for Construction Marketing*, Vol. 3 No. 2, pp. 51-72.

Reve, T. and Levitt, R.E. (1984), "Organization and governance in construction", *International Journal of Project Management*, Vol. 2 No. 1, pp. 17-25.

Shen, L.Y., Wu, G.W.C. and Ng, C.S.K. (2001), "Risk assessment for construction joint ventures in China", *Journal of Construction Engineering and Management*, Vol. 127 No. 1, pp. 76-81.

Soliño, A.S. and Gago de Santos, P. (2009), "Transaction costs in PPP transport infrastructure projects", working paper, European Investment Bank.

Songer, A.D. and Molenaar, K.R. (1997), "Project characteristics for successful public-sector design-build", *Journal of Construction Engineering and Management*, Vol. 123 No. 1, pp. 34-40.

Turner, J.R. and Keegan, A. (2001), "Mechanisms of governance in the project-based organization: roles of the broker and steward", *European Management Journal*, Vol. 19 No. 3, pp. 254-267.

Turner, J.R. and Simister, S.J. (2001), "Project contract management and a theory of organization", *International Journal of Project Management*, Vol. 19 No. 8, pp. 457-464.

Vrijhoef, R. and Ridder, H. (2007), "Supply chain systems engineering in construction", working paper, Delft University of Technology, Delft.

Walker, F. and Pryke, S. (2009), "Role definition and dimensions of incomplete construction contract documents", *Proceeding of RICS COBRA Research Conference*, University of Cape Town, pp. 1258-1275.

Whittington, J.M. (2008), "The transaction cost economics of highway project delivery: design-build contracting in three states", doctoral dissertation, University of California, Berkeley, CA.

Williamson, O.E. (1979), "Transaction cost economics: the governance of contractual relations", *Journal of Law and Economics*, Vol. 22 No. 2, pp. 233-261.

Williamson, O.E. (1985), *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, Free Press, New York, NY.

Williamson, O.E. (1987), *The Economic Institutions of Capitalism*, The Free Press, New York, NY.

Winch, G. (1989), "The construction firm and the construction project: a transaction cost approach", *Construction Management and Economics*, Vol. 7 No. 4, pp. 331-345.

Winch, G.M. (2001), "Governing the project process: a conceptual framework", *Construction Management and Economics*, Vol. 19 No. 8, pp. 799-808.

Yates, D.J. (1999), "Conflict and dispute in the development process: a transaction cost economic perspective", working paper, Department of Real Estate and Construction, the University of Hong Kong, Hong Kong.

Further reading

Bajari, P. and Summers, G. (2002), "Detecting collusion in procurement auctions", *Antitrust Law Journal*, Vol. 70 No. 1, pp. 143-170.

Barclay, D.W., Thompson, R. and Higgins, C. (1995), "The partial least squares (PLS) approach to causal modeling: personal computer adoption and use an illustration", *Technology Studies*, Vol. 2 No. 2, pp. 285-309.

Kaplan, R.S. and Norton, D.P. (1992), "The balanced scorecard – measures that drive performance", *Harvard Business Review*, Vol. 70 No. 1, pp. 71-79.

About the authors

Lei Guo is an Associate Professor in the Department of Water Resources and Hydroelectric Power at the North China University of Water Resources and Electric Power, China. He holds a PhD in Hydraulic Structure Engineering and he conducts research and publishes regularly in the area of hydraulic structure engineering and construction management.

Huimin Li is an Associate Professor in the Department of Construction Engineering and Management at the North China University of Water Resources and Electric Power, China. He holds a PhD in Management Science and Engineering and he conducts research and publishes regularly in the area of transaction costs in construction. His interests also include a range of areas within the construction management discipline including project delivery systems, procurement processes, risk management, and schedule management. Huimin Li is the corresponding author and can be contacted at: ncwulhm@aliyun.com

Peng Li is a Lecturer, PhD, at the North China University of Water Resources and Electric Power. His research interest is engineering philosophy.

Chengyi Zhang is an Assistant Professor in Department of Applied Engineering and Technology at the Eastern Kentucky University. He holds a PhD in Civil Engineering and he conducts research and publishes regularly in the area of civil engineering and construction management.