Article

Structural Equation Model for Investigating the Causal Relationships between Project Complexities and Project Cost: An Empirical Study from New Zealand

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Abstract: Project complexity is usually considered as one of main causes of cost overruns, resulting in poor performance and thus project failure. However, empirical studies focused on evaluating its effects on project cost remain lacking. Given this circumstance, this study attempts to develop the relationships between project cost and the multidimensional project complexity elements. We establish complexity as a multidimensional factor including the task, organization, market, legal, and environment complexities. This study uses an empirical evidence-based structural model to account for the relationships between project cost and project complexity. By doing so, a quantitative assessment of multi-dimensional project complexity has been developed. The findings suggest that task and organization complexities have direct effects on project cost, while market, legal and external environment complexities have indirect effects on project cost. The practical contribution is that the findings can improve the understanding of which dimension of complexity significantly influence project cost, and the need to focus efforts on strategically addressing that complexities.

Keywords: project cost; project complexity; structural equation modeling; New Zealand

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1. Introduction

Construction projects are undertaken in an uncertain and dynamic environment, which presents a raft of challenges for all the stakeholders involved. These challenges are associated with uncertainty and complexity in construction projects [1, 2]. Project complexity impacts the modelling and management of projects and the objectives of cost, time, quality and safety [3-5]. It is usually considered as one of main causes of cost overruns, resulting in poor performance and thus project failure [4]. Construction projects are constantly exposed to a variety of complexities and uncertainties from project inception to completion. These complexities stem from many sources, such as task, organization, and environment, imposing significant upward pressure on the project's cost. It is not uncommon for construction enterprises to suffer massive losses due to ineffective management or unidentified complexities. Identification of potential effects of complexities on project cost improves performance of project management. Therefore, the impacts on cost of various project complexities should be explored.

Project complexities are abstract and difficult to measure, which is multidimensional. There is a need to define project complexity, identify the factors that can represent project complexity. Based on the suggestion of [6], project complexity can be described by a system of several interdependent factors. Assessing the effects of project complexity on project cost can provide reference for industry professionals. However, few studies about project complexity have been conducted [7-9]. Additionally, no previous studies provides a structural model for quantitively evaluating the effects of project complexity on project cost. Therefore, this study tends to develop a systematic model for

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evaluating the effects of project complexity on project cost, using structural equation modelling (SEM). SEM can examine the relationships between the measurement indicators and latent constructs; and investigate the relationships between latent constructs [10]. A valid model that describes the relations between project complexity and project cost is developed by considering New Zealand's construction industry. Therefore, the resulting model can be seen as country specific.

This study is organized as follows. Section 2 reviews the definition of project complexity, categorizes project complexity attributes (elements), and forms the hypotheses. Section 3 presents the data collection and analysis methods. Section 4 illustrates the structural model development and hypotheses testing. Section 5 presents model validation. The results are discussed in Section 6. Section 7 presents the conclusion.

2. Literature review and hypotheses formation

2.1. Project complexity and attributes

A variety of definitions of project complexity have been proposed in the existing literature. There is no uniform definition on what complexity really is, in a project context [11-13]. It is difficult to capture the whole concept with a single definition. In fact, there is still no consensus on the definition of project complexity [14-17]. Many previous studies have made efforts to define project complexity. In [18], complexity is seen as the sum of the factors: the differentiation of functions in a project between clients, consultants, and contractors, or the differentiation of an organization's structure; the dependencies between systems, and the process of decision making. In [19], the study examined the number of influencing factors and their interrelationships as elements of complexity. In [20], complexity was considered as the interdependencies among the product, process, and the difficulties of project objectives. Project complexity can be defined as the number and heterogeneity of different elements that are interdependent [7].

Although the definitions have slightly different views on project complexity, the consensus seems to be that project complexity is inherent, associated with the multi-dimensions of a project and is strongly related to the project management and objectives [21]. Moreover, "project complexity," as used by industry practitioners, usually refers to the challenges associated with project management and the difficulties related to delivering the desired project objectives [22]. These challenges, in turn, link to project tasks, stakeholders' expectations, and a multitude of dimensions related to the projects. The uncertainty and unpredictability induced by the combined effects of such factors pose a variety of challenges for successful project management [23, 24]. Experience suggested that the interdependencies among the project components and project context are more complicated. A model may be produced as a set of interrelated or interacting factors. Hence, in this study, the complexity elements are grouped into categories to formulate a model through which we can consider the project complexity as a whole, and which work collaboratively to impact the project performance.

[25] suggested that project complexity requires a more structured method of project management. Prior to any examination, it is important to first identify the attributes or elements of project complexity. To define project complexity, it is necessary to identity the attributes that can represent complexity. These attributes include project type, project location, project size, project team expertise and experience, market conditions, and political issues [26]. In [27], the study suggested that complexity can be defined in different aspects, such as task, organization and environment complexities. In [28], the study pointed out the attributes of project complexity including project size, project interrelationships, and factors of context. Additionally, this study categorized project complexity by providing a project complexity model called ALOE. [11] suggested that project complexity consists of dynamic, uncertainty and structural complexity. In [29], the study discusses project complexity as being comprised of project type, project size, construction method, and external environment. In [30], the study summarized a list of project complexity attributes, consisting of dispute resolution process, project scope, political issues, market conditions, environment issues, and types of financing.

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2.2. Categories of the project complexity attributes and hypotheses setting

[31] asserted that clustering dimensions of project complexity represents an appropriate way to appraise it. Moreover, [32] concluded that complexity in construction projects has a multi-dimensional nature, supporting the need for developing a comprehensive framework to capture project complexity. Furthermore, several previous studies have categorized project complexity. For example, in [26], the study grouped project complexity into two categories such as stakeholder management and legal complexity. In [33], project complexity was grouped into six categories, including inherent complexity, uncertainty, technological complexity, rigidity of sequence, overlap of phases or concurrency, and organization complexity. In [34], this study developed a framework for characterizing project complexity, which grouped project complexity into three groups: technology, organization and environmental complexity In [35], the study developed a HoPC (house of project complexity) model that classified project complexity into three groups: performance, technical complexity, and organization complexity.

As addressed in [36], categorization of complexity attributes is regarded to be highly subjective. Refinement of the correct measurement indicators to accurately represent the latent constructs is a complex task. A framework consists of 19 attributes, which were categorized into five groups: task, organization, market, legal, and environment complexities. This was formulated based on a comprehensive literature review and experts' opinions. While the definition of project cost could differ from one organization to another, the most reliable and reasonable project cost definition lies in three dimensions: capital construction cost, associated capital cost, and client-related cost [37]. A comprehensive list of attributes or elements that clearly represents the corresponding complexity was developed, as shown in Table 1. The proposed hypotheses are presented in Table 2.

2.2.1 Task complexity

Task dimension can broadly relate to the physical, structural composition of the project, as well as certain aspects of its operating environment, depending on the defined boundaries of the project. Task complexity has been widely cited as a critical *dimension* of project complexity. Task complexity indicates that project complexity originates from the inherent nature of the project tasks, such as complicatedness, scope ambiguity, site location, and technological risks [34, 38-40]. The increasing requirements of construction products and the trend of increasing applications of innovative technology also increase task complexity [41, 42]. Four attributes of task complexity were included in this study: project buildability, the inherent uncertainty in scope, site accessibility, and new technology. Based on previous studies, the following hypothesis can be formulated.

H1: Task complexity can significantly impact project cost

2.2.2 Organization complexity

Project development includes a variety of parties, organizational structures and procedures. Consequently, organizational complexity can also represent a dimension of project complexity [43]. Increasing attention is being paid to the fundamentals of organizational complexity, namely organizational hierarchy structure, administration, technical abilities, and experiences of the working staff [32, 34, 44, 45]. Moreover, [46, 47] also emphasized the importance of the management of material, labor, and suppliers. The study describes a system through which the project planning and controlling strategies, resource market, competition advantage (technologies and relationships) and expertise or experience of project professionals are combined in the project alliance organization [48]. Based on an extensive literature review, four attributes are identified as the principal elements of organizational complexity: resource management, technological and leading ability, experience and collaboration of stakeholders, and planning and controlling. Accordingly, the following hypothesis can be generated.

H2: Organization complexity can significantly impact project cost

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2.2.3 Market complexity

Exogenous factors are defined as the activities that are unavoidable and beyond the control of an organization [49]. Market condition is one of the major exogenous factors. According to [50], for sustainable development, companies should appropriately manage factors they can control, as well as take into account the factors beyond their control. Indeed, project cost performance is heavily affected by market-based factors [51-53]. Moreover, as [51] stated, market uncertainties are an inherent part of the market-based factor. These uncertainties can be caused by government policies, macro-economic conditions, and social effects. Furthermore, [54] suggested that project performance are closely related to their capability of coping with the competition. Additionally, working capital and adequate liquidity are of importance for construction projects. They are vital to enable start up and to support day-to-day construction activities [55]. More projects have failed due to lack of a capital source than from a shortage of technical capability. Also, market complexity can translate into financial impacts on the construction project [56]. The following hypothesis can be proposed.

H3: Market complexity can significantly impact project cost.

2.2.4 Legal complexity

According to [57], legal issues involve legal system effectiveness, the legal framework, judiciary independence, property rights, and intellectual property rights. Legal complexity should not be overlooked when managing the project cost, because it can cause dynamic changes in the project environment, resulting in significant impacts on the construction project. [58] suggested that legal complexity might be induced by contractual conditions such as flawed contractual clauses, improper contractual documents, and inappropriate contract type. Moreover, [56] concluded that unfamiliarity with the administrative procedures and local legal systems causes inefficient and complicated project management, as construction companies are subject to the approval of project development permits. Consequently, administrative procedures, applicable regulations, influences from local councils, and contract conditions were identified as the elements of legal complexity. Thus, the following hypotheses can be proposed.

H4: Legal complexity can significantly impact project cost

2.2.5 External environment complexity

A modern project operating in an increasingly turbulent environment presents unique challenges for the project system, and pressure on project cost [59]. Based on the work of [60], the term "environment" in management does not necessarily represent physical surroundings; it can also be seen as a separate entity representing all the influences that surround and affect business organizations. In recognition of the importance of the environment complexity, previous studies and research have highlighted the relationship between environmental influences and project cost management [59, 61]. In this study, variables describing aspects of environment complexity include factors such as weather conditions, unforeseen nature disasters, and differences in social/culture/language [31, 47, 62, 63]. Based on the existing literature review, the following hypothesis can be proposed.

H5: External environment complexity can significantly impact project cost

2.3 Indirect relationships

The reason why we hypothesized the indirect effect of market complexity on project cost is that market conditions and legal systems create a variety of potential internal and external influences. They can impose either direct or indirect effects on project cost. For example, they can directly increase resources prices to increase project cost. Also, they can indirectly increase financing costs and thereby increase the cost, or they can extend the permit approval process to extend the time and increase project cost. A vast number of factors that are beyond the control of the project team, imposed by the market conditions and legal system can contribute toward project overspending. Accordingly, we proposed that:

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H6: Mediated by task complexity, market complexity has a significantly indirect effect on project cost.

H7: Mediated by organization complexity, market complexity has a significantly indirect effect on project cost

H8: Mediated by task complexity, legal complexity has a significantly indirect effect on project cost

H9: Mediated by organization complexity, legal complexity has a significantly indirect effect on project cost

Furthermore, as construction projects are usually conducted in this dynamic environment, a multitude of factors can impact the project cost through task complexity and organization complexity. Similarly, the external environment complexity can impose indirect effects on project costs, through market complexity or legal complexity. Market conditions may be impacted by the external environment influence, the level depending on the market structure and size. For example, unexpected natural disasters and political instability may significantly influence the market conditions.

H10: Mediated by task complexity, external environment complexity has a significantly indirect effect on project cost

H11: Mediated by organization complexity, external environment complexity has a significantly indirect effect on project cost

H12: Mediated by market complexity, external environment complexity has a significant indirect effect on project cost

H13: Mediated by organization complexity, external environment complexity has a significantly indirect effect on project cost

H14: Mediated by market complexity and task complexity, external environment complexity has a significant indirect effect on project cost

H15: Mediated by market complexity and organization complexity, external environment complexity has a significant indirect effect on project cost

H16: Mediated by legal complexity and task complexity, external environment complexity has a significant indirect effect on project cost

H17: Mediated by legal complexity and organization complexity, external environment complexity has a significant indirect effect on project cost

2.4 Gaps in existing literature

A deeper understanding of project complexity can help industry professionals navigate the challenges brought about by project complexity. Some literature suggests that an understanding of the sources and effects of such complexity can help professionals to select appropriate and efficient management strategies and processes [28, 64]. However, the studies reflecting the current understanding of project complexity and its effects on project cost management are few. In this study, the project complexity attributes are explored, categorized and investigated. The identified project complexity attributes were categorized into five groups based on comprehensive literature review and experts' opinion. Moreover, the five-group project complexity are built into a structural model to examine their holistic effects on project cost.

Table 1. Latent constructs and corresponding measurement indicators

Constructs	Factors	Sources
Task Complexity (TCL)	Buildability (TCL1)	[28, 31, 65]
	Uncertainties in scope (TCL2)	[31, 66]
	Site location (TCL3)	[67, 68]
	Novel technologies (TCL4)	[20, 69]
Organization Complexity (OCL)	Resources management (OCL1)	[31, 46, 47]
	Technological & leadership abilities (OCL2)	[28, 31]
	Experience & collaboration of stakeholders (OCL3)	[31, 44, 45]
	Planning & controlling (OCL4)	[44, 46, 70]
Market Complexity (MCL)	Market uncertainties (MCL1)	[62, 71]
	Competition level (MCL2)	[28]
	Economic & financial dynamics (MCL3)	[31, 47, 72]
	Market structure (MCL4)	[49]
Legal Complexity (LCL)	Administrative procedures (LCL1)	[26, 73]
	Applicable regulations (LCL2)	[31, 73]
	Influence from local councils (LCL3)	[26, 74, 75]
	Contract conditions (LCL4)	[31, 46, 68]
External Environment Complexity (EEC)	Weather conditions (ECL1)	[62, 66]
	Unforeseen natural disasters (ECL2)	[31, 63]
	Differences in social/cultural/language (ECL3)	[46, 47]
Project cost (PC)	Capital construction cost (PC1)	
	Associated capital cost (PC2)	[37]
	Client-related cost (PC3)	

Table 2. Hypothetical relationship of the study

Latent Constructs	Code	Hypothetical relationship
External Environment Complexity	EEC	EEC→ PC; EEC→ TCL→ PC; EEC → OCL→ PC; EEC→ MCL → PC; EEC→ LCL→ PC
Legal Complexity	LCL	LCL→ PC; LCL→ TCL→ PC; LCL → OCL→ PC
Market Complexity	MCL	MCL→ PC; MCL→TCL→ PC; MCL→ OCL→ PC
Organization Complexity	OCL	OCL→ PC
Task Complexity	TCL	TCL→ PC
Project Cost	PC	Goal of the model

3. Research Methodology

The research method includes three principal parts. The first part includes a literature survey and a pilot survey to identify 19 project complexity elements, and then a questionnaire survey that was designed based on the identified project complexity elements. Next, the questionnaire with covering letter was distributed online to contractors and project managers who are registered members of the New Zealand Institute of Building (NZIOB). The third part is data analysis, including model development and assessment.

3.1 Data collection method—questionnaire survey

Before undertaking the survey, a pilot survey was carried out among 15 experts who have extensive experience in the construction industry. The research objectives, scope, and the questions were clearly illustrated to the 15 participants, in order to validate the indicators and constructs. Based

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on the experts' feedback, the questionnaire was refined and reworded in order to improve its clarity. Ethics notification was obtained from the University Human Ethics Committee before distribution of the survey.

A questionnaire was used to collect data from contractors and project managers in the construction industry of New Zealand. The questionnaire includes four main sections. The first section is a covering letter including the research aim and objectives and the Human Ethics Notification. In section two, the participants were requested to rank the importance of the components of project cost on a five-point Likert Scale where 1 represents unlikely important, 2 represents slightly important, 3 represents neutral, 4 represents important, and 5 represents fairly important. The Likert scale was first introduced by Rensis Likert in 1932 [76]. A Likert-scale is a measurement tool that can be used to gauge values, attitudes, and opinions, to assign a quantitative value to qualitative data [77]. A Likert-scale is typically used in a questionnaire-based survey in order to require participants to indicate the extent to which they agree or disagree with a set of statements [78]. Section three required the participants to provide background information, such as profession, position, and experience. The last section was a request form that could be used by participants to request a copy of the research findings. A total of 489 surveys were distributed across New Zealand in an effort to obtain a representative sample of the population. The final count of useable questionnaires was 136, including general contractors and project managers. Contractors made up 43 percent of the participants and project managers the other 57 percent. A summary of the respondents' professional information is shown in Table 3.

Table 3. The respondents' profiles

Profession	Percent	Experience	Percent	Organization	Percent
Contractor	36.2	10-15	13.9	Property Development	18.5
Project Manager	42.7	16-25	30.2	Consultancy	32.1
Construction Manager	19.3	>25	53.6	Construction	47.3
Other	1.80	Others	2.30	Other	2.10

3.2 Data analysis method- Structural equation modelling

Since structural equation modelling (SEM) has the capability of coping with latent variables, it has been widely used as a statistical analysis method in the social sciences [79]. The development of SEM is usually considered as second-generation multivariate analysis, which can be used in empirical validation in many research fields [80]. It has been widely acknowledged that structural equation modelling can perform measurement and structural analysis through factor analysis and path analysis [81-84]. Structural equation modelling (SEM) can 1) handle both observed and latent variables, 2) represent latent variables by using observed variables and 3) estimate causal relationships between variables—either the relationship between latent and observed variables or latent variables and latent variables [80, 85]. Additionally, SEM can provide a vivid graph model of the proposed relationships by using the variables. As explained above, latent variables are difficult to observe and measure. Several observed variables can represent one latent variable [86].

A structural equation model is often comprised of a measurement model, which examines the relationships between the measurement indicators and latent constructs; and a structural model, which tests the relationships between latent constructs [10]. The measurement model includes several latent variables and their corresponding observed variables. The structural model consists of all the latent variables and their relationships. For model development purposes, structural equation modelling (SEM) can be used to examine the hypothesis related to the latent variables and explore the causal relationships between the latent variables. In structural equation modelling, rectangles indicate observed variables, while ellipses denote latent variables, circles indicate errors and arrows denote the direction of effects. The newly-developed computer program AMOS, developed by [87], has made it much easier to carry out SEM analysis. The application of structural equation modelling (SEM) in construction studies is relatively new [88]. SEM can help to deepen the understanding of the studied phenomenon.

 doi:10.20944/preprints201906.0115.v1

4. Data Analysis

4.1. Proposed structural model

For the purpose of the study, Table 1 shows latent constructs (project cost, five- dimension of project complexity), their corresponding measurement indicators and variable abbreviations. There were six latent constructs and 22 measurement indicators. The goal variable was project cost (PC). The three basic measurement indicators of project cost are construction capital cost (PC1), associated capital cost (PC2), and client-related cost (PC3). The project complexity constructs consist of: 1) task complexity (TCL) with four indicators such as buildability (TCL1), uncertainties in scope (TCL2), site location (TCL3), and novel technologies (TCL4); 2) organization complexity (OCL) with four indicators such as resources management (OCL1), technological and leadership abilities (OCL2), experience and collaboration of stakeholders (OCL3), and planning and controlling (OCL4); 3) market complexity (MCL) with four indicators such as market uncertainties (MCL1), competition level (MCL2), economic & financial dynamics (MCL3), and market structure (MCL4); 4) legal complexity (LCL) with four indicators such as administrative procedures (LCL1), applicable regulations (LCL2), influence from local councils (LCL3), and contract conditions (LCL4); 5) external environment complexity (EEC) with three indicators such as weather conditions (EEC1), unforeseen natural disasters (EEC2), and differences in social/cultural/language (EEC3).

Based on the dimension of project complexity and hypotheses setting, the proposed research model is shown in Figure 1. The e1 to e22 indicate the measurement error of observed variables, while e23 to e27 represent the residual error of latent constructs. The proposed research model was used to examine the relationships between measurement indicators and corresponding latent constructs, and among latent constructs. The selection of the best-fit model was carried out based on various criteria recommended by [89].

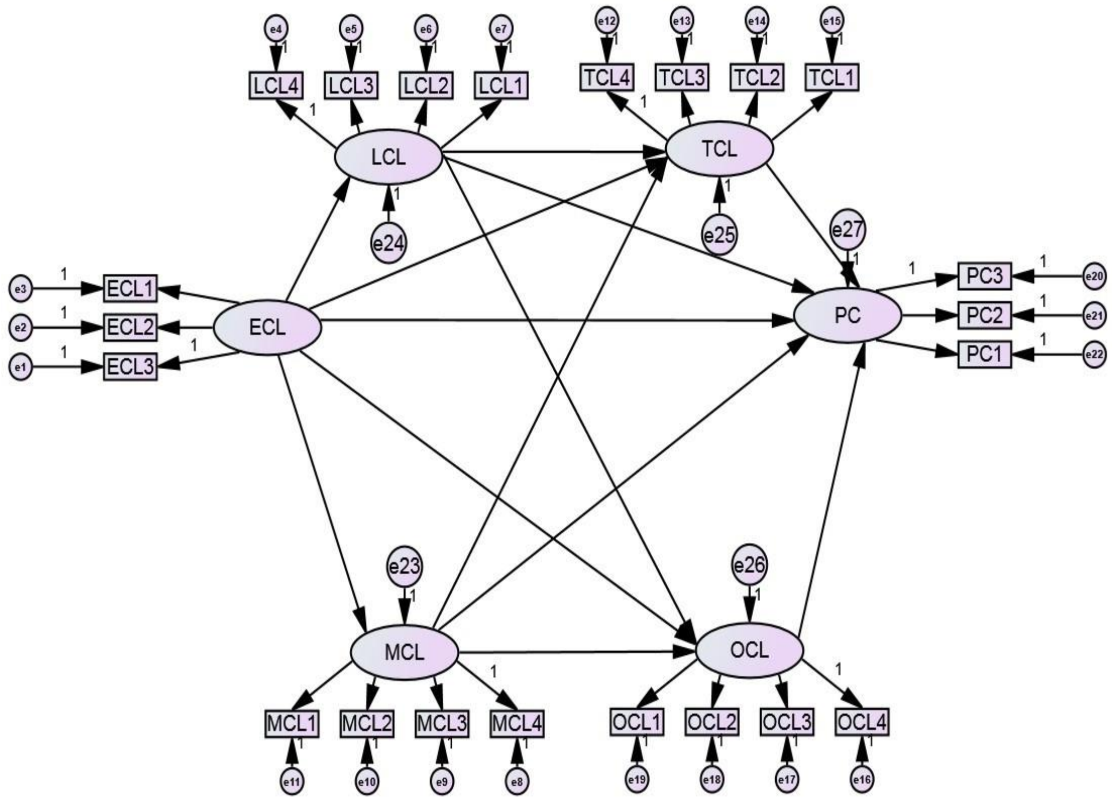

Figure 1. The proposed research model

4.2. Measurement model

Several iterations of competing models and individual model refinement were carried out until the best-fit model was identified for the dataset. Using the proposed research model in Figure 1, the

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collected data were fed into an SPSS program prepared for data imported to AMOS. The analysis results for the measurement indicators and latent constructs are shown in Table 4. Moreover, the internal consistency of the measurement indicators was checked by Cronbach's alpha test. For this test, a threshold value of 0.7 is used to indicate an acceptable level [90]. The results are also shown in Table 4. Considering the measurement indicators in Table 4, the computed *p* value at a 0.001 level indicated that significant relationships existed between all the measurement indicators and their corresponding latent constructs. This suggests that regression coefficients for the 22 measurement indicators in the predication of six latent constructs are significantly different from zero at the 0.001 level (two-tailed). Moreover, all the factor loadings of the 22 measurement indicators exceed the threshold value of 0.5, indicating they are acceptable. Therefore, none of them were dropped from the model.

The overall fit of the research model was assessed by GOF measures. The goodness-of-fit indices were computed using the SEM results from the AMOS analysis. The GOF indices used in this study included a chi-square ratio test (X^2/df), the goodness of fit (GOF), adjusted goodness of fit (AGFI), normed fit index (NFI), comparative fit index (CFI), Tucker- Lewis (TLI) and root mean square error of approximation (RMSEA). The results are shown in Table 6. It could be observed that they are all higher than the acceptable levels cited in the existing literature [91].

Table 4. Measurement model results

Measurement Indicators	Estimate	SE	p-value	Cronbach's alpha
Complicatedness (TCL1)	0.956	0.175	***	
Uncertainties in scope (TCL2)	1.065	0.182	***	0.719
Site location (TCL3)	0.991	0.167	***	
Resources management (OCL1)	0.964	0.085	***	
Technological/Leading ability (OCL2)	1.005	0.085	***	0.818
Experience & Collaboration of stakeholders (OCL3)	1.007	0.087	***	
Market uncertainties (MCL1)	0.986	0.053	***	
Competition (MCL2)	0.985	0.053	***	0.907
Economic & Financial dynamics (MCL3)	0.976	0.057	***	
Administrative procedures (LCL1)	0.976	0.059	***	
Applicable regulations (LCL2)	0.959	0.059	***	0.894
Influence from local councils (LCL3)	0.970	0.059	***	
Weather condition (EEC1)	1.010	0.066	***	0.858
Unexpected natural disasters (EEC2)	1.001	0.062	***	
Capital construction cost (PC1)	0.927	0.100	***	0.756
Associated capital cost (PC2)	1.032	0.120	***	

Notes: SE=standard error; *** =significant at 0.001 level

4.3. Hypothesis Testing

Having examined the adequacy of the model, it was necessary to test hypothetical relationships presented in the initial model. The results are shown in Table 5. According to [92], the critical ratio (CR) value above 1.96 at $p<0.05$ indicates that the hypothesis cannot be rejected at a high level of confidence. The final model results show that task complexity (TCL) has the strongest direct effect on project cost (PC), having the CR value of 3.488 that is greater than 1.96. Then, the hypothesis (H1) TCL→PC is supported. Besides this effect, organizational complexity (OCL) directly affects the project cost (PC) with almost the same significance, with the CR value of 3.299. Hence, the hypothesis (H2) OCL→PC is supported. On the basis of existing literature, the hypothesis (H3) MCL→PC was set to show that market complexity directly affects project cost, but the CR value 0.4 is too small to be significant. Hence, the hypothesis (H3) is not supported. The same is observed for the hypothesis (H4) MCL→PC, having a CR value of 0.221. This suggested that the hypothesis (H4) is not supported.

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As for the hypothesis (H5) EEC→PC with the CR value of 0.645, the data analysis does not support it.

In order to examine the indirect relationship, a new estimated should be generated. If the product of the path coefficients between complexity factor and project cost is greater than 0.3, the project complexity has a significantly indirect effect on project cost. For example, the path coefficient between market complexity (MCL) and organization complexity is 0.734, and the path coefficient between organization complexity (OCL) and project cost (PC) is 0680, then the indirect effect between MCL and PC is 0.499 (=0.734*0.68). As 0.466 is greater than 0.3, MCL has a significantly indirect effect on project cost. Then the hypothesis (H7) MCL→ OCL→ PC is supported by the analysis results. But the hypothesis (H6) MCL→ TCL→ PC with estimate 0.068 that is less than 0.3, is not supported. Moreover, the product of path coefficient between legal complexity (LCL) and task complexity (TCL) and the path coefficient between TCL and PC, is greater than 0.3, then the hypothesis (H8) LCL→ TCL→ PC is supported. Similarly, the hypothesis (H9) LCL→ OCL→ PC is supported with the estimate 0.466. However, the estimate (0.117) of hypothesis (H10) EEC→ TCL→ PC, the estimate (0.150) of hypothesis (H11) EEC→ OCL→ PC, the estimate (0.084) of hypothesis (H12) EEC→ MCL → PC, the estimate (0.035) of hypothesis (H13) EEC→ LCL→ PC, the estimate (0.074) of hypothesis (H14) EEC→ MCL→ TCL→ PC, are less than 0.3, then the hypotheses are not supported. In addition, the hypothesis (H15) EEC→ MCL→ OCL→ PC, the hypothesis (H16) EEC→ LCL→ TCL → PC, the hypothesis (H17) EEC→ LCL→ OCL→ PC, are supported with estimates 0.542, 0.323, and 0.494, respectively.

Of 17 hypothetical relationships among the dimensions of project complexity, eight are shown to be significant. In order to obtain the best-fit model, the insignificant relationships among the latent constructs were removed from the model. The final model is shown in Figure 2, the GOF measures of the final model are presented in Table 6.

Table 5. Structural model results

Hypotheses	Path link	Estimate	SE	CR	p-value	Significant
H1	TCL→ PC	0.993	0.285	3.488	***	Yes
H2	OCL→ PC	0.680	0.206	3.299	***	Yes
H3	MCL→ PC	0.077	0.192	0.400	0.689	No
H4	LCL→ PC	0.033	0.149	0.221	0.825	No
H5	EEC→ PC	0.304	0.472	0.645	0.519	No
H6	MCL→ TCL→ PC	0.068				No
H7	MCL→ OCL→ PC	0.499				Yes
H8	LCL→ TCL→ PC	0.304				Yes
H9	LCL→ OCL→ PC	0.466				Yes
H10	EEC→ TCL→ PC	0.117				No
H11	EEC→ OCL→ PC	0.150				No
H12	EEC→ MCL→ PC	0.084				No
H13	EEC→ LCL→ PC	0.035				No
H14	EEC→ MCL→ TCL→ PC	0.074				No
H15	EEC→ MCL→ OCL→ PC	0.542				Yes
H16	EEC→ LCL→ TCL→ PC	0.323				Yes
H17	EEC→ LCL→ OCL→ PC	0.494				Yes
	MCL→ TCL	0.068	0.463	0.147	0.987	
	MCL→ OCL	0.734	0.243	3.019	0.003**	
	LCL→ TCL	0.306	0.119	2.568	0.010**	
	LCL→ OCL	0.686	0.274	2.502	0.012**	
	EEC→ MCL	1.086	0.075	14.48	***	
	EEC→ LCL	1.061	0.080	13.25	***	
	EEC→ TCL	0.118	0.127	1.486	0.137	
	EEC→ OCL	0.220	0.175	1.258	0.208	

Notes: SE=standard error; ***=significant at 0.001 level; **=significant at 0.05level
Estimate>0.3 indicates significant indirect relationship

Table 6. GOF measures

GOF indices	Recommended values	Proposed model	Final model
X^2/df	1.00-2.00	1.687	1.662
GFI	>0.90	0.910	0.909
AGFI	>0.85	0.883	0.886
NFI	>0.85	0.913	0.912
CFI	>0.90	0.962	0.963
TLI	>0.80	0.956	0.957
RMSEA	<0.05	0.048	0.047

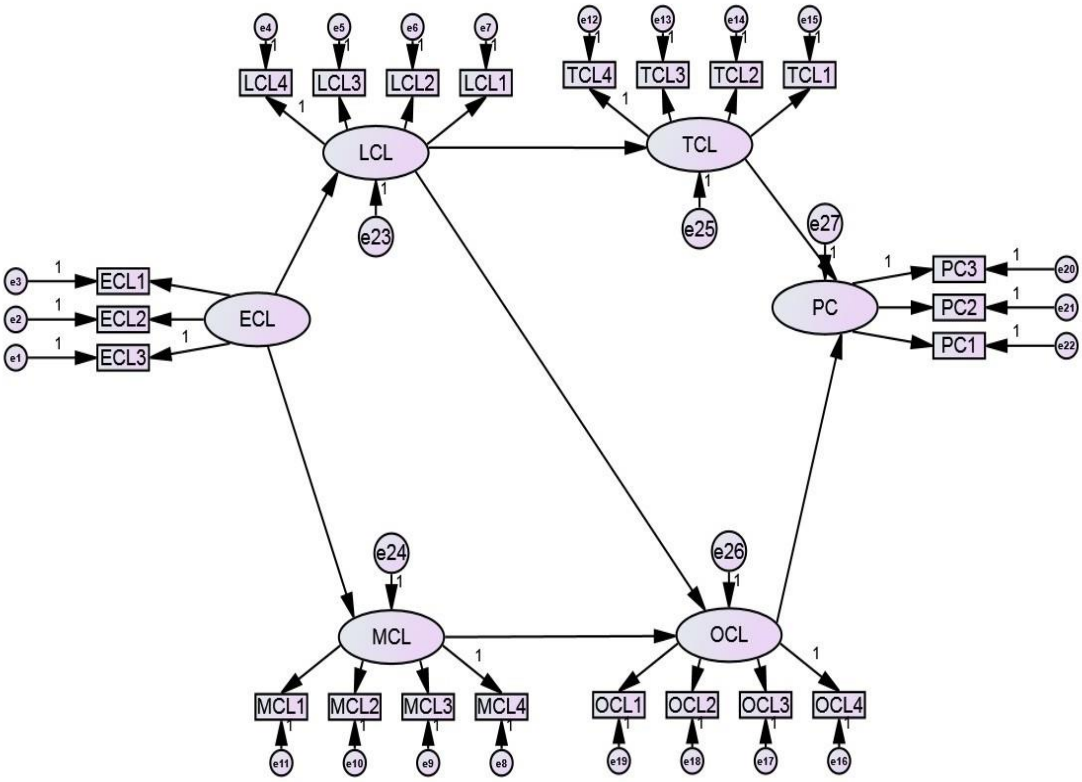

Figure 2. Final research model

4.4. Assessment of Multivariate Normality

As one of the main assumptions in SEM for generating unbiased estimates, multivariate normality should be examined by using multivariate kurtosis in AMOS. The multivariate kurtosis value and related critical value were computed in AMOS. Based on the recommendation by [93], the critical value of multivariate kurtosis greater or equal to 5 suggests a departure from multivariate normality. In this application, the critical value of 80.704 was far greater than the criterion value; thus, multivariate non-normality exists in the sample. Then the boot-strapping procedure in AMOS was introduced to test the appropriateness of the model, without assuming multivariate normality. The model requested 500 bootstrap samples from AMOS. In this study, analysis results explored that model fit in 277 of the 500 samples, indicating 277/500=0.555. The value of 0.555 is the obtained *p*-value of overall model fit, which is greater than significance *p*-value of 0.05. Hence, the hypothesis that the research model is correct, is supported. And the model fits the data well.

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5. Model Validation

In order to obtain a qualified model to support the decision-making model, validation plays an important role in the model development process. Although the internal reliability and validity of the model have been examined by the SEM procedure, the real-world feedback from the industry professionals was considered. The participation of the industry professionals was valuable and appreciated. A total of 27 surveys were received and proved useful. Overall, four participants suggested minor modifications to the best fit model, while the other 23 participants accepted the causal structure of the model. The external feedback helped to identify the model accepted by the industry. Then, the model was slightly adjusted for applicability in the real world.

The top tier in the model involves the more tangible aspects of construction, such as labor, material and project properties, which have direct effects on project costs. This aspect is also supported by the participants, whose suggested modifications did not include any changes in this aspect. That being said, some professionals suggested moving regulatory complexity to the top tier in the model. Based on the feedback and ranking provided, the model can properly describe the relationships between the project complexities and project cost. Task complexity and organization complexity are the top concerns in regard to uncertainties and potential for wide variation.

6. Results Discussion

A structural research model was set up to assess the effects of project complexity on project cost. Model fit and reliability and validity test results were found to be satisfactory. In this model, project complexity was represented by five-dimensional factors: task complexity, organizational complexity, legal complexity, market complexity, and environment complexity. The results indicate task complexity (TCL) and organization complexity (OCL) can significantly impact the project cost. While the market complexity (MCL) has a significantly indirect effect on project cost (PC) mediated by organization complexity (OCL). Similarly, legal complexity (LCL) has a significantly indirect effect on project cost (PC) mediated by task complexity (TCL) and organization complexity, respectively (OCL). Moreover, the external environment complexity (EEC) has a significantly indirect effect on project mediated by market complexity (MCL) and organization complexity (OCL). While the external environment complexity (EEC) has a significantly indirect effect on project cost (PC) mediated by legal complexity (LCL) and task complexity (TCL). Also, the external environment complexity (EEC) has a significantly indirect effect on project cost (PC) mediated by legal complexity (LCL) and organization complexity (OCL).

6.1 Direct Effects

Task complexity includes buildability, uncertainty in scope, site location, and novel technology. Buildability typically relates to the project delivery process. To incorporate construction experience into the design phase, the associated benefits can be realized during project execution. Uncertainties in project scope can be due to several reasons including change orders, inspection issues, and ineffective communication among involved parties. Changes in scope may delay the project process and frustrate the project team, resulting in project cost overruns. These findings are supported by previous studies [67, 94, 95]. It is well acknowledged that new technologies can improve project productivity, which enhances project cost performance. However, successful application of new technologies require regulatory encouragement, strong capabilities of the project team, and adequate industrial structure [96, 97].

Analysis results indicate that organization complexity has significant effects on building project costs in New Zealand. Organization complexity includes resource management, technological and leadership abilities, experience and collaboration of stakeholders, and planning and control. Based on the findings of [98], complexity may impose negative effects on project management performance. A project team with capabilities such as expertise, experience, and effective communication may help keep the project on track. The findings of this study suggest that knowledge and required experience are important to stakeholders and the project team. Continue professional development and training

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is required for project professionals to better understand the project context and innovative technologies. Moreover, the organization should financially support construction research programs to advance construction knowledge and technology.

Moreover, resources in the New Zealand construction industry include financial resources, materials and equipment, and human resources. Sometimes, although a contractor has been awarded a contract, the contractor may face challenges with obtaining the resources that are required to execute the project. This hinders the process of the project, which leads to project cost overruns. Even if the project manager has effectively planned the project prior to its execution, external influences that are beyond the control of the project team can still impose negative effects on the project. This finding agrees with previous studies [99-101] and implies that it is important for New Zealand contractors to have reliable suppliers of resources. Project planning and control play a key role in project goal setting, risk management, and procurement management [102], the importance of which is obvious. Improper planning and control can lead to late completion [103]. Effective planning and control is the backbone of any project. Even if sufficient resources are provided, weak planning and control still lead to project failure and loss of money [104].

6.2 Indirect Effects

As shown in the Table 5, 12 total indirect relationships were developed, six of which are statistically significant. Thus, the combined effect of market complexity, legal complexity, and external environment complexity indirectly or partially impacts the project cost. The total indirect effects indicate the aggregated mediating relationships in the model. Market complexity, although not explicitly intangible, is a concern that is out of a project manager's control, as it relies considerably on other economic and industry influences. Similarly, the regulatory complexity is intangible for the industry professionals, in the sense that they are heavily influenced by the local statutory and regulatory regime. The results showed that these second-tier project complexities are important to the completion of construction projects and are essential to the interrelationship between a project's complexities. The findings of this study supported by [105, 106], which found that exogenous factors, such as market conditions and legal regimes, modify the structure and form of an organization.

[107] suggested that market conditions have the power to affect project cost, through the stakeholders' perceptions and objectives, market power and structure. Moreover, [108, 109] found that the attributes of organizational complexity, such as resource management and planning and controlling, are mainly dependent on the market structure. Additionally, [110, 111] stated that elements in organizational complexity, namely technological/ leading ability and resource management, are strongly related to the market competitive forces that determine the bargaining power of suppliers and the opportunities or threats of new entrants and existing enterprises.

Regulatory policies have a significant impact on the project delivery process and project productivity. Stringent regulations may prolong the process of obtaining a building permit or having an inspection conducted. On the other hand, regulations encourage the application of new technologies and innovations. Regulations may increase the demand for improved technologies in the construction industry, which enhances productivity. Therefore, regulators requires knowledge related to advanced technologies, industry structure and competition, and market structure and conditions so that they can strategically and positively formulate regulations. This finding is also supported by previous studies [96]. A construction contract clearly illustrates the rights and obligations among the involved parties, guarantees, risk allocation, conflict resolution, and assurance [112, 113]. Favorable contract conditions can decrease exposure to risk during a project. It is also suggested that in order to achieve good project cost performance, construction practitioners should improve their understanding of the local regulations and try to develop a good relationship with government agencies. The related regulations might affect the resource management and project planning and control, through the compulsory requirement of innovative construction techniques, equipment and materials.

The results confirm the finding of [114], which emphasized that external environment is very important because construction projects do not operate in a vacuum. The difference in

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social/cultural/language may impose impacts on market structure and regulatory regime and thus finally impact the project delivery process and project productivity. Natural disasters may cause imbalance supply and demand relationships. For example, the 2011 Christchurch earthquake caused a sudden demand of housing, the increased demand led to dramatically increases in prices of materials, skill labor and equipment. This unexpected increases in prices delayed project delivery and raised project cost. However, this effect may alleviate or exacerbate based on the market efficiency to re-balance the supply and demand. Also, the regulatory regime may help during the re-balance process.

In fact, the impacts of the factors such as market conditions, legal system and external environment influence on the project costs are beyond the project team's control. They inherently impose many challenges to meet project objectives. They can impose risks on the projects, but the task complexity and organization complexity can either alleviate or exacerbate the risks.

7. Conclusion

It requires considerable and extensive research to investigate the project complexity relevant to and influencing project cost. This study sheds some light on the puzzle. This study developed a model to evaluate the effects of project complexity on projects using structural equation modelling (SEM). The results identify a set of complexity elements or attributes that truly reflect project complexity. The results indicate that both task and organization complexity can significantly impact project cost, while legal complexity has a significantly indirect effect on project cost mediated by task complexity and organization complexity, respectively. Market complexity has a significantly indirect effect on project cost mediated by organization complexity. External environment complexity has a significantly indirect effect on project cost mediated by market complexity and organization complexity. It has significantly indirect effects on project mediated by legal complexity and task complexity and mediated by legal complexity and organization complexity. Based on the direct and indirect relationships between project complexity and project cost and the quantified effects of project complexity on project cost, decision-makers can obtain the knowledge of project complexity and improve understanding of the inherent risks of projects and thus formulate appropriate strategies for project management.

One of the main contributions of this study is the insight gained in the attempt to classify the project complexity, while also considering the different activities and aspects of project complexity. Project complexity is a multifaceted phenomenon that combines project task, organizational, market, legal, and external environmental activities. The study contributes to the knowledge by using a holistic method, structural equation modelling (SEM), to model project complexity and cost. Moreover, this study takes exogenous factors into account, as they are unavoidable for any construction project, even if rarely discussed in construction management. This study improves the understanding of the effects of the exogenous factors on project cost, where exogenous factors are separated in terms of market-based factors, the legal regime, and external environmental aspects. This study set up a mediation model in which task complexity and organizational complexity mediate the effect of legal complexity, market complexity, and environmental complexity on project cost. Furthermore, this model can be used as a decision support system for monitoring project cost, based on their cost management practices. In addition, by making the construction professional aware of the activities of project complexity that could significantly affect project cost, the construction professional should become more concerned with the critical complex activities for improving project cost performance.

Further investigations are required to develop a greater understanding of the aspects of project complexity for various types of projects. The level of examination has a great potential to be a valuable topic for future research. Moreover, future research can focus on managing risk related to project complexity. Although this model has the flexibility to accommodate various project types in different project operating environments, it is likely that the levels of the dimensions of project complexity that will be affected will differ. Modification of the dimensions and activities could be

 doi:10.20944/preprints201906.0115.v1

undertaken to formulate a qualifying model suitable for a specific construction project. Additionally, this study gathered data from a sample of contractors and project managers; however, future research should address other professions' viewpoints, such as those of clients and consultants, to identify critical project activities in different perspectives.

Author Contributions: Conceptualization, L.Z. and H.Z.; methodology, L.Z.; software, H.Z.; validation, L.Z., H.Z.; resources, L.Z.; writing—original draft preparation, L.Z.; writing—review and editing, H.Z.; visualization, L.Z, H.Z.

Funding: This research was funded by China Scholarship Council, grant number 201206130069, Massey University, grant number 09166424, and Beijing University of Technology, the grant number is 004000514119067. The APC was funded by the three grants.

Acknowledgments: The authors would like to thank the China Scholarship Council (CSC) for its support through the research project and also the Massey University. The authors would like to thank the New Zealand Industry Associations for provide research data. In addition, I would like to thank all practitioners who contributed to this project.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Brady, T.; Davies, A., Managing structural and dynamic complexity: A tale of two projects. *Project Management Journal* **2014**, *45* (4), 21-38.
2. Faridi, A.; El-Sayegh, S., Significant factors causing delay in the UAE construction industry. *Journal of Construction Management and Economics* **2006**, *24* (11), 1167-1176.
3. Qazi, A.; Quigley, J.; Dickson, A.; Kirytopoulos, K., Project Complexity and Risk Management (ProCRiM): Towards modelling project complexity driven risk paths in construction projects. *International Journal of Project Management* **2016**, *34* (7), 1183-1198.
4. Sohi, A. J.; Hertogh, M.; Bosch-Rekveldt, M.; Blom, R. In *Does Lean & Agile Project Management Help Coping with Project Complexity?*, 29th World Congress International Project Management Association (IPMA) Westin Playa Bonita, Panama, 28-30 September – 1 October 2015; Serpell, A.; Ferrada, X., Eds. Procedia - Social and Behavioral Sciences Westin Playa Bonita, Panama, 2016; pp 252-259.
5. Cristóbal, J. R. S. In *Complexity in Project Management*, International Conference on Project MANagement, Barcelona, Spain, 8-10 November 2017; Cruz-Cunha, M. M.; Varajão, J. E. Q.; Rijo, R.; Martinho, R.; Peppard, J.; Cristóbal, J. R. S.; Monguet, J., Eds. Procedia Computer Science Barcelona, Spain, 2017; pp 762-766.
6. Mihm, J.; Loch, C.; Huchzermeier, A., Problem-solving oscillations in complex engineering projects. *Management Science* **2003**, *46* (6), 733-750.
7. Burke, C. M.; Morley, M. J., On temporary organizations: a review, synthesis and research agenda. *Human Relations* **2016**, *69*, 1235–1258.
8. Luo, L.; He, Q.-H.; Xie, J.-X.; Yang, D., Investigating the relationship be- tween project complexity and success in complex construction projects. *Journal of Management and Engineering* **2017**, *33* (2), 1-12.
9. He, Q.; Luo, L.; Hu, Y.; Chan, A. P. C., Measuring the complexity of mega construction projects in China—A fuzzy analytic network process analysis. *International Journal of Project Management* **2015**, *33*, 549-563.
10. Meyer, S. M.; Collier, D. A., An empirical test of the causal relationships in the Baldridge Health Care pilot criteria. *Journal of Operations Management* **2001**, *19* (4), 403-426.
11. Geraldi, J.; Maylor, H.; Williams, T., Now, let's make it really complex (complicated): a systematic review of the complexities of projects. *International Journal of Operations & Production Management* **2011**, *31* (9), 966-990.
12. Padakar, M.; Gopinath, S., Are complexity and uncertainty distinct concepts in project management? A taxonomical examination from literature. *International Journal of Project Management* **2016**, *34*, 688-700.
13. Vidal, L. A.; Marle, F.; Bocquet, J. C., Measuring project complexity using the Analytic Hierarchy Process. *International Journal of Project Management* **2011**, *29* (6), 718-727.
14. Browning, T. R., Managing complex project process models with a process architecture framework. *International Journal of Project Management* **2014**, *32* (2), 229-241.
15. Qureshi, S. M.; Kang, C., Analysing the organizational factors of project complexity using structural equation modelling. *International Journal of Project Management* **2015**, *33* (1), 165-176.
16. Ramasesh, R. V.; Browning, T. R., A conceptual framework for tackling knowable unknown unknowns in project management. *Journal of Operations Management* **2014**, *32* (4), 190-204.
17. Saunders, F. C.; Gale, A. W.; Sherry, A. H., Conceptualising uncertainty in safety-critical projects: a practitioner perspective. *International Journal of Project Management* **2015**, *33* (2), 467-478.
18. Brockmann, C.; Girmscherd, G., Complexity in Megaprojects. In *CIB World Building Congress*, 2007.
19. Ward, S.; Chapman, C., Transforming project risk management into project uncertainty management. *International Journal of Project Management* **2003**, *1* (2), 97-105.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 13 June 2019 doi:10.20944/preprints201906.0115.v1

20. Tatikonda, M. V.; Rosenthal, S. R., Technology novelty, project complexity, and product development project execution success: A deeper look at task uncertainty in product innovation. *IEEE Transactions on Engineering Management* **2000**, *47* (1), 74-87.
21. Ahn, S.; Shokri, S.; Lee, S. H.; Haas, C. T.; Haas, C. G., Exploratory study on the effectiveness of interface-management practices in dealing with project complexity in large-scale engineering and construction projects. *Journal of Management & Engineering* **2017**, *33* (2), 1-12.
22. Kiridena, S.; Sense, A., Profiling project complexity: Insights from complexity science and project management literature. *Project Management Journal* **2017**, *47* (6), 56-74.
23. Cicmil, S.; Cooke-Davies, T.; Crawford, L.; Richardson, K., *Exploring the complexity of projects: Implications of complexity theory for project management practice*. Project Management Institute: Newtown Square, PA, 2009.
24. Kapsali, M., Equifinality in project management: Exploring causal complexity in projects. *Systems Research and Behavioral Science* **2013**, *30* (1), 2-14.
25. Gransberg, D. D.; Shane, J. S.; Strong, K.; Puerto, C. L., Project complexity mapping in five dimensions for complex transportation projects. *Journal of Management & Engineering* **2013**, 316-326.
26. Dao, B.; Kermanshachia, S.; Shaneb, J.; Andersona, S.; Hareb, E. In *Identifying and measuring project complexity*, International Conference on Sustainable Design, Engineering and Construction, Procedia Engineering: 2016; pp 476-482.
27. Gidado, K. Numerical Index of Complexity in Building Construction with Particular Consideration to its Effect on Production Time. University of Brighton, UK, 1993.
28. Vidal, L.; Marle, F., Understanding project complexity: Implications on project management. *Kybernetes* **2008**, *37* (8), 1094-1110.
29. Xia, B.; Chan, A. P. C., Measuring complexity for building projects: A Delphi study. *Engineering Construction and Architectural Management* **2012**, *19* (1), 7-24.
30. Owens, J.; Ahn, J.; Shane, J. S.; Strong, K. C.; Gransberg, D. D., Defining complex project management of large US transportation projects: a comparative case study analysis. *Public Works Management & Policy* **2012**, *17* (2), 170-188.
31. Geraldi, J. G.; Adlbrecht, G., On faith, fact, and interaction in projects. *Project Management Journal* **2007**, *31* (1), 32-43.
32. Xia, W.; Lee, G., Grasping the complexity of IS development projects. *Communications of the ACM* **2004**, *47* (5), 69-74.
33. Wood, H.; Ashton, P., The factors of project complexity. In *18th CIB World Building Congress*, Salford, UK, 2010.
34. Bosch-Rekveldt, M.; Jongkind, Y.; Mooi, H.; Bakker, H.; Verbraeck, A., Grasping project complexity in large engineering projects: The TOE. *International Journal of Project Management* **2011**, *29* (6), 728-739.
35. Lessard, D.; Sakhrani, V.; Miller, R., House of project complexityunderstanding complexity in large infrastructure projects. *Engineering Project Organization Journal* **2013**, *4* (4), 170-192.
36. Aikin, L. S.; Stein, J. A.; Bentler, P. M., Structural equation analysis of clinical sub-population differences and comparative treatment outcomes: characterizing the daily lives of drug addicts. *Journal of Consulting and Clinical Psychology* **1994**, *62*, 488-499.
37. ICMS. *Global consistency in presenting construction costs*; International Construction Measurement Standards: London, UK, 2017.
38. Geraldi, J.; Maylor, H.; Williams, T., Now, let's make it really complex (complicated): A systematic review of the complexities of projects. *International Journal of Operations and Production management* **2011**, *31* (9), 966-990.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 13 June 2019 doi:10.20944/preprints201906.0115.v1

39. Kendrick, T. *Identifying and managing project risk*; American Management Association.: New York, 2003.
40. Remington, K.; Pollack, J., *Tools for complex projects*. Routledge, Taylor & Francis Group: UK, 2007.
41. Harty, C.; Goodier, C. I.; Soetanto, R.; Austin, S.; Dainty, A. R. J.; Price, A. D. F., The futures of construction: a critical review of construction future studies. *Construction Management and Economics* **2007**, *25* (5), 477-493.
42. Hu, Y.; Chan, A. P. C.; Le, Y., Understanding determinants of program organization for construction megaprojects success — a Delphi survey of the shanghai expo construction. *ASCE Journal of Management in Engineering* **2014**, *31* (5).
43. Lu, Y. L., L.; Wang, H.-I.; Le, Y.; Shi, Q., Measurement model of project complexity for large-scale projects from task and organization perspective. *International Journal of Project Management* **2015**, *33*, 610-622.
44. Curlee, W.; Gordon, R. L., *Complexity theory and project management*. John Wiley & Sons: New Jersy, 2010.
45. Taylan, O.; Bafail, A. O.; Abdulaal, M. S.; Kabli, M. R., Construction projects selection and risk assessment by fuzzy AHP and fuzzy TOPSIS methodologies. *Applied Soft Computing* **2014**, *17*, 105-116.
46. Sohrabinejad, A.; Rahimi, M., Risk determination, prioritization, and classifying in construction project case study: Gharb Tehran commercial- administrative complex. *Journal of Construction Engineering* **2015**, 1-10.
47. Yoon, Y.; Tamer, Z.; Hastak, M., Protocol to enhance profitability by managing risks in construction projects. *Journal of Management & Engineering* **2015**, *31* (5), 1-10.
48. Matinheikki, J.; Aaltonen, K.; Walker, D., Politics, public servants, and profits: Institutional complexity and temporary hybridization in a public infrastructure alliance project. *International Journal of Project Management* **2019**, *37* (2), 298-317.
49. Isik, Z.; Arditi, D.; Dilmen, I.; Birgonul, M. T., The role of exogenous factors in the strategic performance of construction companies. *Engineering, Construction and Architectural Management* **2010**, *17* (2), 119-134.
50. Barney, J., Firm resources and sustained competitive advantage. *Journal of Management* **1991**, *17* (1), 99-120.
51. Porter, M. E., *Competitive strategy*. Free Press: New York, 1980.
52. Prescott, J. E., Environments as moderators of the relationship between strategy and performance. *Academy of Management Journal* **1986**, *29*, 329-346.
53. Scherer, F. M., *Industrial market structure and economic performance*. RandMcNally & Co: Chicago, IL, 1980.
54. Kale, S.; Arditi, D., Differentiation, conformity and construction firm performance. *Journal of Management in Engineering* **2003**, *19* (2), 52-60.
55. Nesan, L. J., Project finance model for small contractors in USA. *Australasian Journal of Construction Economics and Building* **2012**, *6* (1), 25-41.
56. Ling, Y. Y.; Hoang, T. P., Political, economic, and legal risks faced in international projects: Case study of Vietnam. *Journal of Professional Issues in Engineering Education and Practice* **2010**, *136* (3), 156-164.
57. Business Monitor. *Vietnam business forecast report 2007*; Business Monitor International Ltd.: London, 2007.
58. Bing, L.; Tiong, L.-K.; Fan, W. W.; Chew, A.-S., Risk management in international construction joint ventures. *Journal of Construction Engineering & Management* **1999**, *125* (4), 277-284.
59. Akanni, P. O.; Oke, A. E.; Akpomiemie, O. A., Impact of environmental factors on building project performance in Delta State Nigeria. *HBRC Journal* **2015**, *11* (1), 91-97.
60. Bennett, J., *International construction project management: General theory and practice*. Butterworths-Heinemann: Oxford, 1991.
61. Martin, L., *Essentials of construction project management*. University of New South Wales Press Ltd: Australia, 2003.

 doi:10.20944/preprints201906.0115.v1

62. Kerur, S.; Marshall, W., Identifying and managing risk in international construction projects. *International Review of Law* **2012**, *8*, 1-14.
63. Khodeir, L. M.; Mohamed, A. H. M., Identifying the latest risk probabilities affecting construction projects in Egypt according to political and economic variables. *Housing and Building National Research Center Journal* **2015**, *11* (1), 129-135.
64. Antoniadiiis, D. N.; Edum-Fotwe, F. T.; Thorpe, A., Socio-organo complexity and project performance. *International Journal of Project Management* **2011**, *29* (7), 808-816.
65. Crawford, L., Senior management perceptions of project management competence. *International Journal of Project Management* **2005**, *23* (1), 7-16.
66. Prasad, K. V.; Vasugi, V.; Venkatesan, R.; Nikhil, B., Analysis of causes of delay in Indian construction projects and mitigation measures. *Journal of Financial Management of Property and Construction* **2019**.
67. Jarkas, A. M.; Radosavljevic, M.; Liu, W., Prominent demotivational factors influencing the productivity of construction project managers in Qatar. *International Journal of Productivity and Performance Management* **2014**, *63* (8), 1070-1090.
68. Muller, R.; Turner, J. R., Matching the project manager's leadership style to project type. *International Journal of Project Management* **2007**, *25* (1), 21-32.
69. Morris, P. W. G.; Pinto, J. A., *The resource book on the management of projects*. John Wiley: New York, 2004.
70. Thomas, J.; Mengel, T., Preparing project managers to deal with complexity - Advanced project management education. *International Journal of Project Management* **2008**, *26* (3), 304-315.
71. Williams, T. M., *Modeling complex projects*. John Wiley & Sons: London, 2002.
72. Anton, A. J. M.; Rodriguez, G. S.; Lopez, A. R., Financial risks in construction projects. *African Journal of Business Management* **2011**, *5* (31), 12325- 12328.
73. Deng, X.; Pheng, L. S.; Zhao, X., Project system vulnerability to political risks in international construction projects: the case of Chinese contractors. *Project Management Journal* **2014**, *45* (2), 20-33.
74. Chu, D.; Strand, R.; Fjelland, R., Essays & commentaries: theories of complexity. *Complexity* **2003**, *8*, 19-30.
75. Koivu, T.; Tukiainen, S.; Nummelin, J.; Atkin, B.; Tainio, R. *Institutional complexity affecting the outcomes of global projects*; Aalto University: Finland, 2004.
76. Subedi, B. P., Using likert type data in social science research: Confusion, issues and challenges. *International Journal of Contemporary Applied Sciences* **2016**, *3* (2), 36-49.
77. Holt, G. D., Asking questions, analysing answers: relative importance revisited. *Construction Innovation* **2014**, *14* (1), 2-16.
78. Harada, T.; Abe, T.; Kato, F.; Matsumoto, R.; Fujita, H.; Murai, S.; Miyajima, N.; Tsuchiya, K.; Maruyama, S.; Kudo, K.; Shinohara, N., Five-point Likert scaling on MRI predicts clinically significant prostate carcinoma. *BMC Urology* **2015**, *15* (91), 1-7.
79. Bentler, P. M., Multivariate analysis with latent variables: causalmodeling. *Annual Review of Psychology* **1980**, *31* (1), 419-456.
80. Kline, R. B., *Principles and Practice of Structural Equation Modeling*. Guilford Press: New York, 2005.
81. Bagozzi, R. P.; Yi, Y., Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science* **2012**, *40* (1), 8-34.
82. Byrne, B. M., *Structural equation modelingwith AMOS: Basic concepts, applications, and programming*. Lawrence Erlbaum Associates: London, 2001.
83. Hair, J. F., *Multivariate Data Analysis*. Pearson Prentice Hall: Upper Saddle River, N.J., 2006.

84. Ozorhon, B.; Arditi, D.; Dikmen, I.; Birgonul, M. T., Effect of partner fit in international construction joint ventures. *Journal of Management in Engineering* **2008**, *24* (1), 12-20.
85. Xiong, B.; Skitmore, M.; Xia, B.; Masrom, M. A.; Ye, K.; Bridge, A., Examining the influence of participant performance factors on contractor satisfaction: a structural equation model. *International Journal of Project Management* **2014**, *32* (3), 482-491.
86. Chinda, T.; Mohamed, S., Structural equation model of construction safety culture. *Engineering Construction and Architectural Management* **2008**, *15* (2), 114–131.
87. Arbuckle, J. L., Computer announcement amos: analysis of moment structures. *Psychometrika* **1994**, *59* (1), 135-137.
88. Xiong, B.; Skitmore, M.; Xia, B., A critical review of structural equation modeling applications in construction research. *Automation in Construction* **2015**, *49*, 59-70.
89. Oke, A. E.; Ogunsami, D. R.; Ogunlana, S., Establishing a common ground for the use of structural equation modeling for construction related research studies. *Australasian Journal of Construction Economics and Building* **2012**, *12* (3), 89-94.
90. Field, A., *Discovering statistics using SPSS*. Sage: London, 2005.
91. Hu, L.; Bentler, P. M., Cut-off criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling* **1999**, *6* (1), 1-55.
92. Byrne, B. M., *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. Routledge, Taylor & Francis Group.: Canada, 2010.
93. Bentler, P. M., *EQS 6 Structural equations program manual*. Multivariate Software Inc: Encino, CA, 2005.
94. Enshassi, A.; Mohamed, S.; Abu Mustafa, Z.; Mayer, P., Factors affecting labour productivity in building projects in the Gaza Strip. *Journal of Civil Engineering and Management* **2007**, *13* (4), 245-254.
95. Jarkas, A.; Radosavljevic, M., Motivational factors impacting the productivity of construction master craftsmen in Kuwait. *Journal of Management in Engineering* **2013**, *29* (4), 446-454.
96. Blayse, A. M.; Manley, K., Key influences on construction innovation. *Construction Innovation* **2004**, *4* (3), 143-154.
97. Walker, D.; Hampson, K.; Ashton, S., Developing an innovative culture through relationship-based procurement systems. In *Procurement strategies*, Walker, D.; Hampson, K., Eds. Blackwell: UK, 2003.
98. Hanisch, B.; Lindner, F.; Mueller, A.; Wald, A., Knowledge management in project environments. *Journal of knowledge management* **2009**, *13*, 148-160.
99. Ruuska, I.; Teigland, R., Ensuring project success through collective competence and creative conflict in public-private partnerships – a case study of Bygga Villa, a Swedish triple helix e-government initiative. *International Journal of Project Management* **2009**, *27* (4), 323-334.
100. Fabian, C.; Amir, A., The Chad-Cameroon pipeline project – assessing the World Bank's failed experiment to direct oil revenues towards the poor. *The Law and Development Review* **2011**, *4* (1), 32-65.
101. Damoah, I. S.; Kumi, D. K., Causes of government construction projects failure in an emerging economy: Evidence from Ghana. *International Journal of Managing Projects in Business* **2018**, *11* (3), 558-582.
102. Phua, F. T. T.; Rowlinson, S., How important is cooperation to construction project success? A grounded empirical quantification. *Engineering, Construction and Architectural Management* **2004**, *11*, 45-54.
103. Arain, F. M.; Low, S. P. In *Lesson learned from past projects for effective management of variation orders for institutional building projects*, MICRA 4th Annual Conference, Kuala Lumpur, Malaysia, Kuala Lumpur, Malaysia, 2005; pp 1-18.

104. Toor, S.; Ogunlana, S. O., Construction professionals' perception of critical success factors for large-scale construction projects. *Construction Innovation* **2009**, *9* (2), 149-167.
105. Goswami, C.; Goswami, S., Role of organization structure in facilitating marketing. *Global Business and Management Research: An International Journal* **2010**, *2* (2-3), 162-183.
106. Wholey, D. R.; Sanchez, S. M., The effects of regularity tools on organizational populations. *Academy of Management Review* **1991**, *16* (4), 743-767.
107. Kim, H. J.; Reinschmidt, K. F., Market structure and organizational performance of construction organizations. *Journal of Management in Engineering* **2012**, *28* (2), 212-220.
108. Bryan, C., The marketing resource management market. *Journal of Database Marketing & Customer Strategy Management* **2006**, *13* (2), 126-133.
109. Di Maio, F. R., P. C.; Baldé, K.; Polder, M., Measuring resource efficiency and circular economy: A market value approach. *Resources, Conservation & Recycling* **2017**, *122*, 163-171.
110. Chiesa, V., *R & D strategy & organization: Managing technical change in dynamic contexts*. Imperial College Press: River Edge, NJ, 2001.
111. Lipczynski, J.; Wilson, J. O. S.; Goddard, J. A., *Industrial organization: Competition, strategy, policy*. 2nd ed.; New York Prentice Hall/Financial Times: New York, 2005.
112. Deng, X.; Low, S. P.; Zhao, X.; Chang, T., Identifying micro variables contributing to political risks in international construction projects. *Engineering, Construction and Architectural Management* **2018**, *25* (3), 317-334.
113. Chapman, C.; Ward, S., Developing and implementing a balanced incentive and risk sharing contract. *Construction Management and Economics* **2008**, *26* (6), 659-669.
114. Kuye, J. O., Continental policy targeting and the nepadisation process: Issues, trends and options. *Journal of public Administration* **2004**, *39* (4), 458-469.