IMPACT OF PROCUREMENT SYSTEMS ON TRANSACTION COSTS: A STRUCTURAL EQUATION MODELLING METHODOLOGY

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ABSTRACT

Within construction procurement, Transaction cost economics (TCE) offers a mechanism to understand 'unseen' costs associated with the pre and post-contract work. Pre-contract, these include costs related to information gathering and procurement. Post-contract they include activities of contract administration ***and*** *enforcement. This paper aims to estimate transaction costs (TCs) for different delivery systems used in construction projects in New Zealand, specifically the Traditional and Design-Build.*

This study develops a conceptual model for the relationship between project delivery systems and TCs. The model was operationalized and developed into a questionnaire. A cross-sectional sample approach was deployed, involving pilot and survey questionnaires. Data was sought from construction professionals in management, design and operations. TCs were measured using professionals' time-spent in procurement as a surrogate for cost. Using using a Likert-Scale 1-5 in evaluation, comparing the Traditional and Design-Build systems. Data was triangulated with 'real world' cases to test and explain the developed model. The test included Validity and Reliability, Path Analysis, Regression Analysis, Factor Analysis, and Structural Equation Modelling (SEM). The primary analytical technique used was SEM to yield information on Goodness-of-Fit, model development and comparison, and confirmatory strategies. SPSS Amos 21 was used for data analysis and model development.

The results suggest that project delivery systems have indirect effect on TCs. This effect is fully mediated by the costs of information, procurement, administration, and enforcement. Applying the developed models to 'real world' cases, it was found that TCs in the Traditional systems amounts to 18.5% of the annual salary cost of a project manager, while in the

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Design-Build systems, it amounts to 14.5% of the annual salary cost of a project manager. The findings have practical implications on construction business practice due to their robust empirical nature and theoretical framework, which might enhance the performance of the construction industry.

KEYWORDS: Construction, Procurement Systems, Structural Equation Modelling, Transaction Costs

INTRODUCTION

Transaction costs (TCs) are the price that market participants have to pay in order to reach an agreement, develop rules to implement this agreement, and establish the appropriate delivery system as part of the agreement. In construction, TCs are primarily linked to costs at the pre and post-contract phases. Pre-contract costs borne by construction owners in information search and procurement. Post-contract costs borne by construction owners in contract administration and enforcement (Lynch, 1996; Rindfleisch & Heide, 1997; Williamson, 2010b; Li et al., 2013). These unseen costs are incurred because of professionals' time-spent in procurement activities, which can be considered as a waste of social resources and wealth (Wenan & Mengjun, 2010; Wenan & Tianhua, 2010). Thus, they are among the important factors that affect the construction projects' performance. So far, there have only been a few attempts to apply the transaction cost framework to determine the 'unseen' costs in procurement in the construction industry. This is even more unknown within New Zealand's construction industry.

This study examines the relationship between project delivery systems and TCs in the framework of New Zealand's construction industry. Three central issues are explored. First, what are transaction costs? Second, to what extent are the TCs in construction related to its procurement? Third, can a construction firm improve its procurement practices in New Zealand?

In addressing the first issue, a search for a robust conceptualization of TCs is required. Transaction costs might tentatively be associated with the professionals' time-spent on procurement during the pre and post-contract phases. But is procurement activities described in terms of information search, negotiation and preparing bid documentation, contract administration, and contract enforcement? Evidently the definition of TCs in construction requires considerable thought and reflection.

The second issue lies in determining whether the TCs of a construction project relates to its procurement practices, or there are other factors such as uncertainties in the transaction environment that influence the TCs. An initial response from practitioners and academics might be that best practice procurement is more likely to achieve superior project execution.

Given that the most suitable procurement practice leads to improved productivity within construction, the third issue arises: Can a construction firm improve its procurement practices in New Zealand? Solely focusing on the design of formal procurement processes and procedures is not enough for cost savings, minimizing claims, and reducing conflict and dispute. There is a need to consider the interaction of uncertainties in the transaction environment, and the unseen costs of information, procurement, contract administration, and contract enforcement in the procurement decision.

There are relatively few studies that have attempted to apply the concept of TC across a wide range of construction centric topics. For example, Winch (2001) applied the concept of TC to evaluate the project organization and determine the appropriate governance structure. A study by Eccles (1981) used the TCs to evaluate construction market with a focus on sub-contracting. Lynch (1996) adopted the transaction costs framework to determine the appropriate delivery systems for construction projects. A study conducted by Dudkin and Valila (2005) tried to measure and evaluate transaction costs in public private partnership projects (PPPs) in the U.K. Recently, a study conducted by Li et al. (2013) evaluated the project performance based on TCs incurred.

The majority of studies applying TC concept in construction have different definitions of the concept, and focusing on theoretical and qualitative aspects of the concept. For example, some researchers define TCs as the contract cost while others call it procurement cost. Williamson (1985) in the organization theory (TCE) defines transaction costs to include the costs of drafting, negotiating, contract administration, and contract enforcement. Some authors have suggested including other costs such as costs of acquiring information, legal, organizational (Joskow, 2002), and costs of breaching contractual agreements (Rahman & Kumaraswamy, 2002). In the context of a contractual arrangement, TCE has traditionally examined the customer-supplier relationship. With the assumption that this relationship is associated with TCs including costs of information, negotiation, competitive advantage, contract administration and management, market structure, enforcement and measuring/monitoring of performance (Heide & Stump, 1995; Artz, 1999; Melese & Franck, 2005).

In construction projects, Turner and Simister (2001) identified a different set of TCs throughout the project lifecycle such as specifying the product and the worked method in the tender documentation, managing variation to the project specification and process specification during project delivery. Moreover, Hughes et al. (2006) classified TCs in three project phases: - In the pre-tendering phase, mainly the costs of marketing and information search were included. In the tendering phase, it is the costs of bidding and negotiation. While in the post-tendering phase, it is the costs of dispute resolution, monitoring and control, and contract enforcement. Similarly, the study by Wittington (2008) included TCs from the costs of advertisement and bids preparation and award, to the cost of contract execution. Finally, according to Lingard et al. (1998) one should distinguish between the pre and post-contract transaction costs. Pre-contract costs incurred in information, communication, negotiation, bids documentation, and project preliminary design. Post-contract costs incurred in disputes resolution, contract administration and enforcement. In summary, concepts related to transaction costs are inconsistent in definition and there is little agreement how the concept is constructed. This means inconsistency in data, and renders data analysis almost impossible (Farajian, 2010).

Throughout this research the term transaction costs refers to costs borne by construction owners because of professionals' time-spent on procurement in the pre and post-contract phases. In the pre-contract phase, TCs include the costs of information search and project procurement. While in post-contract phase, TCs include the costs of contract administration and enforcement. In construction projects, the chosen delivery systems may significantly influence costs of information, procurement, administration, and enforcement, which in turn considerably affect the TCs. According to Williamson (1981), the key sources of TCs are economic actors' behavioral assumptions (e.g. opportunistically and bounded rationality) and transaction characteristics such as asset specificity, uncertainty, frequency, complexity, and contestability. The opportunity costs relate to renegotiation and delays in delivery, which may significantly undermine expected benefits of the project (Ho & Tsui, 2009). Similarly, if the construction owners outsourced project activities, this in turn could involve extra TCs such as negotiation, measuring, and monitoring costs because of opportunistic behavior of the actors involved in the contractual agreement (Frank et al., 2007). Bounded rationality of the contractual parties may cause another set of costs such as those incurred in information search and procurement. This is reflected in administrative, technical, and professional staff growing at the expense of tradesmen and operatives (Lockyer & Scholarios, 2007). Therefore, as information cost increases, there will be higher transaction costs incurred.

Transaction characteristics such as uncertainty and complexity affect the ability of contracting parties to fully define contingencies in the contract. Uncertainties are external and internal factors that affect the project execution (Walker & Pryke, 2009; Jin & Zhang, 2011; Li et al., 2013). Political, legal, social, economical, technological and competition all refer to external environmental uncertainties. While corporate culture, project location, finance and ownership, and information systems all refer to internal environmental uncertainties (Ford & Slocum, 1977; Marcus, 2005; Grimm et al., 2006; Elliott et al., 2008; Foss & Foss, 2008). Winch (1989) identified other set of uncertainties within the construction process such as task, natural, organizational, and contracting uncertainties that cause most of the problems in construction. The high level of uncertainties forces contractors to jack up their bids, file numerous claims, substantial extra work and rework, and antagonistic relationships with owners, which end up in dispute and conflict. Those in turn are more likely to increase TCs because of information incompleteness, the time-spent in contract documentation and negotiation, increased number of staff for contract administration and enforcement of the contract such as quality control etc.

The construction projects are described as unique, complex, uncertain, and high-risk. In such an environment, questionable decisions on planning and design can be made in the pre-contract phase, and disagreements, change orders, claims, conflicts, and disputes can occur in the post-contract phase. In addition, because of the one-off production operation in construction, the procurement process has to begin from scratch every time the client purchases a good or service. These problems contribute to increase the unseen costs (TCs) in project procurement. It is anticipated that applying the TC concept in procurement decision may lead to improve the projects' performance. Which could lead to an improvement of the procurement process through better contractual agreements, enhanced long-term strategic procurement approaches, improved cost estimation, and defining the most feasible contractual approach under certain circumstances. However, measuring and evaluating TCs in construction projects is always difficult and often broad and subjective (Dudkin & Valila, 2005; Ho & Tsui, 2009; Solino & Gago de Santos, 2010).

Although, previous work on applying the TC concept in construction provides useful information, but there have been only a few studies attempting to quantify TCs in construction. There are very few studies that have explored links between TCs and project delivery systems, and determining the impact of the adopted delivery systems on the magnitude of transaction costs in construction. This research established through relevant literature a thorough compilation of the definition of client-borne TCs in project procurement by joining the views of previous researches, and an empirical study to find the impact of project delivery systems on TCs. This study looks outside traditional construction practices to other fields of study especially organization theory. A better balance of best practices with insightful theories would benefit the construction industry. Also, the current research estimates client-borne TCs at the individual level of construction professionals conducting procurement activities, different from Dudkin and Valila (2005) in the UK (infrastructure projects) and Whittington (2008) in the US (infrastructure projects) who focused on costs incurred at the project level only.

Since productivity is a function of cost versus revenues, developing and improved understanding of the basis of costs offers significant potential to affect construction productivity. More so that the New Zealand construction industry has poor productivity (Tran & Tookey, 2011) records and extensively making efforts to have a 20% increase in productivity by 2020 (see www.buildingvalue.co.nz). There is a current pressing needs to examine the relationship between project delivery systems and TCs in the New Zealand construction industry. The research project is a unique study in New Zealand that quantifies

TCs in construction procurement, and there has been no research before empirically estimate TCs of construction procurement.

THEORETICAL FRAMEWORK

A conceptual model was developed on the basis of theoretical expectations and previous empirical studies by incorporating the constructs with their corresponding measures. It models the direct and an indirect relationship between constructs (i.e. information, procurement, contract administration, contract enforcement, project delivery systems, and TCs). In this study, it is assumed that Information (INFO), Procurement (PROC), Administration (ADMIN), and Enforcement (ENFO) costs collectively determine the Transaction cost (TCs) for the delivery system used.

“Information cost” (INFO) is defined as a factor involving two key activities namely information gathering and communication. “Procurement cost” (PROC) is attributable to six key activities namely attending meetings, preliminary design, translation of client’s needs, transition observation, training, and site visits (Hobbs, 1996; Solino & Gago de Santos, 2010). Transaction cost theory is based on the assumption of bounded rationality and opportunism of human behavior and the characteristics of transactions such as uncertainty (Williamson, 1985). This is reflected in administrative, technical, and professional staff growing at the expense of tradesmen and operatives (Lockyer & Scholarios, 2007). Therefore, as information cost increases, there will be higher transaction costs incurred. In this study, information and procurement costs are incurred because of professionals’ daily time-spent in information gathering and procurement.

“Contract Administration cost” (ADMIN) is associated with three key activities: contract administration, conflicts resolution, and decision-making. “Contract Enforcement cost” (ENFO) is defined as a factor involving two key activities namely enforcement (monitoring and control) and verifying compliances. The source of enforcement cost is uncertainties about transaction compliance with specified terms, possible changes in the quality of goods and services, the level of damages to a transacting party arising from contractual non-compliance, and the use of third party in solving disputes (Hobbs, 1996; Solino & Gago de Santos, 2010). Therefore the consequences of enforcing the contract are tangible forms of transaction costs.

For example personnel time, auditing fees, inspection charges and investments in measurement devices, arbitration, legal court fees, and costs to bring social pressure. While, the source of administration cost is uncertainties about the willingness of others to trade on certain terms, comply with terms of the contract, and decision-making. These in turn is reflected in tangible forms of transaction costs such as personnel time, travel expense, communication, consulting/service fees, licensing fees, and insurance premiums (Solino & Gago de Santos, 2010). Contract administration and enforcement costs are included in cost estimates as unforeseen and management contingencies. In this study, contract administration and enforcement costs are due to professionals' daily time-spent in implementing the contract terms and conditions (Lynch, 1996; Tridico, 2007; Farajian, 2010). All these procurement attributes are important for understanding transaction costs in procurement.

Using this framework of factors and dimensions of transaction cost theory, a hypothetical diagram is presented in Figure 1. The direction of the arrow and the sign represent hypothesized relations among the constructs. The corresponding hypotheses are as follows:

H1: Project delivery systems (SYSTM) would have a significant direct effect on the costs of information (INFO), procurement (PPRO), contract administration (ADMIN) and enforcement (ENFO).

H2: The costs of information (INFO), procurement (PPRO), contract administration (ADMIN) and enforcement (ENFO) would mediate the relationship between project delivery systems (SYSTM) and transaction costs (TCs).

H3: Pre-contract TCs, borne by the client in information gathering and procurement, are significantly higher in the Traditional systems than in Design-Build systems.

H4: Post-contract TCs, borne by the client in contract administration and enforcement, are significantly higher in the Design-Build systems than in Traditional systems.

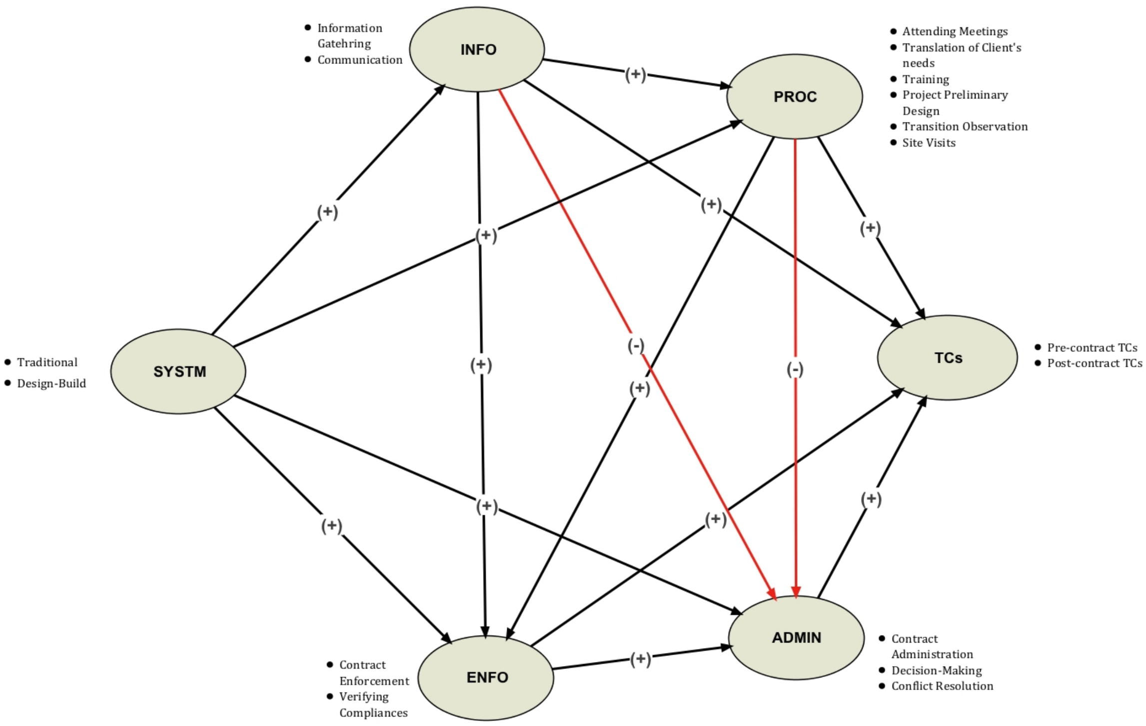

Figure1: Conceptual model of the link between project delivery system and TCs

The determinants of TCs are presented in Table 1. These determinants were used to estimate the overall TCs for different delivery systems, specifically the Traditional and Design-Build systems for comparison.

Table 1: Constructs and initial measures of Transaction Costs

Construct	Indicator	Description
Information Cost **(INFO)**	Information Gathering **(IG)**	Getting information about: potential suppliers/contractors and their behavior, labour market, and prices of construction materials. They are a function of opportunity costs of agent's time and personnel time (Gabre-Madhin, 2001; Baiden et al., 2006).
	Communication **(CM)**	Effective communication resulting in better cooperation among project stakeholders that eliminates uncertainties in terms of individuals' roles and responsibilities, hence reducing TCs (De Silva et al., 2008; Yang et al., 2009).
Procurement Cost (**PROC**)	Attending Meetings **(AM)**	Meetings are a major form of communication during project execution. These include pre-bid, pre-construction, progress, and safety or tool box meetings (Klinger & Susong, 2006; Mincks & Johnston, 2010)
	Translation of Client's Needs **(TN)**	Translation of client's needs in terms of specifications, functional requirements and constrains, and to translate them into perspective information that can be communicated with a contractor (Anumba & Evbuomwan, 2002; Lindahl & Ryd, 2007)

	Project Preliminary Design **(PD)**	Project preliminary design is the first phase of design process. It aims to formalize approved design scheme into more detailed sketches of architectural, structural, and service components. Project managers coordinate a series of meetings with users and the design team for information gathering (Loosemore, 2003).
	Transition Observation **(TZ)**	Transition observation including change to procedures and role or responsibilities (Rahman & Kumaraswamy, 2004; Pryke & Pearson, 2006).
	Training **(TR)**	In training project managers aim at improving the procurement performance, supervision of all procurement activities, and decision-making processes of a project (Edum-Fotwe & McCaffer, 2000; Walker & Rowlinson, 2007).
	Site Visits **(SV)**	Site visits could be for coordination, inspection, resolving dispute, and other interactions (Walker & Shen, 2002).
Administration Cost (**ADMIN**)	Contract Administration **(AD)**	Contract administration such as change order and claims administration (Bajari & Tadelis, 2001a; Cibinic Jr et al., 2006).
	Conflicts Resolution **(CR)**	Dispute resolution aims at providing effective resolutions to construction disputes and enabling clients to avoid conflict as possible. This include negotiation, renegotiation, mediation, and arbitration that need the deployment of extra resources (Gebken & Gibson, 2006).
	Decision-Making **(DM)**	Decision making for example dealing with contractor's problems, making policies, and coordinating with local and central Authorities (Bardhan, 2002; Thomson & Jackson, 2007).
Enforcement Cost (**ENFO**)	Contract Enforcement **(EN)**	Enforcement activities such as monitoring and control, and contract enforcement mechanisms (Ryall & Samspson, 2008).
	Verifying Compliances **(VC)**	Verifying compliances such as time spent in inspection and translation of client's needs (Ryall & Samspson, 2008).

RESEARCH APPROACH

This study investigates the relationship between project delivery systems and TCs in the New Zealand construction industry, and consequently develops a model for this relationship. The model was operationalized and developed into a questionnaire. A cross-sectional sample approach was deployed, involving pilot questionnaire, survey questionnaire and 'real world' cases. Data was sought from professionals in management, design and operations (i.e. Project Managers, Architects, Engineers, Quantity Surveyors, and Procurement Officers). These professionals represented several construction organizations and Councils staff in NZ major city centers (Auckland, Hamilton, Wellington, Christchurch, and Dunedin). TCs were measured using time-spent conducting procurement related activities as a surrogate for cost. Professionals evaluate their time-spent in procurement activities using a Likert-Scale 1-5 in which 1 denoted *very low* and 5 *very high*, comparing the Traditional and Design-Build delivery systems.

In the first stage, a qualitative method is used seeking experts' opinions on the terminology included in the proposed wide range industry survey questionnaires. A pilot questionnaire was conducted via email among six project managers, an architect, and a civil engineer working on ongoing projects. Based on the feedback received, the questions were refined. A quantitative method was used in the second stage seeking information through a questionnaire survey administered via a web-link (SurveyMonkey). 96 responses (but 74 usable) were received from a sampled population of 320 (23% response). The valid dataset was then tested for Validity and Reliability, Path Analysis, Regression analysis, and Factor analysis utilizing Structural Equation Modelling (SEM). SEM technique was used to yield information on Goodness-of-Fit, model development and comparison, and confirmatory strategies. SPSS Amos 21 was used for data analysis and model development. Finally, in the third stage and for results verification and generalization, a quantitative method was deployed seeking information from real-life cases (projects). Six projects in the Auckland Regional Area were chosen; four projects were procured using Traditional delivery system and two projects were procured using Design-Build system. The data collected were used to test the developed models (Traditional and Design-Build). TCs were calculated using regression equations based on the factor loadings in these models.

RESULTS AND FINDINGS

Demographic information

The results obtained from the wide industry survey show that the respondents' main areas of activity are: Infrastructure (63.64%), Housing (35.71%), Commercial (25.71%), and Industrial (11.43%). Regarding the respondents' role in the construction process: Project managers (41.43%), Architects (14.29%), Engineers (17.14%), Surveyors (8.57%), Construction Managers (15.71%), and others (i.e. Procurement officers, 22.86%). Further, 25.72% of the respondents have less than 10 years of work experience in the construction industry, 15.71% have less than 20 years experience, 31.43% have more than 20 years experience, with 27.14% have more than 30 years. Regarding contract values of projects handled by the participants, 38.57% of the respondents were involved in projects of less than $1 million, 30% of respondents were involved in projects of $5 million or less, 8.57% involved in project of less than $10 million, 15.71% involved in project of less than $20 million, 5.71% involved in projects of less than $30 million, and 11.43% involved in project of more than $30 million in value. Apparently, the Traditional delivery system is widely used by state owned organizations throughout New Zealand.

Analysis Of Information And Procurement Costs

Respondents were asked to evaluate (using a Likert-Scale 1-5, with 1 denoting *very low* and 5 *very high*) the time-spent daily in information search and procurement activities relative to other project activities. The results show (fig. 2) that the time-spent in information gathering and project preliminary design for Design-Build system is significantly higher than the Traditional system. While the time-spent in communication, attending meetings, translation of client's needs, and transition observation for the Traditional system is higher than the Design-build system. The time-spent on training for both systems is similar.

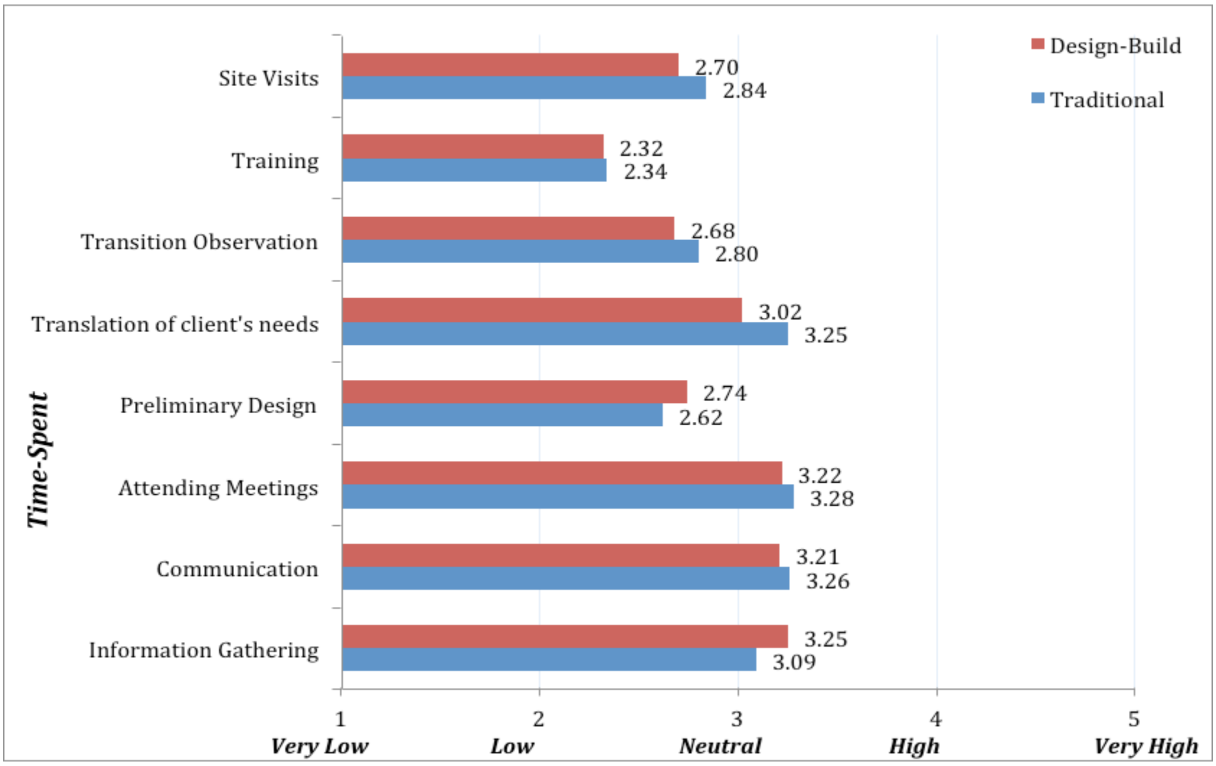

Figure 2: Time-Spent in Information and Procurement

Because the time-spent is used as a surrogate of cost, thus it is apparent that pre-contract TCs for the Traditional systems are higher than Design-Build systems. As mentioned earlier, in the Traditional delivery systems the design is very often completed before construction begins, thus pre-contract TCs are likely to be higher because of the time-spent in defining the project scope before construction begins. Figure 2 shows that the most important drivers of TCs at the pre-contract stage are information gathering, communication, attending meetings, and translation of client's needs. Therefore, a strategy for executing a project should focus on minimizing these particular costs categories, for example this may be achieved by integrating the design and construction phases.

Analysis of administration and enforcement costs

Respondents were required to evaluate (using a Likert-Scale 1-5 in which 1 denoted *very low* and 5 *very high*) the time-spent in contract administration and enforcement (post-contract TCs) relative to other project activities. The results show (fig. 3) that the time-spent in contract administration, conflict resolution, decision-making, enforcement, and verifying compliances for the Traditional systems is significantly higher than Design-Build systems.

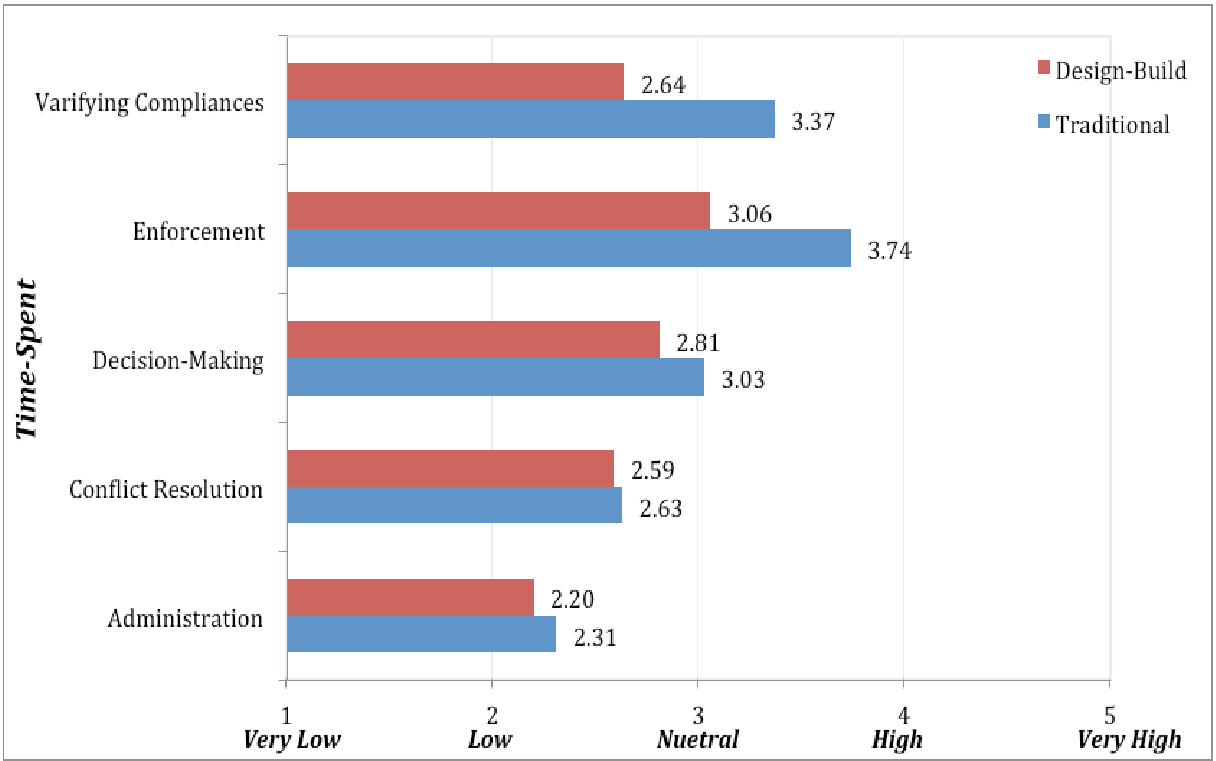

Figure 3: Time-Spent in Contract Administration and Enforcement

Figure 3 therefore depicts that post-contract TCs for the Traditional systems are higher than Design-Build systems using time-spent as a proxy. The main contributors to higher TC at the post-contract stage are decision-making, enforcement, and verifying compliances. Therefore, it is suggested that early contractor involvement at the design phase could be client's strategy for minimizing the costs associated with these cost drivers.

Analysis of SEM results

Data in the previous section have been analyzed using bar charts, but it has limited evidence to support the validity and reliability of the various measures. Validity and reliability of indicators can change when embedded in a theoretical context (Hair et al., 2012). Therefor, for generalized the results this section presents the analyses of Validity and Reliability, Path Analysis, Regression Analysis, Factor Analysis, and SEM. The primary analytical technique used was SEM to yield information on Goodness-of-Fit, model development and comparison, and confirmatory strategies. SPSS Amos 21 statistical software was used for data analysis and model development.

Theoretically, SEM encompasses two types of models: the measurement model and the structural model. The measurement model incorporates confirmatory factor analysis, which is concerned with how satisfactory the variables measure the latent variables, also in addressing issues such as validity and reliability. The structural model reflects multi-regression analysis and path analysis that model the relationship between the latent variables through outlining the explained and unexplained variance. This is equivalent to the examination of the relationship by the regression models (Molenaar et al., 2000). Typically, the measurement model includes the overall variables without causal relationships among them, and the structural model identifies the nature and existence of relationships among variables.

Reliability and Validity Test

Validity and reliability are essential features of a quantitative research inquiry (Li et al., 2012). Prior to data analysis using SEM and to confirm the constructs internal consistency, the scales of the items used to measure each construct are tested for reliability (Hair et al., 2007). Researchers (Amaratunga et al., 2002; Saunders et al., 2011) indicated that reliability is important for the consistency of research findings offered by the data collection techniques used. Cronbach's alpha values (Table 2) were measured by utilizing SPSS 20, to determine the intercorrelation and reliability of the constructs. Cronbach's test tells how well a set of observed variables measures a single unidimensional latent construct (Gerbing & Anderson, 1988). A Cronbach's alpha coefficient of $\alpha > 0.7$ is considered acceptable reliability for a set of observed items (De Vaus, 2002).

Table 2.0 shows that all Cronbach's alpha coefficients calculated are above the threshold level of $\alpha > 0.7$, which suggests that the set of observed variables are good measures of a single unidimensional latent construct (Gerbing & Anderson, 1988). All factors loading (Fig.1) of the measurement items should be above 0.5 for good model fit. After constructs were tested for reliability and validity, the measurement and structural model are evaluated using confirmatory factor analysis. Model evaluation including examines: the model identification, the relative value of Chi-square, and goodness-of-fit indices.

Table 2: Reliability test of Constructs

Items	Item Correlation Traditional	Item Correlation Design-Build	Cronbach's Alpha Traditional	Cronbach's Alpha Design-Build
Traditional System			.822	.830
Design-Build System			.827	.830
Attending Meeting	.611	.650	.785	.808
Communication	.743	.777	.778	.800
Information	.687	.732	.804	.804
Translation of Client's Needs	.751	.827	.802	.798
Training	.327	.570	.801	.812
Project Preliminary Design	.368	.640	.798	.807

Conflict Resolution	.396	.232	.794	.829
Transition Observation	.463	.646	.776	.809
Verifying Compliances	.548	.606	.788	.811
Decision Making	.779	.751	.782	.801
Enforcement	.647	.691	.784	.804
Site Visits	.708	.684	.822	.805
Administration	.664	.675	.827	.805

Model Goodness-of-Fit Evaluation

A confirmatory factor analysis was conducted for both models (the Traditional and Design-build models) to examine the models identification, the relative value of Chi-square, and goodness-of-fit indices. The developed models using structural equation modelling are over identified, which means the number of parameters is less than the number of observed covariances and variances. In this instance, the degree of freedom augmented and the possibility that the model fits in the population is plausible. Also, the measurement portion of the model is examined so that every latent variable has its scale.

Table 3: Model identification and goodness-of-fit indices

Items	Traditional	Design-Build	Recommended Levels
Model identification	Over identified	Over identified	
Degree of Freedom df	77	77	
Relative Chi-square X^2 / df	2.72	2.72	< 3.0
Root Mean Square Residual *RMR*	0.09	0.091	< 0.05
Goodness-of-fit index *GFI*	0.975	0.98	> 0.9
Adjusted goodness-of-fit index *AGFI*	0.966	0.973	> 0.8

Parsimonious goodness-0f-fit index *PGFI*	0.715	0.719	> 0.5

For acceptable model fits, the goodness-of-fit index (GFI) should be greater than 0.9; the adjusted goodness-of-fit index (AGFI) greater than 0.8; the parsimonious goodness-of-fi index (PGFI) greater than 0.5; the root mean square residual (RMR) should be less than 0.09; and the relative value of chi-square (X^2 / df) should be less than 3.0 (Hair et al., 2012; Li et al., 2013).

Table 3.0 shows that all the parameters except RMR are within the recommended limits for good fit model, which means that the traditional and design-build models fits the data well. The RMR indices become difficult to interpret if a questionnaire contains items evaluated based on Likert-Scale 1-5, however values as high as 0.09 are deemed acceptable (Hu & Bentler, 1999; Kline, 2011). Lastly, as shown in Table 2 all the constructs are significantly correlated with each other.

Model development: Traditional and Design-Build Models

This study aims at estimating TCs for two delivery systems used in construction projects in New Zealand, specifically for the Traditional and Design–Build delivery systems for comparison. Relationships were proposed in this study through direct and indirect relationships among constructs. Single head arrow pointing towards a variable with path coefficient represents direct relationship, while an indirect relationship is represented with intervening variable (i.e. mediator and moderator variable). The theoretical framework (fig. 1) of the relationships between TCs, project delivery systems, and information, procurement, administration, and enforcement costs was developed to structural model. According to Gerbing and Anderson (1988), developing and assessing a structural model provides an excellent and comprehensive confirmatory evaluation of construct validity.

Amos 21 was utilized to develop the pattern of relationships among the constructs. The structural models were recursive (repeated or related relationships among variables), which means all paths proceeded from a predictor construct to the resulting construct. Meanwhile, a non-recursive relationship between any two constructs implies that their relationship is causal and they influence each other. As stated by Hair et al. (2012), the situation of a causal relationship is unlikely with cross-sectional data. The resulting paths from conducting SEM using Amos 21 were indicated on a path diagram, which depicts the relationships among variables through principal regression equations that were solved for various parameters.

Finally, in this study the costs of information, procurement or contracting, administration, and enforcement were hypothesized through first-order factors (direct relationship). Transaction costs were hypothesized through a second-order structure, and project delivery systems impact was also hypothesized through a second-order structure. The hypothesized relationships were finally presented in two comprehensive models: for the Traditional (fig. 4) and Design-Build (fig. 5) delivery systems. The models explain the hypothesized impact of project delivery systems on TCs. They were used to test the developed Hypotheses and estimate TCs, by means of factor loadings and regression relation between constructs.

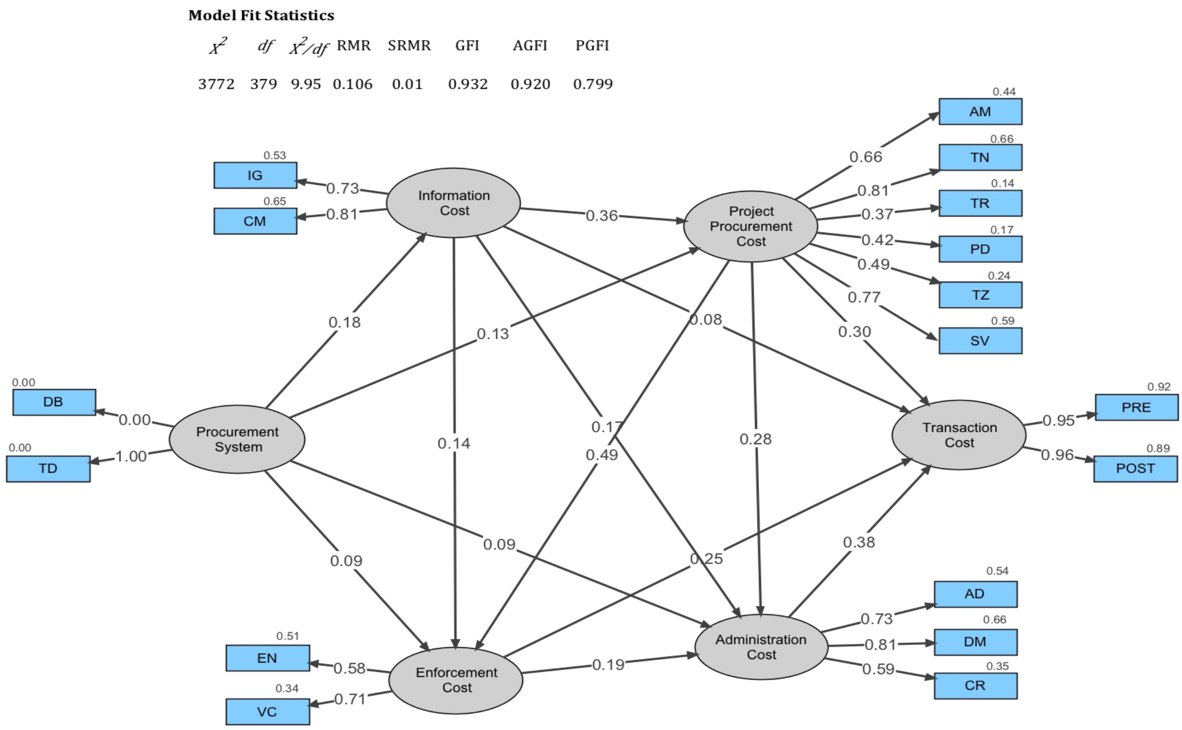

Figure 4: The Traditional Model

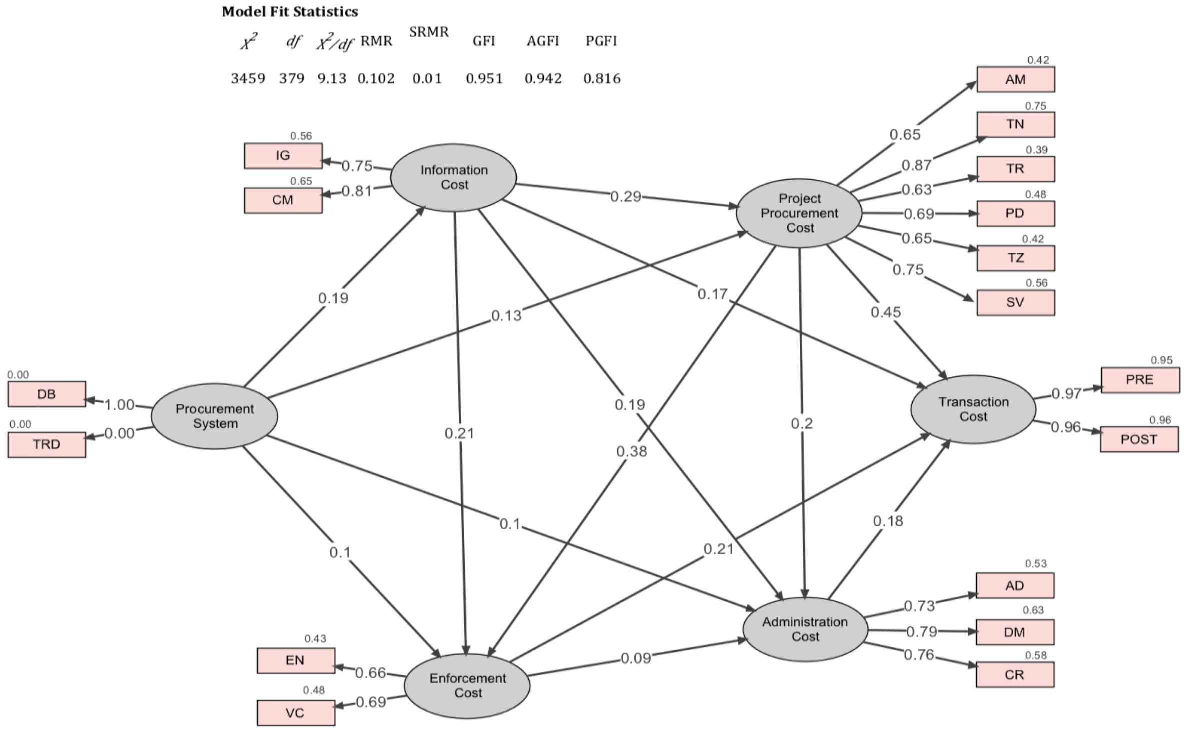

Figure 5: Design-Build Model

Hypothesized Relationships

The structural models (fig. 4 and 5) reflect multi-regression analysis and path analysis that model the relationships between the latent variables by outlining the explained and unexplained variance. Sign, size, and statistical significance of the path coefficients represent the strength of relationships among the constructs. The hypothesized relationships were determined by testing the developed models using Amos 21. Maximum likelihood and bootstrap function were used to estimate hypothesized paths with a resampling size (a so-called "Bootstrapping" exercise) of 1000. The hypothesized relationships as shown in fig. 4 and 5, and based on path coefficients are positive and significant (i.e. $\beta > 0.01$).

Further, the Traditional and Design-Build models are used to test the study Hypotheses. They provide support for the study Hypotheses (1 and 2) through the significance of the paths coefficients. For instance, as shown in the models, Hypothesis 1 *(Project delivery systems would have a significant direct effect on the costs of information, procurement, contract administration and enforcement)* is supported. INFO is significantly influenced by SYSTM at $\beta = 0.18$ for the Traditional and $\beta = 0.19$ for Design-Build. Also, SYSTM has a substantial effect on PPRO at $\beta = 0.13$ for both systems. Further, SYSTM has a significant effect on ADMIN at $\beta = 0.09$ for the Traditional and $\beta = 0.1$ for Design-Build. Finally, SYSTM significantly influence ENFO at $\beta = 0.09$ for the Traditional and $\beta = 0.1$ for Design-Build.

Hypothesis 2 *(INFO, PPRO, ADMIN and ENFO would mediate the relationship between SYSTM and TCs)* is also supported. INFO fully mediates the relationship between SYSTM and TCs, which is significant at $\beta = 0.26$ $(SYSTM \rightarrow INFO \rightarrow TCs)$ for the Traditional and $\beta = 0.36$ for Design-Build. Also, PPRO is fully mediated the relationship between SYSTM and TCs, which is significant at $\beta = 0.43$ for the Traditional and $\beta = 0.58$ for Design-Build. Further, ADMIN mediates the relationship between SYSTM and TCs, which is substantial at $\beta = 0.47$ for the Traditional and $\beta = 0.28$ for the Design-Build. Finally, ENFO mediates the relationship between SYSTM and TCs, which is significant at $\beta = 0.34$ for the Traditional and $\beta = 0.31$ for the Design-Build.

Applying the Models Using real-life Cases

For results verification and generalization six projects were selected to test the developed models, and to calculate and compare TCs for the Traditional and Design-Build systems. The six projects comprise: four infrastructure projects, one project from residential sector, and one asset management project. Out of the six projects, two infrastructure projects (one from the Traditional and the other from Design-Build) of same contract value and duration were chosen for comparison.

A survey questionnaire was sent via e-mail to 6 subject matter experts mainly project managers involved in ongoing projects. This included four project managers working on infrastructure projects, a project manager working on asset management projects, and an architect working on residential projects. Respondents were asked to estimate their time-spent daily in conducting procurement activities. The key theme is to set a benchmark on how to calculate TCs in construction procurement using the developed models, with the intention of this practice to be carried out for other project delivery systems used in construction. The findings from this questionnaire provide a further insight to the understanding of TCs in construction. Also, by conducting this practice, bias can be minimized and the validity/generalization of the findings can be enhanced.

Table 4 shows that four of the projects (case 1 to 4) were procured using the traditional delivery system. The two infrastructure projects that were chosen for comparison are: Case 2 and 5. Case 2 is a project for the improvement of a main road in West Auckland procured in a Traditional delivery system, with a contract value of NZ$50M and scheduled to be delivered in 48 months. Case 5 is a NZ$40M project for upgrading a main road in Central Auckland, scheduled to be completed in 48 months and procured in a Design-Build delivery system.

Table 4: Project's Demographic Information

Case	Project Type	Contract Value	Project Duration	Delivery System
Case 1	Infrastructure	$25 million	60 months	Traditional
Case 2	Infrastructure	$50 million	48 months	Traditional
Case 3	Infrastructure	$654,000	12 months	Traditional
Case 4	Infrastructure	$600,000	8 months	Traditional
Case 5	Infrastructure	$40 million	48 months	Design-Build
Case 6	Housing	$2.8 million	12 months	Design-Build

Table 5 summarizes the estimated time-spent by the project manager at the pre and post-contract phases for Case 2. Data analysis shows that the project manager spent in aggregate $5^{1/}{}_{2}$ hrs. in conducting procurement activities. However, the total time might have a percentage of overlaps between activities, which might compromise the aggregate time-spent on each activity alone. For instance, out of the total time-spent, this research considered the time-spent by project managers in information search, procurement, administration, decision-making, and conflict resolution as contributing to increased TCs.

Table 5: Time-Spent Estimates for Case 2

Participant's Designation	Phase	Activity	Measure	Time-spent (hrs./day)	Total Time-spent (hrs./day)
Project Manager	Pre-Contract	Information Search	IG	1/4	$1^{1}/_{4}$
			CM	1	
		Project Procurement	AM	$1^{1}/_{4}$	2
			TN	0	
			TR	0	
			PD	1/4	
			TZ	0	
			SV	1/2	
	Post-Contract	Contract Administration	AD	1/2	$1^{1}/_{2}$
			DM	1/2	
			CR	1/2	
		Contract Enforcement	EN	1/4	3/4
			VC	1/2	

While, the estimated time-spent by the Project Manager for Case 5 is summarized in Table 6. It shows that the project manager spent in aggregate $4^{3}/_{4}$ hrs. in conducting procurement activities.

Table 6: Time-Spent Estimates for Case 5

Participant's Designation	Phase	Activity	Measure	Time-spent (hrs./day)	Total Time-spent (hrs./day)
Project Manager	Pre-Contract	Information Search	IG	1/4	3/4

			CM	1/2	
		Project Procurement	AM	1	$1\frac{1}{2}$
			TN	0	
			TR	0	
			PD	0	
			TZ	0	
			SV	1/2	
	Post-Contract	Contract Administration	AD	1/2	$1\frac{3}{4}$
			DM	1	
			CR	1/4	
		Contract Enforcement	EN	1/4	3/4
			VC	1/2	

To calculate TCs for the two delivery systems in a way that it aids clients' procurement decisions, Hypotheses (3 and 4) assumed that pre and post-contract TCs are higher in the Traditional systems than in Design-Build systems. For instance, the models can be used to estimate and evaluate the root causes of high TCs. They are calculated on the basis of regression equation analysis, which is explained by the interrelationship strength coefficients between latent variables in the developed models. Simple and multi regression analyses were employed for predicting the time-spent. Simple regression involves measuring a single measured dependent variable, while multi-regression involves more than one measured independent variables. Accordingly, TCs were predicted in accordance to the procedures described below.

For the Traditional delivery systems

1. Predicted time-spent in information search

$$\boldsymbol{INFO} = B + 0.81*\boldsymbol{CM} + 0.73*\boldsymbol{IG}$$

2. Predicted time-spent in procurement

$$\boldsymbol{PPRO} = B + 0.66*\boldsymbol{AM} + 0.81*\boldsymbol{TN} + 0.38*\boldsymbol{TR} + 0.42*\boldsymbol{PD} + 0.49*\boldsymbol{TZ} + 0.77*\boldsymbol{SV}$$

3. Predicted time-spent in contract administration

$$\boldsymbol{ADMIN} = B + 0.73*\boldsymbol{AD} + 0.81*\boldsymbol{DM} + 0.6*\boldsymbol{CR}$$

4. Predicted time-spent in contract enforcement

$$\boldsymbol{ENFO} = B + 0.59*\boldsymbol{VC} + 0.71*\boldsymbol{EN}$$

5. Predicted total time-spent with mediation and moderation effects

$$\boldsymbol{TS} = B + 0.36*\boldsymbol{INFO} + 0.3*\boldsymbol{PPRO} + 0.08*\ \boldsymbol{INFO}\ *\boldsymbol{PPRO}\ 0.19*\boldsymbol{ENFO} + 0.38*\boldsymbol{ADMIN} + 0.25*\boldsymbol{ENFO}*\boldsymbol{ADMIN}$$

6. Predicted Transaction costs

$$\boldsymbol{TCs} = \boldsymbol{TS}*\boldsymbol{HR}$$

Where:

B is a constant where to anchor the line slope in the Traditional model, $B = 0$ when the linear relationship starts at 0,0 origin

HR is the hourly-rate for a construction professional

Case 2

Applying the steps 1-6 to calculate TCs using Table 5

1. ***INFO*** *= 0.99 hrs. /day*
2. ***PPRO*** *= 1.32 hrs. /day*
3. ***ADMIN*** *= 1.07 hrs. /day*
4. ***ENFO*** *= 0.47 hrs. /day*
5. ***TS*** *= 1.478 hrs. /day*
6. ***TCs*** = 1.478 * 65 = $96.1/day

Note: For an experienced project manager such as in this case, the annual salary is NZ$135,000 (i.e. Hourly-rate $65/hr.) obtained from:

http://www.careers.govt.nz/jobs/management-consulting/project-manager/

The results show that the magnitude of TCs, as a result of Project Manager performing procurement activities, is **$96.1** per day. Thus, for a project procured in a traditional delivery system with contract value of NZ$50 million, and scheduled to be complete in 48 months as in case 2, the total TCs incurred while a Project Manager performs procurement activities is equal to **$99,951**. Representing **18.5%** of the annual salary cost of a Project Manager.

For Design-Build delivery systems

1. Predicted time-spent in information search

$$\boldsymbol{INFO} = B + 0.81*\boldsymbol{CM} + 0.75*\boldsymbol{IG}$$

2. Predicted time-spent in procurement

$$\boldsymbol{PPRO} = B + 0.65*\boldsymbol{AM} + 0.87*\boldsymbol{TN} + 0.63\boldsymbol{*TR} + 0.69\boldsymbol{*PD} + 0.65\boldsymbol{*TZ} + 0.75\boldsymbol{*SV}$$

3. Predicted time-spent in contract administration

$$\boldsymbol{ADMIN} = B + 0.73*\boldsymbol{AD} + 0.79*\boldsymbol{DM} + 0.76\boldsymbol{*CR}$$

4. Predicted time-spent in contract enforcement

$$\boldsymbol{ENFO} = B + 0.66*\boldsymbol{VC} + 0.69*\boldsymbol{EN}$$

5. Predicted total time-spent with Mediation & Moderation effects

$$\boldsymbol{TS} = B + 0.29*\boldsymbol{INFO} + 0.45*\boldsymbol{PPRO} + 0.17\boldsymbol{*INFO*PPRO} + 0.09\boldsymbol{*ENFO} + 0.18\boldsymbol{*ADMIN} + 0.21\boldsymbol{*ENFO*ADMIN}$$

6. Predicted Transaction costs

$$\boldsymbol{TCs} = \boldsymbol{TS*HR}$$

Case 5

Applying the steps 1-6 to calculate TCs using Table 6

1. ***INFO*** *= 0.578 hrs. /day*

2. ***PPRO*** = *1.025 hrs. /day*
3. ***ADMIN*** = *1.345 hrs. /day*
4. ***ENFO*** = *0.503 hrs. /day*
5. ***TS*** = *1.159 hrs. /day*
6. ***TCs*** = 1.159 * 65 = $75.34/day

The results show that the magnitude of TCs, as a result of project manager performing procurement activities, is **$75.34** per day. Thus, for a project procured in a Design-Build delivery system with contract value of NZ$40 million, and scheduled to be complete in 48 months as in case 5, the total TCs incurred while a project manager conducts procurement activities is equal to **$78,354** (worked out on 260 working days/year). Representing **14.5%** of the annual salary cost of a Project Manager.

DISCUSSION

To estimates the TCs for different delivery systems in line with Williamson (1998) wherein human and environmental forces were considered the most important contributory factors to TCs; cognitive mapping and path models were used to depict and interpret various factors highlighted in Table 1. Reliability and validity of the eight constructs (in Table 2) focused on by this study are satisfactory. The Goodness-of-Fit Indices of the structural models (Tablet 3) are also quite satisfactory for both models. Models for Traditional and Design-Build systems were developed to test Hypotheses of the study. Sign, size, and statistical significance of the path coefficients represent the strength of relationships among constructs. The hypothesized relationships in the models were tested using SPSS Amos 21. Maximum likelihood and bootstrap function were used to estimate hypothesized paths with resampling of 1000. The results indicate that all path coefficients were statistically significant at $\beta > 0.01$ (fig. 4 and 5). In addition, the results of applying the models to real life cases confirmed the hypothesized relationships between the project delivery systems and the magnitude of the pre and post-contract TCs. Summaries of Hypotheses testing are discussed in further detail in the next section.

"*Project delivery systems would have a direct significant effect on the costs of information, procurement, contract administration and enforcement".*

The figure 4 and 5 confirms that the project delivery systems have a direct effect on the costs of information, procurement, contract administration and enforcement. The effect of the Traditional system on information cost is significant at $\beta = 0.18$ while for Design-Build system, it is significant at $\beta = 0.19$. Therefor both systems have similar impact on information cost. Project complexity and uncertainty is the main contributor to high information cost whether the project is procured using Traditional or Design-Build. Similarly, the project delivery systems have a direct effect on procurement cost. It is significant at $\beta = 0.13$ for both systems. Both human and environmental uncertainties are the most contributors to higher procurement cost.

Procurement's impact on contract administration cost is significant for both systems at $\beta = 0.09$ and $\beta = 0.1$ respectively. The results show that conflict, disputes, and decision-making are the main factors that influenced contract administration cost. Also, project delivery systems have a significant direct impact on contract enforcement cost at $\beta = 0.09$ and $\beta = 0.1$ respectively (fig. 4 and 5). Conflict, disputes, and decision-making are the main factors that influenced the contract enforcement cost.

"*TCs are higher in the Traditional systems than in Design-Build systems"*

In addition, the results of applying the models to real-life cases confirmed Hypotheses (3 and 4), which assume pre and post TCs are higher in the Traditional system than Design-Build system. TCs represents **18.5%** of the annual salary cost of a Project Manager in the Traditional system, and represents **14.5%** of the annual salary cost of a Project Manager in the Design-Build system.

Implications of TCs

This study finds there is a significant relationship between project delivery systems, information cost, procurement cost, contract administration and enforcement costs, and TCs for construction projects. The finding has implications for construction business practice because the research is empirical in nature, relied on construction professionals experience, case studies, and feedback. Also, the study is based on a robust theoretical framework (fig. 1) that illustrates the impact of TCs on procurement decision, and the associated practice in construction projects. The findings allow organizational and economic implications of TCs to be assessed, which demonstrates how the adoption of the TCs perspective alters the organizational dynamics of the construction and project delivery systems.

The developed models will inform strategic thinking with regards to the importance of identifying unseen cost in construction procurement. Solely focusing on the design of formal procurement processes and procedures is not enough for cost savings, minimizing claims, and reducing conflict and disputes in construction projects. There is a further need to consider the interaction of transaction costs, and the costs of information, procurement, contract administration, and contract enforcement, which has been clearly demonstrated by the current study investigation.

CONCLUSION

Transaction cost evaluation provides a practical framework for selecting the appropriate delivery systems in construction. Many researchers have applied the TCE concept in different topics in construction (Eccles, 1981; Gunnarson & Levitt, 1982; Reve & Levitt, 1984; Winch, 1989; Lynch, 1996; Bremer & Kok, 2000; Bajari & Tadelis, 2001b; Turner & Simister, 2001; Miller et al., 2002; Dudkin & Valila, 2005; Antinori & Sathaye, 2007; Whittington, 2008; Ho & Tsui, 2009; Farajian, 2010; Solino & Gago de Santos, 2010; Aibinu et al., 2011). However, there are only a few studies that attempt to quantify TCs in construction. This study has shown the potential for estimating the magnitude of TCs for two project delivery systems in construction. Hence the TCs associated with the pre and post contract phases (e.g. information, procurement and contracting, administration, and enforcement) on projects procured through Traditional and Design-Build systems are determined.

A cross-sectional sample approach was deployed; involving pilot and survey questionnaires, and the results of the investigation was verified using 'real world' cases. Data was collected from construction professionals in management, design and operations (e.g. Project Managers, Architects, Engineers, Quantity Surveyors, and Procurement Officers). TCs were measured using time-spent on procurement related activities as a surrogate for cost. The participants evaluated their time-spent (using a Likert Scale 1-5) on procurement activities, within projects procured through Traditional and Design-Build delivery systems. The collected data was analyzed using a structural equation modelling technique.

The pre and post-contract TCs are determined through a developed path analysis model or structural model utilizing SPSS 20 and Amos 21. Structural and measurement models were used to determine: firstly, the existence of a single latent independent variable as a result of a set of measurement items, and secondly, the relationship between the latent variable and observed variables by means of the path direction and coefficients strength. In conclusion, for projects that have the same contract value with the same scheduled delivery time, it was found that the amount of TCs relative to Project Managers' annual salary cost was **18.5%** and **14.5%** for the Traditional and Design-Build delivery systems respectively.

Finally, regression equations were formulated to guide decision-makers on the use of the developed models for estimating in-house TCs borne by clients because of professionals' involvement in conducting procurement activities. The developed models could benefit construction owners practices through: firstly, improving the ability to estimate unseen procurement costs; secondly, ensuring adequate funding because of certainties in cost estimation; and finally defining the most appropriate delivery system under certain circumstances.

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