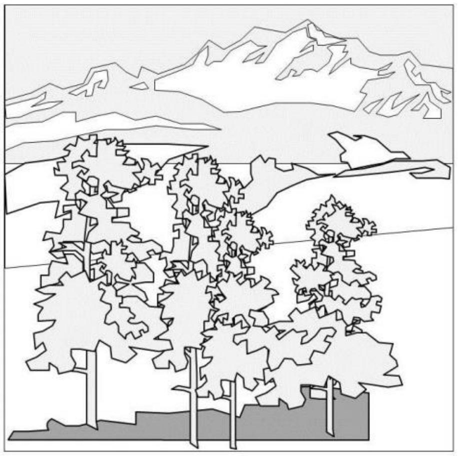

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EFFECTS OF PMS PROCESS QUALITY IN CONSTRUCTION FIRMS

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ABSTRACT

Performance measurement has received significant research interests in the construction industry, but the literature in construction mainly focuses on developing a set of key performance indicators (KPIs) or a conceptual framework (e.g. balanced scorecard). However, little is known about how these KPIs or performance measurement system (PMS) in a much broader scope are designed, implemented, used, reviewed, and updated in a specific organizational context. Thus, the *purpose* of this paper is to identify structured processes of developing PMS – including *organizing*, *designing*, and *implementing* (follow the literature in operations management) – and to empirically investigate their effects on perceived PMS effectiveness and organizational performance in construction. The hypotheses were tested using partial least squares structural equation modeling (PLS-SEM). The data were collected in the UK construction industry by a web-based questionnaire survey. Consistent with the theory, the results strongly suggest that PMS process quality can be treated as a hierarchical construct including three dimensions: *PMS organization quality*, *PMS design quality*, and *PMS implementation quality*. The results also point out that the more extensive adoption of structured processes (better PMS process quality) leads to higher perceived PMS effectiveness and organizational performance. While perceived PMS effectiveness does not directly lead to the improvement of organizational performance, it partially mediates the effect of PMS process quality on organizational performance. This paper primarily contributes to providing an alternative approach (in comparison with KPI identification) of developing PMS in construction. It also contributes to the provision of empirical evidence on the usefulness of structured processes in general.

KEYWORDS: Performance measurement; structured processes; KPIs; effectiveness; PLS-SEM

INTRODUCTION

Performance measurement of construction firms has received increasing interest in recent years. The most significant development in performance measurement in construction is perhaps the establishment of national benchmarking programs throughout the world, such as the UK (CBPP 2000), the USA (Lee et al. 2005), Canada (Nasir et al. 2012; Rankin et al. 2008), the Netherlands (Bakens et al. 2005), Portugal (Horta et al. 2010), and Brazil (Costa et al. 2006). A contemporary performance measurement system (PMS) comprises both financial and non-financial performance measures, which are used to operationalize strategic objectives (Franco-Santos et al. 2012). There are mainly two types of empirical studies at the project level in this area: (1) those that focus on merely identifying KPIs (e.g., Chan and

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Chan 2004; Haponava and Al-Jibouri 2009; Yeung et al. 2008); and (2) those that focus on identifying KPIs as well as providing benchmarks or benchmarking tools (Hwang et al. 2008; Nasir et al. 2012). Some recent studies on performance measurement focus on specific types of construction projects (e.g., Toor and Ogunlana 2010; Yeung et al. 2008; Yuan et al. 2011). Another stream of research has investigated process-based KPIs (e.g., Haponava and Al-Jibouri 2009)). These studies argue that construction activities *per se* are process-based, and therefore, performance measurement should be process- rather than outcome-oriented.

Construction management research (CMR) on performance measurement at the firm level has focused mainly on the development of frameworks for measuring overall firm performance, including, for example, balanced scorecard (BSC) (Kagioglou et al. 2001), BSC in combination with the European Foundation for Quality Management (EFQM) excellence model (Bassioni et al. 2005). Other CMR studies have attempted to develop PMSs for benchmarking purposes (El-Mashaleh et al. 2007; Horta et al. 2010; Luu et al. 2008; Yu et al. 2007). The most recent papers have extended performance measurement to the supply chain (Halman and Voordijk 2012) and international construction (Jin et al. 2013) arenas. However, most of these frameworks focus on the general characteristics rather than the specific context of construction firms.

A key issue with the national benchmarking programs and empirical CMR studies is that they tend to be rather generic – and not specific to a particular organization and how they might adopt/use the KPIs and conceptual frameworks. From a resource-based (Barney 1991) and contingency theory perspective (Venkatraman 1989), various organizational contingencies, such as structure, culture, strategy, technology and external environment would shape the development and implementation of a PMS. This points to the importance of contextualizing the PMS in the organization. As these contextual issues have the potential to generate conflict and tension when developing a PMS in a specific organization (Bourne et al. 2000; Kennerley and Neely 2002), there is a need for structured and evidence-based processes of PMS development (Neely et al. 1996). Although processes of developing the PMS *per se* may significantly vary among different industries and organizations, there may exist a set of generalized processes, which could be adopted fully or partially by construction firms. However, there is a paucity of CMR that addresses this issue. Some CMR studies have attempted to investigate the processes of PMS development within an organization. Beatham *et al.* (2005) examined eight phases under four stages of an 'integrated business improvement system' (IBIS) within a UK construction firm using action research. Robinson *et al.* (2005) examined the practices and processes adopted by UK construction firms during PMS development using case studies. However, empirical studies are needed that examine whether structured processes of PMS development can help construction firms successfully tackle the context related issues. The purpose of this paper is to empirically test whether PMS process quality influences managerial perceptions on PMS effectiveness and organizational performance. The remainder of this paper is organized as follows. First, the study hypotheses are rationalized. The methods for data collection and analysis are then described. Next, the results are presented and discussed. Finally, the conclusions and implications of the study are outlined.

HYPOTHESES DEVELOPMENT

This section defines structured processes of PMS development and rationalizes the hypothesized relationships among PMS process quality (the extent to which structured process were adopted to develop PMS), perceived PMS effectiveness, and organizational performance. More specifically, it is hypothesized PMS process quality (adoption of structured processes) partially mediates the effect of PMS process quality on organizational performance. Hypothesized relationships are shown in Fig.1.

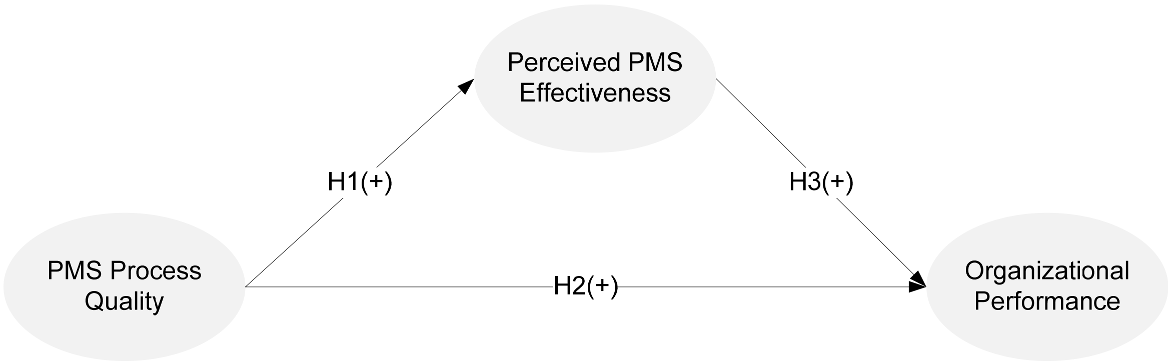

Fig.1. Hypothesized Relationships

Processes of PMS Development

Structured process of PMS development is not a totally new concept (e.g. Neely et al. 1996), but rare literature is found to systematically understand and explore it. This concept is closely related to performance measurement literature in the discipline of operations management. Thus this section attempts to investigate the literature mainly from operations management and explore its importance in developing a rigorous PMS.

Structured processes of PMS development may be a beneficial concept for the construction industry. Existing conceptual frameworks (e.g. BSC) are inadequate to develop PMS in a specific organization (Neely 2005), as it may face contextual barriers to design, implement, use, update and review PMS (e.g., Bourne et al. 2005; Bourne et al. 2000; Bourne et al. 2002; Franco-Santos and Bourne 2003; Kennerley and Neely 2002; Kennerley and Neely 2003; Neely and Bourne 2000; Neely et al. 2000; Neely et al. 1996; Neely et al. 1997; Nudurupati et al. 2011). Herein, we build the construct on three processes of PMS development: organizing the PMS development initiative, designing PMS, and implementing PMS. Franco-Santos et al. (2007) argues that only three processes are necessary to a PMS within the organization – information provision, measure design and selection, and data capture, whilst other processes are unnecessary for developing a PMS, such as using, and reviewing and updating. These three necessary processes can be further categorized into two processes, i.e., designing PMS (measure design and selection) and implementing PMS (information provision and data capture). Further, the process of organizing PMS is added because the formality of well-organized PMS development reflects the organization's emphasis on PMS, though it is not essentially necessary. Other processes (using, and reviewing and updating) refer to PMS validation (checking whether or not the developed PMS is useful). These three phases of PMS development are then discussed in details.

First, the organizing process of PMS development captures the extent to which the processes of PMS are formally organized when a PMS initiative is on agenda. When a PMS is initiated within the organization, processes of achieving this need to be carefully organized (de Haas and Kleingeld 1999). Indeed, a PMS development process starts when the incompleteness of the system is perceived widely in the organization (Wouters and Wilderom 2008). The greater the incompleteness, the more the PMS may be perceived as a “negative”, “unfair”, “coercive”, and “threatening” control system (Wouters 2009; Wouters and Wilderom 2008). In this case, organizations may choose to loosen control reactions to variances, implement more innovative PMS, integrate with other management systems, or use measurement weightings (Lillis 2002). Activities in the organizing phase may include defining the constituencies of the firm, identifying the interdependences among these constituencies, composing the design team, and deciding on the design sequence (de Haas and Kleingeld 1999).

Second, the designing process of PMS development refers to the extent to which the PMS is formally designed following the instructions identified in the organizing phase. In the designing phase, two essential sub-phases are identifying the key objectives to be measured and designing measures (Bourne et al. 2000). As discussed previously, the importance of identifying the key strategic objectives for PMS has been extensively highlighted. For example, BSC has been transformed from a performance measurement framework to a strategy implementation tool. In this case, explicitly stating the firm strategy and formally identifying relevant objectives become the fundamental step, and empirical evidence also shows that the use of PMS positively influences both number and variety of strategic decisions (Gimbert et al. 2010). This interprets that the process of formulating strategy and identifying objectives interacts with the process of PMS design and use. Further, many operations management scholars have proposed various structured processes to design performance measures. For example, Neely et al. (1997) present a tested “performance measure record sheet” to design performance measures through a structured approach. Neely and his colleagues further extend the scope of designing PMS (Neely et al. 2000). Extended processes include grouping products, agreeing business objectives, agreeing performance measures, signing off top level measures, embedding top level measures, identifying drivers of the performance, deciding key drivers, agreeing performance measures for key drivers, signing off performance measures for key drivers, embedding performance measures for key drivers (p.1139). Their structured processes of designing a PMS in a specific organization have potential application and generalization in the context of construction (Beatham et al. 2005), though minor modification is needed, such as the process of grouping products.

Finally, the implementation of PMS refers to the extent to which systems and procedures are formally put in place to progress and collect data that enabling the measurement to be made regularly (Bourne et al. 2000). Indeed, the processes of PMS design, implementation, and use are not linear but overlapped as different individual measures are implemented at different rates (Bourne et al. 2000), while the implementation of individual measures can be viewed as processes of data collection, collation, sorting and distribution. In the implementing phase, many factors may have impact on the success of PMS, such as computer systems issues and top management commitment being distracted. It is argued that formal implementation will at least help organizations realize these barriers and eliminate the risk of failure during the implementing phase. It also seems that the rates of success in terms of PMS development are related to the organization's experience with implementing PMS (Bourne et al. 2003).

Effect of PMS Process Quality

Indeed, those firms who utilize structured processes to design PMS find easier than those who do not, to: decide what they should be measuring; decide how they are going to measure it; collect appropriate data; and eliminate conflict in the their PMSs (Neely et al. 1996). It indicates that organizations may benefit from the formality of PMS development, whilst the benefit varies significantly on an industry-and-industry basis. Neely et al. (1996) find that those process-based industries (e.g. primary metals industry) tend to benefit from informal processes of PMS design because many well established measures are available in these industries. Formal processes of PMS design may emphasize uniqueness, and variations between measures developed in the organization and well-established measures in the industry may result in inconsistencies and conflicts. Though the construction industry is characterized as a process-based industry (Haponava and Al-Jibouri 2009; Haponava and Al-Jibouri 2012), the premise of well-established measures is not of the truth for this industry (e.g., Bassioni et al. 2004; Beatham et al. 2004; Costa et al. 2006; Fernie et al. 2006). Construction firms who simply adopt KPIs established in the sector may save time and resources needed to design a specific PMS. Nevertheless, the danger is that they would narrow their vision and scope in terms of performance measurement as most of these KPIs are lagging and lacking of formal validation (Beatham et al. 2004). This contradicts the premise of contemporary PMSs comprising both financial and nonfinancial measures. Instead, formal/structured processes of PMS development may help construction firms clarify their strategic objectives and gain business benefits from formally developing a PMS (Robinson et al. 2005). Further, it is also clear to see that a structured PMS can help construction firms to successfully address all stakeholders requirement, emphasize on critical improvement areas, and promote cultural changes (Nudurupati et al. 2007).

Overall, structured processes of PMS development may benefit for managing professionals in establishing a clear route, improving the quality of measures, eliminating contextual barriers, and further increasing the success rate of PMS. However, effects of these formal/structured processes are still implicit as no empirical research attempts to systematically investigate this issue, though many scholars have appealed for more research in this area (e.g. Bourne et al. 2003). Prior literature points out that structured processes of PMS development will help organizations establish a contemporary PMS. These processes of PMS development discussed above can help practitioners eliminate related pitfalls when either adopting different general KPIs from the industry (such as UK KPIs) or developing specific KPIs for their companies. It seems that the effect of these structured processes on PMS can be reflected by the system users' perceptions, such as their satisfaction and perceived benefits. In other words, these structured processes may lead to user satisfaction and perceived benefits of PMS developed in the organization, mainly because these structured processes help system users better organize PMS, explicitly point out where the system will lead to, and eliminate associated complexities and uncertainties of PMS development eventually. To conclude, the discussion can be formally hypothesized as:

H1: Maintaining PMS process quality (the extent to which structured processes were adopted to develop PMS) positively influences perceived PMS effectiveness.

H2: Maintaining PMS process quality positively influences organizational performance.

Effect of Perceived PMS Effectiveness

The system user's satisfaction and their perceived benefits represent different aspects of positive perceptions on PMS effectiveness, and these two constructs have been used as the dependent variable when investigating the effects of PMSs (e.g., Cavalluzzo and Ittner 2004; Hoque and Adams 2011; Ittner et al. 2003; Tung et al. 2011). Specifically, Ittner et al. (2003) point out that the more extensive use of a broad set of financial and nonfinancial measures leads to higher system (user) satisfaction. Hoque and Adams (2011)'s empirical evidence supports the positive association between the implementation of BSC and perceived benefits in government departments. Further, Tung et al.'s (2011) research also demonstrates that the implementation of the multidimensional PMS leads to enhanced (perceived) effectiveness. It is argued by them that the implementation and extensive use of multidimensional PMS would not directly but indirectly result in economic performance improvements by their effects on improvements in organizational processes (or routines).

Indeed, perceived PMS effectiveness tend to influence organizational performance. First, perceived effectiveness motivates the organization to continue PMS initiatives. The benefit(s) of performance measurement perceived by managers is regarded as the most important factor of PMS implementation success (Bourne et al. 2002). According to Bourne et al.'s (2002) case studies, perceived benefits are cited by all successful companies as the major reason of continuing performance measurement, and these managers believed that it was delivering business results. By contrast, the lack of perceived benefits is cited by many unsuccessful companies. These evidence points out that perceived benefits tend to be the original motivation of continuing the performance measurement, which in turn pushes the company to achieve business excellence through continuous improvements. Second, perceived effectiveness *per se* reflects on the improvement of managerial processes and organizational routines, which sustain performance. Theoretically, Pavlov and Bourne (2011) argue that performance measurement can trigger the change of, intensify the iterations of, and guide the direction of organizational routines. These adjustments of organizational routines and continuous changes further sustain the organizational performance. Empirically, Bititci et al. (2011) find that managerial perceptions (e.g. perceptions on PMS), developed from managerial cognition and mental model, may play a critical role in determining the interconnectedness and organization of managerial systems (e.g. PMS) and therefore may sustain the organizational performance. Finally, managers' perceptions on PMS effectiveness also partly reflect their managerial performance, which eventually contribute to the overall organizational performance. Tung et al. (2011) emphasize the importance of staff-oriented effectiveness in achieving better organizational performance, and suggest that PMS should be designed to achieve employee effectiveness. In this regard, these managers/executives' perceived PMS effectiveness can lead to better organizational performance from the resource-based view (Wright et al. 2001; Wright et al. 1994). These discussions lead to the second hypothesis:

H3: Perceived PMS effectiveness positively influences organizational performance.

H4: Perceived PMS effectiveness partially mediates the effect of PMS process quality on organizational performance.

RESEARCH METHODS

Sample

The sample comprised 44 construction firms with mostly 100 or more employees (95%). Respondents were senior managers or directors with more than 5 years experience in construction (see Appendix 1). About 85% of them have more than 10 years experience in construction and 70%, more than 6 years tenure in their present companies. The sample represents about 4% of the circa 1000 UK construction companies with more than 100 employees (ONS 2011).

Data Collection Procedure

The questionnaire instrument was piloted with seven senior managers from the UK construction industry using face-to-face and telephone interviews. Some minor revisions were made to the questionnaire instrument as a result of their feedback, such as providing an explicit definition of PMS development and other changes in wording. Subsequently, a web-based version of the questionnaire was developed for data collection, following conservative guidance provided by Dillman (2007). A cover letter with a URL to the online questionnaire was emailed to 3310 potential respondents in 1018 mostly medium to large UK construction companies (i.e. those with 100 and above employees). Email addresses for potential respondents were retrieved from the professional membership directory of the Chartered Institute of Building (CIOB) and the FAME database, which holds 10 years of financial data and corporate information on about 7 million companies in the UK and Ireland. The administration of this survey produced a total of 76 unique responses from UK construction companies, while the invitation emails to 930 respondents comprising 155 UK companies were undelivered. This represents a response rate of 8.9% (=76/853). Low response rates are a common feature of studies of the kind reported here which involve the collection and use of quantitative strategic data from senior managers (e.g., Lim et al. 2010; Ling et al. 2012)

The initial sample of 76 cases was examined for potential systematic bias using four procedures. First, item non-response bias was examined using the missing value analysis module in SPSS. This led to the deletion of 32 cases for missing extensive data. The resulting dataset with 44 cases was missing data on between 2 and 4 cases only. Little's test of data missing completely at random (MCAR) was non-significant (χ^2=135, *df* =131, *p*=0.385). Second, Harman's single-factor test was run on the dataset with 44 cases to test for the presence of common method bias. An exploratory factor analysis (EFA) of all item measures in the study generated an 8-factor solution. The eight factor components explained 82.9% of the total variance, with the largest factor accounting for only 21.9% of the total variance explained. This demonstrates that the common method bias was not present in the dataset

(Podsakoff et al. 2003). Third, early (N=20) and late respondents (N=24) were examined for systematic differences in their responses on the 35 item measures included in this study. The comparison showed no systematic differences in responses between early and late respondents ($p>0.10$). Finally, a similar comparison showed no systematic differences between respondents from the CIOB and FAME databases ($p>0.05$). Overall, the sample of 44 cases retained for the subsequent data analysis was considered adequate and robust, and free from any potential systematic bias.

Measurement of Constructs

To maintain the content validity, measurement instruments (previously validated) were directly adopted from the prior literature, such as user satisfaction (Ittner et al. 2003), perceived benefits (Cavalluzzo and Ittner 2004; Hoque and Adams 2011), and organizational performance (Henri 2006; Henri 2010). When measurement instruments are not available, they were developed from the empirical literature, such as structured processes of PMS development (Bourne et al. 2000; Bourne et al. 2003; de Haas and Kleingeld 1999; Neely et al. 2000; Neely et al. 1997).

PMS process quality

This construct was conceptualized as a second-order formative construct with three dimensions: PMS organization quality; PMS design quality; and PMS implementation quality. Reflective item measures for the three dimensions were developed based on previous research. Specifically, four items were adapted from de Haas and Kleingeld (1999) to measure the PMS organization quality. The items assessed the extent (1 = 'no at all' to 5 = 'to a large extent') to which structured processes were adopted for: defining the constituencies of the firm (ORG1); identifying the interdependences among those constituencies (ORG2); composing the design team (ORG3); and deciding on the design sequence (ORG4). Nine items were developed based on Neely *et al.* (1997) to measure the PMS design quality. The items assessed the extent (1 = 'not at all' to 5 = 'to a large extent') to which the design of performance measures included: clear purposes for the indicator (MEA1); explicit linkages to business objectives (MEA2); explicit targets (MEA3); standard formulas (MEA4); (5) fixed frequency of reporting on measures (MEA5); clear delineation of responsibility for measures (MEA6); clear source(s) of data (MEA7); clear delineation of responsibility to act on the data (MEA8); and clear exploration and identification of the actions to be taken (MEA9). Based on the empirical work of Bourne *et al.* (2000), five items were developed to measure PMS implementation quality. The five items assessed the extent to which the implementation of the PMS included structured processes for: setting up the required infrastructure (IMP1); clearly identifying the process of data collection, collation, sorting and dissemination (IMP2); embedding top management commitment (IMP3); explicitly identifying barriers to PMS implementation (IMP4); and explicitly identifying factors facilitating PMS implementation (IMP5). The dimensionality of PMS process quality was examined by subjecting the 18 items to principal components EFA. Confirming expectations, three factor components were extracted based on both the scree plot and eigenvalue higher than unity criteria, and all items loaded significantly (i.e. > 0.70) on only their hypothesized factor components. Cronbach's α for the three dimensions of PMS process quality were 0.967, 0.970 and 0.888 for PMS organization quality, PMS design quality, and PMS implementation quality, respectively. Thus, the exploratory factor analysis (EFA) provided support for operationalizing PMS process quality as a second-order construct with three formative dimensions in subsequent data analysis (see Appendix 2).

Perceived PMS effectiveness

This construct reflects managers' satisfaction with the functionality and benefits of the PMS and was assessed with six items. These asked respondents to indicate the extent to which they agree or disagree (1 = 'strongly disagree' to 5 = 'strongly agree') that the PMS in their company: meets their expectations (SAT1); is close to their concept of an "ideal" system (SAT2); (3) a system they are satisfied with (SAT3); has improved the organization's efficiency (BEN1); has improved the organization's effectiveness (BEN2); and will improve the organization's operations in the future (BEN3). The first three items (SAT1-3) were adapted from Ittner *et al.* (2003), the fourth and fifth (BEN1-2) items were adapted from Hoque and Adams (2011), while the sixth item (BEN3) was adapted from Cavalluzzo and Ittner (2004). A principal components EFA of the six items produced a single factor component, thus confirming the one-dimensionality of the construct (see Appendix 2). Cronbach's alpha for the six-item scale was 0.928, showing excellent internal consistency.

Organizational performance

This construct is multidimensional in nature and has been measured in previous research using objective accounting data or self-report subjective data from respondents (Devinney et al. 2010; Richard et al. 2009; Venkatraman and Ramanujam 1986), with available research suggesting there is no significant difference between the two approaches (Venkatraman and Ramanujam 1987). In the current study, organizational performance was assessed using self-report measures. Specifically, three ratings were employed: economic outcomes – revenue (EXP1), return on investment (EXP2), profit margin (EXP3) and overall achievement of business goals (EXP4) – against firm expectations (1 = 'does not meet any expectation' to 5 = 'consistently exceeds expectations'; economic outcomes – revenue (COM1), return on investment (COM2), and profit margin (COM3) – against main competitors' (1 = 'never better' to 'always better'); and project outcomes – in/on time delivery (PRO1), within budget delivery (PRO2), no defects (PRO3), satisfied client (PRO4), zero accidents (PRO5), and achievement of overall project goals (PRO6) – on a Likert response format with anchors 1 = 'on no project' to 5 = 'on all projects'. A principal components EFA of the 13 items produced two distinct factor components (see appendix 2). The six economic outcome items loading significantly on the first factor while the four project outcome items loaded significantly on the second factor. Cronbach's α for the *economic outcomes* and *project outcomes* scales were 0.934 and 0.813, respectively, showing satisfactory internal consistency.

PLS-SEM

Partial least squares structural equation modeling (PLS-SEM) was used to analyze the data. PLS-SEM, introduced by Wold (1974), is a latent variable modeling technique for analyzing cause-and-effect relationships among various latent constructs (Hair et al. 2011). PLS-SEM, in contrast to covariance-based structural equation modeling (CB-SEM), prediction-oriented and focuses on maximizing the explained variance in (i.e., R^2 values of) the endogenous constructs in the model (Hair et al. 2013)). PLS-SEM has many benefits not offered by CB-SEM, such as the ability to cope with non-normal data, small sample sizes and formative constructs. PLS-SEM was adopted in this study, as in previous studies in construction (cf. Aibinu et al. 2011; Lim et al. 2010; Ling et al. 2012; Mohamed 2002), because of these benefits.

Like CB-SEM, PLS-SEM comprises a measurement model that specifies the relationships between latent constructs and observed (manifest) variables (referred to *outer model*) and a structural model that shows the relationships between latent constructs (referred to *inner model*) (Hair et al. 2011). The basic PLS-SEM algorithm follows a two-stage approach. Specifically, the latent construct scores are estimated in the first stage, and final estimates of outer loadings (for reflective constructs) or weights (for formative constructs) as well as path coefficients are calculated in the second stage. The graphic software *SmartPLS 2.0 (M3)* developed by Ringle *et al.* (2005) was used for the modeling. The construct adoption of structured processes was modeled as a reflective-formative hierarchical construct; that is, the first order constructs *PMS organization quality*, *PMS design quality*, and *PMS implementation quality* were reflective constructs while the second-order construct *PMS process quality* was a formative construct. The repeated indicator approach was used to examine this higher order construct (cf. Becker et al. 2012). Organizational performance was modeled as a reflective-reflective hierarchical construct (cf. Wetzels et al. 2009); that is, both first order constructs (i.e., *economic outcomes* and *project outcomes*) and the second-order construct (i.e. *organizational performance*) were reflective constructs. The convergent and discriminant validity of the measurement model were assessed using the established standard approaches in the extant literature (Hair et al. 2011). Convergent validity is indicated composite reliability (CR) values of 0.70 or higher and average variance explained (AVE) estimates of 0.50 or higher (Fornell and Larcker 1981). Discriminant validity is indicated if the AVE of each latent construct is higher than the construct's highest squared correlation with any other latent construct (Fornell and Larcker 1981).

RESULTS

Measurement Model

Table 1 shows the factor loadings (for reflective constructs) and weights (for formative constructs) in the PLS-SEM. Table 2 shows descriptive statistics, AVE estimates, CRs and inter-construct correlations for the first-order constructs in the PLS-SEM model. As shown in Table 1, all items loaded significantly on their hypothesized constructs except PRO5, which was discarded. All CRs in Table 2 are substantially higher than 0.70 and all AVE values are higher than 0.50. CRs and AVE values for PMS process quality (AVE=0.598; CR=0.961) and organizational performance (AVE=0.509; CR=0.924) are also satisfactory. Taken together, these results suggest adequate convergent validity (Hair et al. 2011). The diagonal entries in Table 2 are the square roots of the AVE estimates. As is clear to see, these diagonal entries are higher than the correlations in the corresponding rows and columns. This demonstrates satisfactory discriminant validity. Overall, these tests also show that the sample size has not affected the criterion validities of the study variables.

Table 1: Factor loadings in the PLS-SEM model

	PMS Process Quality			4.Perceived	**Performance**	
Items	1. Organize	2.Design	3.Implement	Effectiveness	5.Economic	6.Project
ORG1	0.911					
ORG2	0.935					
ORG3	0.958					
ORG4	0.953					
MEA1		0.916				
MEA2		0.915				
MEA3		0.839				
MEA4		0.852				
MEA5		0.855				
MEA6		0.928				
MEA7		0.887				
MEA8		0.920				
MEA9		0.919				
IMP1			0.776			
IMP2			0.881			
IMP4			0.904			
IMP5			0.901			
SAT1				0.894		
SAT2				0.911		
SAT3				0.775		
BEN1				0.915		
BEN2				0.810		
BEN3				0.796		
EXP1					0.861	
EXP2					0.864	
EXP3					0.784	
EXP4					0.805	
COM1					0.826	
COM2					0.914	
COM3					0.841	
PRO1						0.675
PRO2						0.800
PRO3						0.757
PRO4						0.725
PRO6						0.840
Weights	0.208^{***}	0.689^{***}	0.244^{***}			
(*t*-stat)	(5.012)	(14.293)	(7.816)			
Loadings					0.940^{***}	0.785^{***}
(*t*-stat)					(56.438)	(11.029)

Note: ORG: Organizing PMS design process; MEA: Design measures; IMP: Implementing PMS; SAT: User satisfaction; BEN: Perceived benefits; EXP: Performance against expectation; COM:

Performance against competitors; PRO: Performance on projects completed. AVE: Average Variance Explained; CR: Composite Reliability. ***$p<0.001$.

Table 2: Descriptive results, AVE, reliability and correlations of lower-order constructs

				Correlations					
Variables	M *(SD)*	AVE	CR	*1*	*2*	*3*	*4*	*5*	*6*
1.Organization quality	2.84(1.01)	.88	.97	*.94*					
2.Design quality	3.59(0.98)	.79	.97	.48**	*.89*				
3.Implementation quality	3.32(0.93)	.75	.92	.48**	.69**	*.87*			
4.Perceived Effectiveness	3.40(0.83)	.72	.94	.39**	.68**	.48*	*.85*		
5.Economic outcomes	3.15(0.71)	.71	.94	.19	.43**	.48**	.42**	*.84*	
6.Project outcomes	3.67(0.55)	.56	.86	.31*	.46**	.38*	.46**	.51*	*.75*

Note: AVE: Average Variance Explained; CR: Composite Reliability. Diagonal elements are the square roots of the AVE statistics, while off-diagonal elements are the correlations between the latent variables. **$p<0.01$; *$p<0.05$.

Tests of Hypotheses

Unlike CB-SEM which aims to achieve the *fit* between theoretical model and estimated model, PLS-SEM maximizes the variances explained, and thus, the primary evaluation criteria for the structural model are the R^2 and the level and significance of path coefficients (Hair et al. 2011). The value of R^2 demonstrates the exogenous constructs' (independent variables) ability of explaining the variances of endogenous constructs (dependent variables), and thus its value should be high. Further, as PLS-SEM does not make prior assumption of data distribution (i.e. the normality of variables), non-parametric bootstrapping technique is applied to estimate the significance of path coefficients. Bootstrapping involves repeated random sampling with replacement from the original sample to create a bootstrap sample, to obtain standard errors for hypothesis testing (Hair et al. 2011; Ringle et al. 2005). The replacement is set at 5,000 samples in this research as recommended by Hair et al. (2011).

The result of structural relationships is shown in Fig.2, structured processes and organizational performance are treated as hierarchical constructs. As shown in Fig.2, the R^2 values of perceived PMS effectiveness and organizational performance are satisfactory, with 0.454 and 0.335, respectively. PMS process quality positively contributes to users' perceived PMS effectiveness (β_1=0.674, t=7.710, $p<0.001$), and it also positively influences organizational performance (β_2=0.366, t=2.391, $p<0.05$). However, the relationship between perceived PMS effectiveness and organization performance is not statistically significant (β_3=0.266, t=1.525, $p>0.1$). These evidences point out that the more extensive adoption of structured processes when developing PMS leads to significantly higher perceived PMS effectiveness and superior organizational performance. However, there is no evidence to support the positive relationship between perceived PMS effectiveness and organizational performance. Overall, H1 and H2 are supported while H3 is not supported.

To test H4, a Sobel's z test is applied by using bootstrapping standard errors derived from SmartPLS (Baron and Kenny 1986). The results show that the indirect effect (=β_1*β_3=0.179) is significant (z=2.283, $p<0.05$). Hence, H4 is supported (partial mediation).

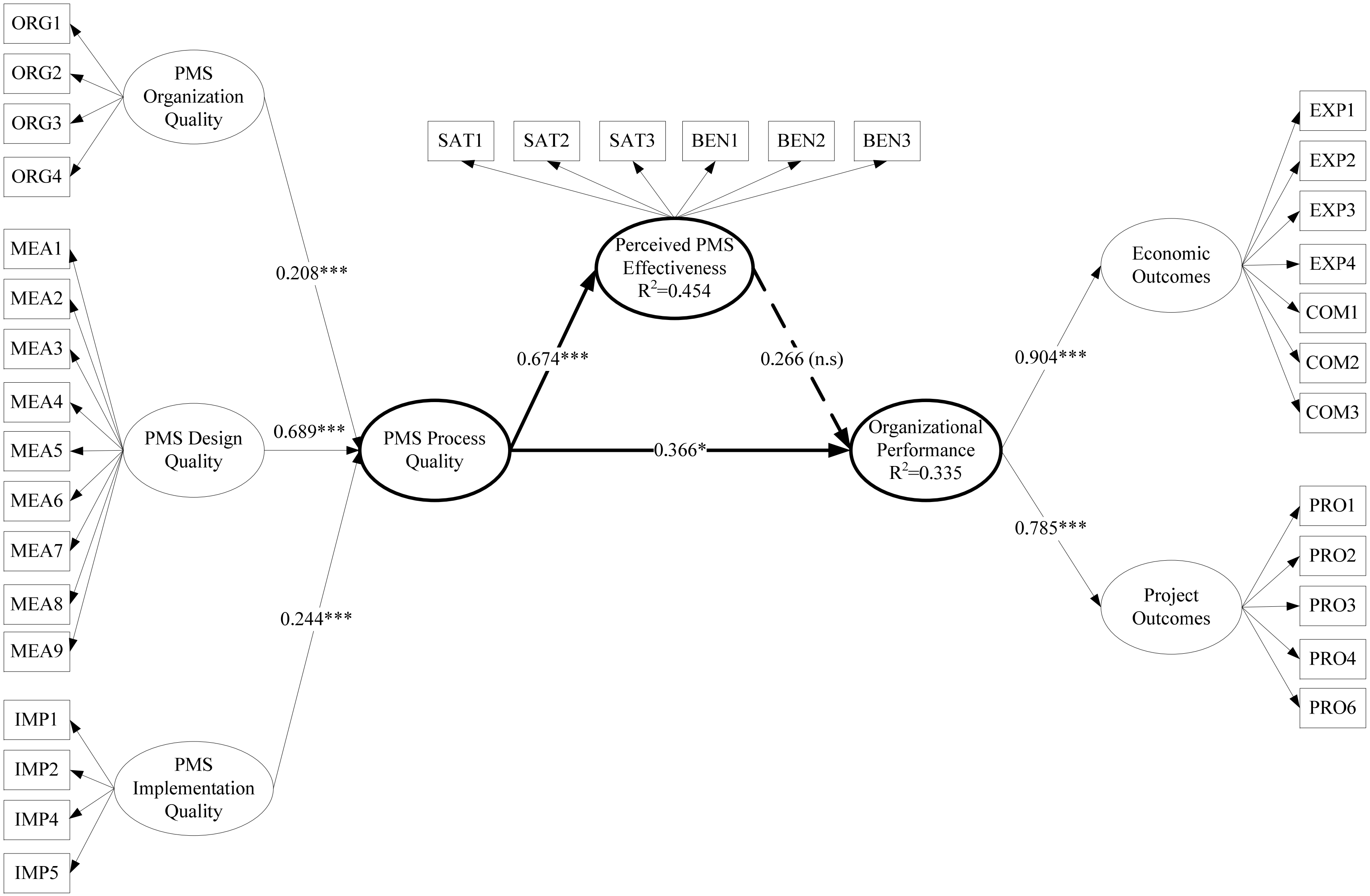

Fig.2. Results for Structural Relationships (****p*<0.001; ***p*<0.01; **p*<0.05)

DISCUSSION

Structured processes of PMS development have been conceptually defined and empirically examined by using PLS-SEM. The results have many theoretical and practical implications.

First, the results have strongly supported that this structured approach of developing PMS can be very helpful for construction organizations. The structured approach can also successfully complements the traditional approach of performance measurement research in construction, i.e. identification of KPIs or development of conceptual frameworks. The positive relationship between structured processes and user satisfaction and perceived benefits is consistent with Neely et al.'s (1996) findings observed in manufacturing industries. The empirical evidence from the construction industry also challenges Neely et al.'s (1996) conclusion that these industries with standard performance measures benefit much less from the adoption of structured processes. The result suggests that maintaining process quality by extensive adoption of proposed processes should be encouraged in the construction industry, although standard performance measures have been widely established (for example, in the UK construction industry).

Second, the results of this study have strongly supported that maintaining PMS process quality largely helps construction firms achieve business excellence, and perceived PMS effectiveness partially mediate this relationship. Construction firms tend to benefit from their employees' (those in managing positions) satisfaction and their perceived benefits of PMS initiatives. Prior evidence has pointed out that PMS *per se* would have limited direct effect on the organizational performance (Hall 2008; Henri 2006), while what PMS has effects on are more likely to be people's behavior (Burney et al. 2009; Hall 2008; Hall 2011; Ittner et al. 2003) and organizational capabilities (Chenhall 2005; Grafton et al. 2010; Henri 2006). The satisfaction and perceived benefits reflect employees' overall realization on PMS, and further lead to the change of employees' behavior and the process improvement of project and company operations. Therefore, the evidence from the context of construction provides new evidence to support the relationship between PMS process quality and organizational performance. The results strongly suggest the necessity of adopting structured processes to develop PMS in the construction industry (Beatham et al. 2005), even though some standard metrics and benchmarking tools have been established by some non-for-profit or government-supported organizations (e.g. Constructing Excellence and Centre for Construction Innovation in the UK construction industry).

Fourth, the results point out that construction firms mainly rely on three major phases of PMS development, while they tend to have different effects. More specifically, the process of preparing for design and design of performance measures are more critical than the other two phases – *organizing* and *implementing*. This is coincidently consistent with the prior literature in operations management which argues that the processes of developing the initiatives starts with the perceived incompleteness of existing PMS, and companies tend to fix it rather than developing a totally new one (Wouters and Wilderom 2008). In this regard, organizing attribute tends to be less important, while the implementation of new measures or improved measures becomes fragmented. In spite of less importance placed on processes of organizing and implementing, the result strongly supports the applicability of Neely et al.'s (1997) measure record sheet in the construction industry. Therefore, the design of measures by explicitly exploring the measures' purpose, linkage to business objectives, targets, metric, source of data, related action plan, and frequency of reporting is the most important part of PMS development. The explicit recording of these areas seems to be extremely important when some unique measures are derived from the specific organization strategy and business objectives. As many project KPIs have been extensively studied in construction, then the items shown in Appendix 3 can be very useful for designing specific organizational KPIs within construction organizations. It can also serve the review and update of existing KPIs.

Finally, the result supports the multidimensional nature of organizational performance. As this research adopts a multiple perspective on organizational performance in construction, some divergent results may be achieved. In construction, the benchmarking philosophy seems to be dominating the performance measurement practice (Deng et al. 2012), and thus it is meaningful to measure the performance against expectations (internal benchmarking) and against main competitors (external benchmarking). While these two perspectives produce a unidimensional construct, performance on projects completed generate another dimension with less reliability (see Appendix 3). It is inappropriate to measure organizational performance by solely using either project performance criteria or other perceptual evaluations on financial criteria. Indeed, the results point out that broader perspective(s) should be employed to understand and measure the dependent variable–firm performance (Deng and Smyth 2013).

LIMITATIONS

However, the findings should be interpreted in light of the limitations of the study. First, various structured processes of PMS development have been developed, while there is little evidence confirming that these processes fully suit the context of construction. Future research may apply case studies or action research to investigate what processes are exactly adopted by construction firms and further to dig the impacts of the variances. Second, the result largely supports the importance of designing process while little evidence is available for the other two phases. In this regard, future interview-based studies could be conducted to investigate these inconclusive points within the construction organization. Third, little is known about why some firms more extensively adopt these structured processes than others. Therefore, future research may investigate the drivers of these structured processes. Fourth, the measurement of user satisfaction and perceived benefits may be biased by one response involved in one company (Franco-Santos et al. 2012). It would be interesting to conduct research with multiple responses from the same company and to investigate differences of perceptions on PMS among various levels of employees. Finally, the findings are limited with the small sample size used in this research. The findings of this research can be regarded as an exploratory and preliminary explanation of the role of structured processes in developing PMS in construction.

CONCLUSION

Performance measurement in construction has been extensively studied in recent years, while the literature is limited with the identification of KPIs for construction projects and/or development of conceptual frameworks for construction firms. This paper extends the existing research streams into a novel area in construction, while the approach adopted has been extensively discussed in other disciplines, such as operations management and management accounting.

More specifically, it is concluded that construction firms can largely benefit from maintaining PMS process quality. This paper provides empirical evidence for supporting the significance of applying these structured processes in practice. It primarily contributes to opening a debate on whether PMS has effects on the organizational performance in construction and more importantly how it happens or not. These items used for measuring PMS process quality can also be applied to guide the development of PMS in practice although further revision is necessary, especially after more in-depth investigation by involving case studies or action research. Furthermore, the study also demonstrates how PLS-SEM can be used to model complicated causal relationships involving sophisticated measurement theories (such as formative/reflective constructs and hierarchical constructs) in the context of construction. Finally, the authors of this paper recommend more extensive investigation of PMS by paying closer attention to the contextualization related issues and applying contingency theory to understand how PMS interacts with organizational and individual characteristics in construction.

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APPENDIX 1. PROFILE OF THE RESPONDENTS (N=44)

Respondents' Profile	Number	Percentage
Working Experience in the Construction Industry		
Less than 5 years	0	0.0%
5 to 10 years	7	15.9%
11 to 20 years	7	15.9%
21 to 30 years	12	27.3%
More than 30 years	18	40.9%
Working Experience in the Company		
Less than 3 years	5	11.4%
3 to 5 years	9	20.5%
6 to 10 years	11	25.0%
11 to 20 years	7	15.9%
More than 20 years	12	27.3%
Job Position		
Director (managing director, finance director, construction director etc.)	15	34.1%
Department head (business improvement, management service etc.)	2	4.5%
Manager (contracts, quality, project, site, construction etc.)	11	25.0%
Professional positions (surveyor, consultant, engineer etc.)	9	20.5%
Company Size		
Less than 50 employees	1	2.3%
50 to 99 employees	2	4.5%
100 to 249 employees	14	31.8%
250 to 499 employees	6	13.6%
500 to 999 employees	3	6.8%
1000 to 2999 employees	7	15.9%
3000 to 9999 employees	2	4.5%
10000 and over	9	20.5%
Business Areas		
Construction of buildings	27	61.4%
Civil engineering (roads, railways, utility projects etc.)	16	36.4%
Specialised construction (demolition and site preparation, electrical, plumbing and other installation, and building completion and finishing etc.)	18	40.9%
Property development (commercial, industrial, retail, and mixed use property etc.)	9	20.5%
Support services (maintenance, facility management, environmental services etc.)	16	36.4%
Professional services (programme and project management, construction management, project design, planning, consultancy etc.)	12	27.3%
Public-private partnership investments	11	25.0%
Others, including refurbishment, MEP installation, energy etc.	8	18.2%

APPENDIX 2. RESULTS OF EXPLORATORY FACTOR ANALYSIS

Structured Processes of PMS Development

To what extent were the following processes adopted when the PMS was initiated, designed, and implemented in your company? (1=Not at all to 5= To a very great extent)

	Component		
Measurement Items	1	2	3
Organizing PMS Development Initiative			
Defining the constituencies of the firm (ORG1)	.160	**.914**	.034
Identifying the interdependences among these constituencies (ORG2)	.133	**.882**	.297
Composing the design team (ORG3)	.239	**.901**	.224
Deciding on the design sequence (ORG4)	.271	**.899**	.189
Design of Measures			
Clear purpose of the indicator (MEA1)	**.824**	.221	.284
Explicit linkage to business objectives (MEA2)	**.801**	.250	.347
Explicit target (MEA3)	**.735**	.357	.201
Standard formula (MEA4)	**.787**	.238	.207
Fixed frequency of reporting (MEA5)	**.856**	.167	.048
Clear identification of whom should measure it (MEA6)	**.867**	.078	.326
Clear source of data (MEA7)	**.872**	.021	.220
Clear identification of whom should act on the data (MEA8)	**.808**	.257	.399
Clear exploration and identification of what actions should be taken (MEA9)	**.841**	.193	.312
Implementation of PMS or Measures			
Setting up required infrastructure, such as computer systems (IMP1)	.088	.179	**.807**
Clearly identifying the process of data collection, collation, sorting and dissemination (IMP2)	.379	.164	**.746**
~~Embedding top management commitment (IMP3)~~	**.549**	.185	**.525**
Explicitly identifying barriers for implementing the system (IMP4)	.351	.208	**.802**
Explicitly identifying facilitating factors for implementing the system (IMP5)	.519	.168	**.705**

Extraction Method: Principal Component Analysis (PCA).

Rotation Method: Varimax.

Variances explained: 78.732%.

KMO= 0.827; Bartlett's Test: χ^2 =934, *d.f.*=210, *p*=0.000.

Values of Cronbach's α for three components:

Component 1 – Designing Process (ORG1 – ORG4): 0.967;

Component 2 – Organizing Process (PRE1 – MEA9): 0.970;

Component 3 – Implementing Process (IMP1 – IMP5): 0.888 (after deletion).

Perceived PMS Effectiveness

To what extent do you agree or disagree with the following statements about your company's PMS? (1=Largely disagree to 5=Largely agree)

Measurement Items	**Component**
User Satisfaction	
The PMS meets our expectations (SAT1)	**.903**
The PMS is close to our concept of an "ideal" system (SAT2)	**.807**
We are satisfied with the system (SAT3)	**.785**
Perceived Benefits	
The efforts to design, implement and use the PMS to date have improved the company/project organization's efficiency (BEN1)	**.906**
The efforts to design, implement and use the PMS to date have improved the company/project organization's effectiveness (BEN2)	**.925**
The implementation of the PMS will improve the company/project's operations in the future (BEN3)	**.824**

Extraction Method: PCA. Rotation Method: Varimax. Variances explained: 73.9%. KMO= 0.829; Bartlett's Test: χ^2 =244, *d.f.*=15, *p*=0.000. Value of Cronbach's α is 0.928.

Organizational Effectiveness

During the last three financial years, please rate the firm performance on each of following dimension against expectations (1=Does not meet any expectation to 5=Consistently exceeds expectations), against main competitors (1=Never better to 5=Always better), or the number of projects completed (1=No project to 5=All projects).

	Component	
Measurement Items	1	2
Performance against expectations		
Revenues (EXP1)	**.864**	.162
Return on investments (EXP2)	**.872**	.084
Profit margin (EXP3)	**.837**	-.010
Achievement of overall business goals (EXP4)	**.814**	.161
Performance against main competitors		
Revenues (COM1)	**.725**	.389
Return on investments (COM2)	**.832**	.340
Profit margin (COM3)	**.797**	.239
Performance on projects completed		
In/on time (PRO1)	.039	**.793**
Within budget (PRO2)	.354	**.606**
No defects (quality) (PRO3)	.435	**.536**
The client is satisfied (PRO4)	.191	**.859**
Zero accident (PRO5)	-.018	**.665**
High achievement of overall project goals (PRO6)	.280	**.759**

Extraction Method: PCA. Rotation Method: Varimax. Variances explained: 67.58%. KMO= 0.764; Bartlett's Test of Sphericity: χ^2 =390, *d.f.*=78, *p*=0.000. Values of Cronbach's α for component 1 and 2 are 0.934 (standardized) and 0.813, respectively.