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Original Article

Identification and analysis of project-based organization's workload fluctuation factors

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Keywords:

Holistic view, literature review, system dynamics, planning and control.

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Abstract

Multiple factors that impact project-based organizations' workload fluctuation have already been identified by researchers. Although much effort has been devoted to finding these aspects, extant literature reviews lack systematic analysis and are confined to a few articles. This study tackles the lack of a systematic evaluation and content analysis of published studies related to workload fluctuation and offers statistics on the most prevalent variables in both the pre-award and post-award phases. The available body of knowledge is analyzed using the relative usage index (RUI) and social network analysis (SNA). RUI defines the gap in the frequency of modeling the variables. SNA defines the gap between mental models linking the variables affecting this problem and the applied dynamic models used to solve it. Results reveal some gaps, for instance, owner strictness and bid time have received very little attention in the literature.

1. INTRODUCTION

Project-based organizations (PBOs) are companies that rely on a continuous supply of projects to make a profit. Their structure evolves to develop a temporary system leading to the project's success. Through this system, the organization's workload is planned and managed[1]. Multiple factors in such systems are interacting together and affect the PBO, which strives to achieve harmony between project and portfolio workload management to provide tangible value to stakeholders.

The tangible deliverables are the end of the workload cycle. This cycle could be considered generally as two phases interacting together, workload acquisition (pre-award phase) and workload execution (after-award phase). Existing studies considered workload acquisition from the perspective of the contractor and owner. The contractor perspective studies focused on Bidding decisions using different tools such as the Logistic regression model[2], Adaptive Neuro-Fuzzy Inference System[3], Fuzzy TOPSIS method[4], and Multi-criteria decision analysis[5]. These studies centered around the application of a process system to aid project selection and portfolio design to have a consistent characteristic of workload[6]. Other studies focused on competition and increasing the probability of winning in the bidding process. These studies utilized different tools to define the markup percent such as Bayesian statistics and correlation between bid items[7], and hybrid Bayesian-fuzzy to optimize the bid price in the negotiation phase[8].

On the other hand, existing studies from the owner's perspective were focused on contractor selection and its effect on project success. For example, Nasir and Hadikusumo (2019) utilized a hybrid system dynamic and agent-based model to study the relationship between owner and contractor[9]. They found that the pre-award policies have a greater effect on project performance. Semaan and Salem (2017) developed a multi-criteria decision support system to evaluate and select contractors in the bidding phase[10]. Other models utilized the fuzzy technique[11], and a hybrid fuzzy-AHP model[12].

Moreover, existing studies considered the after-award phase were oriented toward project execution management. These studies have endeavored to address operational-level performance issues by seeking a local optimum solution (i.e., at the project level)[13]. This results from the application of traditional tools that typically focused on project performance without consideration for the effect of one project's performance on other projects operated by the same contractor[14]. This can have a butterfly effect in long-term implications[15]. As such, it is crucial to link the performance of all projects operated by a given organization (i.e. the portfolio level).

The interaction between the two phases (pre-award and after-award) and the uncertainty in the external and internal environment of the organization directly affect the organization strategic plan[16]. The application of traditional tools in strategic planning affects its reliability[17], and can give rise to schedule delays and budget overruns.

This stems from the traditional management model's main assumption that is, if elements are understood, then the project/program/portfolio can be controlled. However, experience suggests that the interrelationships among elements are more complex than has been stated in the traditional work breakdown structure of project networks[18].

I. Dynamic planning of PBO

The problem of adapting the organization to dynamic changes, such as factors fluctuation and project-based decisions, has been investigated in existing studies and is addressed in the theories of Dynamic Capabilities (DC) and Absorptive Capacity (AC). Several theories have been proposed for strategic management, such as the Resource-Based View (RBV) and the aforementioned DC and AC[13]. The foundational and most popular theory is RBV, which proceeds from the premise that competing organizations' resources and competencies are not uniform and leverages this concept of heterogeneity to explain variances in organizational success. RBV theory also notes that intangible resources (e.g., intellectual property rights, reputation, brand, culture) are more likely than material ones to provide a competitive advantage. However, the application of this theory, in reality, may necessitate both internal organizational stability and external environmental stability. Hence, DC theory endeavored to build on RBV to fill this gap by defining a set of organizational capabilities and systematic procedures or operational routines that enable businesses to successfully adjust to dynamic changes in the environment in which they compete. However, DC theory cannot provide value on its own, as the current resource base must be reconfigured to obtain value[13]. AC theory subsequently emerged, building on the foundation of RBV and DC while seeking to address this shortcoming. The key to AC theory is the notion that the internal process of learning from previous experience and present activities strengthens the imperative to acquire information from the external world. Broadly speaking AC theory can be understood as a holistic perspective that understands an organization's dynamic capacity as something inextricably linked to its systems, processes, and structures[13].

PBO applies these theories in its business modeling (BM). BM is a general overview of a company and how it operates to achieve its objectives, and it encompasses sustainability, growth, creativity, social influence, and value development. BM has emerged as a central process for characterizing business strategy by modeling how a company operates to achieve its objectives[19].

At the project/portfolio level, the most widely adopted management approach is open systems[20]. The open system considers the flow of actions without considering their feedback. This static approach is not capable of representing the dynamic complexities of the business and market landscape[21]. Open system tools focus on the logical, top-down, and structural characteristics of strategy. As a result, this approach tends to overlook the underlying practices generated by the strategy, as well as how these practices may affect strategy implementation. Successful project management, in contrast, requires integration among the various dimensions of PBO (i.e. strategy, structure, human resource, behavior, and process).

Planning and management of workload in PBO is a dynamic process affected by the sequential decisions applied, where "the actual sequence of decisions is determined not only by planning, but also by emergent variables, decisions, and actions that arise within an enterprise that adds to the pattern but are not expected in the strategy"[16]. SD theory evolved from systems thinking, which not only considers components but also the holistic view, and focuses on reliably predicting behavior based on the underlying structure[22]. SD considers the lag between an action and its consequences, as well as the nonlinear relationships between attributes[23]. From this perspective, SD is used to capture the causality relationships and feedback loops in the system[24], and to adopt multiple perspectives in a single model.

II. SD in PBO workload management

In recent years the SD approach has been integrated with strategic management to support the PBO, given its effectiveness in promoting strategic learning, thereby facilitating decision-making and performance enhancement from a systemic viewpoint[21].

Existing studies have examined the application of SD to construction projects in the area of strategic planning[18]. Despite the holistic perspective of SD being its main advantage, the use of SD in the construction industry has been characterized by the focus of researchers on operational problems without due consideration of the entire cycle. Dabirian *et al*, (2019) applied SD in human resource management to simulate the exact amount of labor needed for a project[25]. Their model focused on the internal project dynamics related to labor resource needs. Shafieezadeh *et al*., (2020) used SD to capture both the hierarchical and dynamic complexities of projects in consideration of the rework cycle and the ripple effects in the long term[26]. Their model did not consider market changes and external dynamics. In this regard, Lo, *et al* (2007) applied SD to study market dynamics and the balanced cost of a construction project (which was found to be closely related to the "owner's management strictness")[27]. Their model did not consider the internal dynamics of project management.

The objective of this study is to identify and analyze the factors affecting PBO's workload fluctuation using relative usage index (RUI) and social network analysis (SNA). Each analysis encompasses two clusters of existing studies: dynamic modeling studies and non-dynamic modeling studies. SNA is utilized to represent the difference between expert mental models and actual dynamic models. Also, RUI is utilized to find the differences in the frequency of variables used to represent the workload fluctuation problem. This highlights the gap that should be addressed in future holistic studies.

2. METHODOLOGY

The objective of this study is achieved through a multi-step methodology: literature review, screening, and analysis of the selected articles as shown in Fig. 1. The process starts by selecting a suitable search engine platform. Google Scholar is selected because it is more inclusive than other search engines and covers other databases such as Scopus and Web of Science[28]. Also, Scopus and Web of Science are screened with the same keywords to make sure that most of the sources are reviewed. To address the issue of a search yielding non-reviewed sources. Then, a systematic review is conducted using predefined keywords: dynamic/modeling of contracting organization performance, dynamic/modeling of construction project performance, dynamic/modeling of contracting organization workload, and dynamic/modeling of contracting organization bidding process. The keywords are carefully selected to cover the entire process of workload generation and execution. The title, abstract, and conclusion of each article returned in the search are screened.

The second step is reviewing the full papers to ensure that their content is sufficient for analysis and characterizing the relationships among variables. Then, the content of the selected articles (see Table 1) is analyzed to identify the variables responsible for the dynamics of PBO's workload. The articles, listed in Table 1, are classified into three categories: survey, non-dynamic modeling, and SD modeling. The survey category includes studies that focus mainly on defining variables affecting a specific problem using surveys, questionnaires, and interviews and carrying out statistical analysis of the results. Non-dynamic modeling category includes studies that use modeling tools (e.g., fuzzy modeling, equation modeling, neural networks) to analyze the surveyed variables. SD modeling category includes studies that apply SD theory to model the surveyed variables.

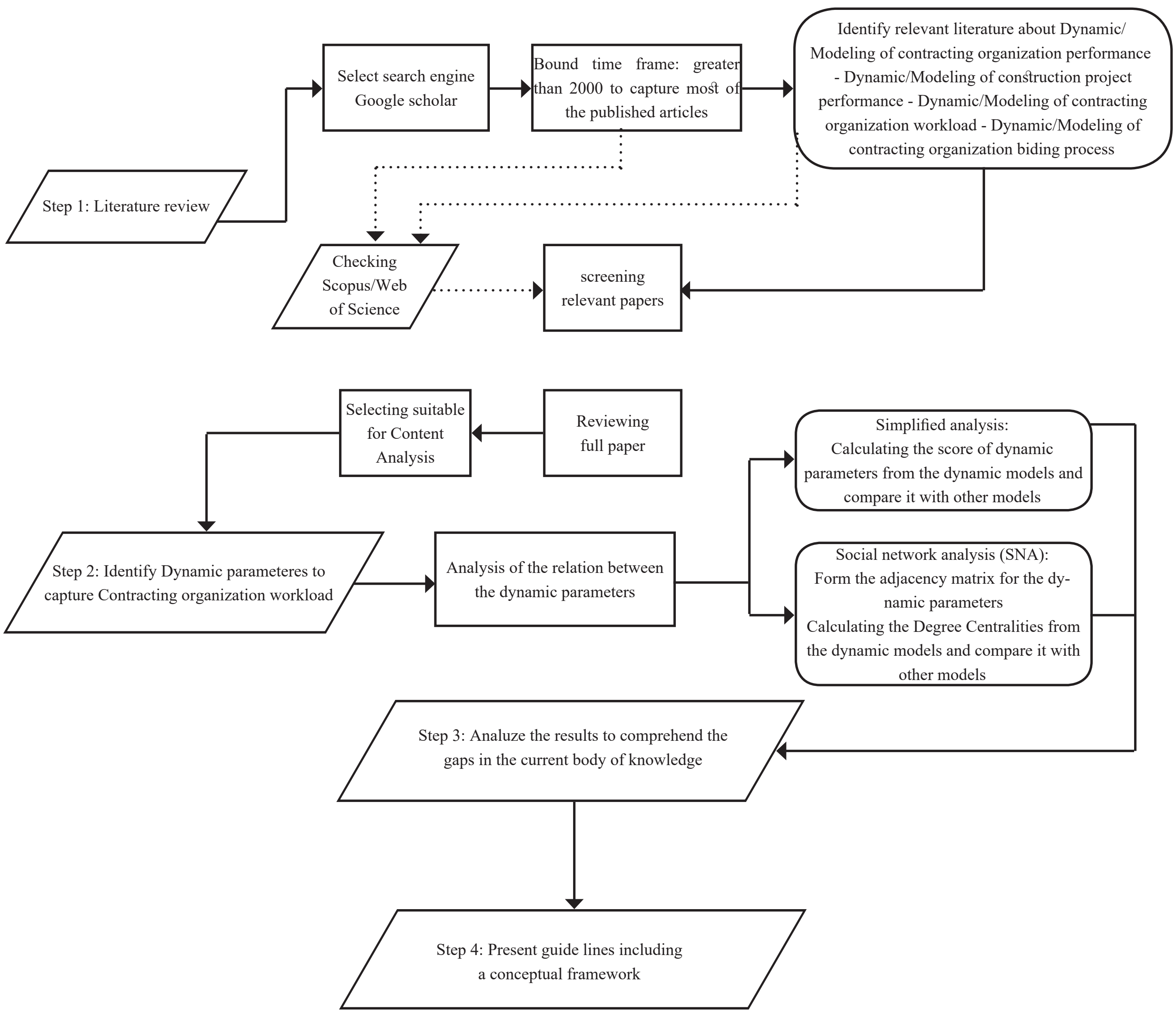


Fig. 1: Research methodology (adopted from[55])

Table 1: Papers studied

Item	Source (Reference No.)	Survey	Non-dynamic modeling	SD model
S1	[29]			√
S2	[30]			√
S3	[27]			√
S4	[31]			√
S5	[32]		√	
S6	[33]	√		
S7	[34]			√
S8	[35]			√
S9	[36]	√		
S10	[37]			√
S11	[38]			√
S12	[39]			√
S13	[40]	√		
S14	[41]	√		
S15	[42]			√
S16	[43]	√		
S17	[3]		√	
S18	[44]	√		
S19	[45]			√
S20	[46]		√	
S21	[47]	√		
S22	[48]	√		
S23	[49]			√
S24	[50]		√	
S25	[51]	√		
S26	[52]	√		
S27	[53]			√
S28	[54]			√
S29	[55]			√
S30	[56]		√	
S31	[57]			√
S32	[58]	√		
S33	[59]		√	
S34	[26]			√
S35	[60]			√

I. Conventional analysis

The conventional analysis begins with calculating the sum of each row of the reference matrix (both dynamic and non-dynamic sources). Since the number of sources varies between the two matrices, the summation is normalized to compare the ranking of variables for both matrices using Equation 1. Hence, the score of each variable range from 0 to 1.

$$\chi_{normalized} = \frac{\chi - \chi_{min}}{\chi_{max} - \chi_{min}} \quad (1)$$

To this point, the interconnections among the various variables have not been factored into the analysis. Accordingly, another technique is required to determine how the variables relate to one another and thereby provide a more accurate picture of their relevance and gaps. Social network analysis (SNA) is utilized for this purpose.

II. Social network analysis

SNA is used to investigate how variables are connected[61]. In the present study, the previously built matrices (SD and non-SD) are used to build the network. Each variable is considered a node in the network. If two variables are mentioned in the same source, this indicates a relation (edge) between them. This network is considered undirected because it considers the study of two variables simultaneously, not the effect of one variable on another.

The networks are built, analyzed, and presented using Gephi software. Gephi is an interactive visualization and exploration tool for all kinds of networks, complex systems, and hierarchical graphs[61]. The measures used for social networks are divided into two categories: those that provide information about individual positions and interactions, and those that provide information about the SN's overall structure[62]. For this research, the first category is adopted.

The main assumption to build the network of variables from the existing studies states that the link/connection between these variables is the mention of these variables in one study. Hence, some SNA measures cannot provide a real reflection of the value generated from the measurements. For example, the degree to which a node is between other nodes in the network is measured by node betweenness. The variables with a higher degree of betweenness (gatekeepers) might function as an interface between closely knit groups. They are vital pieces in the connection between distinct parts of the network because they tend to regulate data flow across variables. Yet, based on the assumption the network is not mimicking the data flow between variables. The same concept is applied to the closeness measure as well. Hence, both are not calculated.

3. DYNAMIC VARIABLES AFFECTING THE PBO WORKLOAD CYCLE

A review of the selected articles (shown in Table 1) reveals that 28 dynamic variables are affecting the PBO workload cycle. These variables are defined and categorized in Table 2. These categories will help researchers to define selected variables based on the model boundaries to be included in the study. Most of the variables investigated are related to the contractor. The little attention given to other categories affects the efficiency of the workload dynamic modeling. Hence, a detailed analysis of other categories is suggested for future research.

Table 2: Identification of dynamic variables

Category	Item	Variable	Identification
Contractor	V1	Organization Cash	This variable indicates the cash balance of the organization, the financial capacity of the contractor, and the available cash for running projects and upcoming projects.
	V2	Organization experience	This variable indicates the experience of the organization with this type of project, management competency, work quality, the percentage of errors in work, and the rework percentage.
	V3	Resources	This variable indicates the availability and capacity of the contractor's equipment, qualified staff, booked value, and assets.
	V4	Bid price	This variable indicates the size of the project, the contract price, or the awarded price.
	V5	Productivity	This variable includes labor productivity, equipment productivity, and crew productivity.
	V6	Debit	This variable indicates the number of contractors' loans from financial institutions, interest rate, and payment terms.
	V7	Bid manipulation	This variable includes overbidding, low tender sum, and beyond contractual reword or abnormal claims for contractor behavior.
	V8	Markup	This variable indicates the profit margin in similar projects and the expected return on investment.
	V9	Organization utilization	This variable indicates the utilization of resources, their allocation, and organizational capacity relative to workload.
	V10	Overhead cost / organization overheads	This variable indicates the indirect costs incurred, such as the cost of measures to satisfy the safety level required.
	V11	Tender preparation cost	This variable indicates the cost for an organization to prepare a plan and estimate the bidding price of the potential project.
	V12	Winning percent	This variable indicates the probability of winning the tender based on the tendering method, evaluation criteria, and contractor's history.
Owner	V13	Owner strictness	This variable indicates owner auditing or leniency of the owner in reviews, the quality level required, the required level of supervision, the owner's reputation, and the type.
	V14	Payment	This variable indicates the terms of payment, advanced payment, and payment delay.
	V15	Tender document purchasing fees	This variable indicates the purchasing price of contract documents and other administrative fees to participate in the bidding phase.
	V16	Compensation	This variable includes the value of liquidated damage, penalties for non-completion, and the bonus for early completion.
	V17	Bonds value	This variable indicates the size of the contractor in the market, its running financial power, and the size and validity of the bonds required.
	V18	Bid time	This variable indicates the time allowed for bid preparation and tendering duration.

Market	V19	Projects availability	This variable indicates the market conditions and severity/intensity of competition in the industry.
	V20	Market share	This variable includes the current and expected market share based on the expected awarded projects.
	V21	Outsource quality	This variable refers to the availability of qualified subcontractors and material suppliers
	V22	Number of bidders	This variable indicates the level of interest in the project.
	V23	Price feasibility	This variable indicates the efficiency of the costing method, uncertainty in cost estimation, and the feasibility of cost to market.
Project	V24	Outsource percent	This variable indicates the amount of work that is allowed to be subcontracted according to the contract.
	V25	Project schedule	This variable indicates planned/approved contract duration.
	V26	Risk	This variable indicates safety incidents, safety hazards, the possibility of environmental issues during execution, resource price fluctuations, schedule pressure or delays, and change in scope.
	V27	Design complexity	This variable indicates the design difficulty, clarity of requirements, quality, and potential for design rework.
	V28	Project scope	This variable indicates the workload required and the project type of work.

Table 3: Reference matrix

	SD Sources																		None SD Sources																
	S1	S2	S3	S4	S7	S8	S10	S11	S12	S15	S19	S23	S27	S28	S29	S31	S34	S35	S5	S6	S9	S13	S14	S16	S17	S18	S20	S21	S22	S24	S25	S26	S30	S32	S33
V01	1				1	1					1	1					1		1	1	1	1	1	1	1	1		1		1		1	1		1
V02		1		1	1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1		1			1		1	1		1
V03		1			1	1	1	1	1			1	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1	1	1	1
V04			1			1						1									1	1	1	1		1	1	1	1	1	1	1	1		1
V05				1	1		1	1	1				1	1	1	1	1	1											1						
V06		1			1															1	1			1											
V07			1								1																							1	
V08												1								1		1	1	1	1		1	1	1	1	1	1	1		1
V09		1					1	1							1				1	1	1	1	1	1		1	1	1		1		1	1		1
V10																					1		1	1									1	1	
V11																										1									
V12																					1		1	1		1			1					1	
V13											1								1	1	1	1	1	1		1	1	1		1		1	1	1	1
V14					1	1				1						1	1	1		1	1	1	1	1	1	1		1	1	1			1		1
V15																					1		1	1									1		
V16																					1	1	1	1								1			1
V17																					1		1	1	1	1	1			1		1	1		1
V18																				1	1	1	1	1	1	1	1			1		1	1		1
V19			1			1					1	1							1	1	1	1	1	1				1		1		1	1		1
V20		1				1					1								1	1	1	1	1	1	1	1				1			1		
V21								1									1		1	1	1	1	1	1	1		1	1	1			1	1	1	1
V22		1	1			1					1	1								1	1	1	1	1				1		1	1		1		1
V23											1												1			1									
V24								1									1		1	1		1	1									1	1		1
V25		1		1	1			1	1	1		1	1		1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1
V26		1		1		1	1	1	1				1	1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1		1
V27								1		1										1	1	1	1	1	1	1	1	1				1	1		1
V28		1						1	1			1	1		1	1	1	1			1	1	1	1		1	1	1		1	1	1	1	1	1

Note: S1 means Sours number 1, and V1 means Variable number 1. The details of each source and variable are mentioned in Table 1 and Table 2respectively.

4. ANALYSIS OF DYNAMIC VARIABLES

A reference matrix is developed using the 28 variables in Table 2 as rows and the 35 sources in Table 1 as columns. For each cell (i.e., the intersection between row and column), if the variable is mentioned in this source, the value of the cell equals 1; otherwise, 0, as shown in Table 3. The purpose of this matrix is to illustrate what the consensus is among academics and professionals regarding the variables in general. The matrix is then split into two matrices, one for SD modeling and the other for non-dynamic modeling. Finally, the two matrices are analyzed using the relative usage index (RUI) and SNA. The results of these methods are presented in the following section.

5. RESULTS AND DISCUSSION

I. Conventional analysis

The results of the normalized RUI are shown in Fig. 2. This score reflects the frequency of using variables in existing studies, that may be indicative of its relevance. Figure 2 indicates that the most used variables are V3

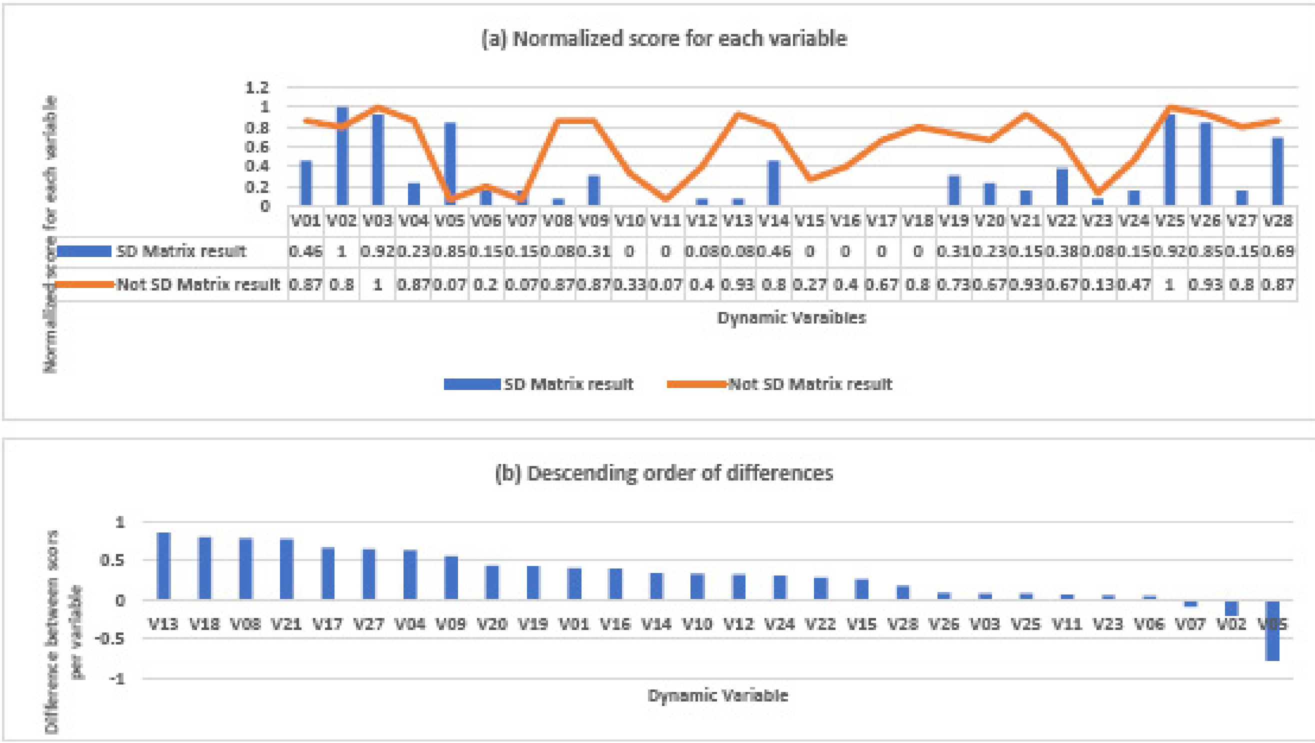
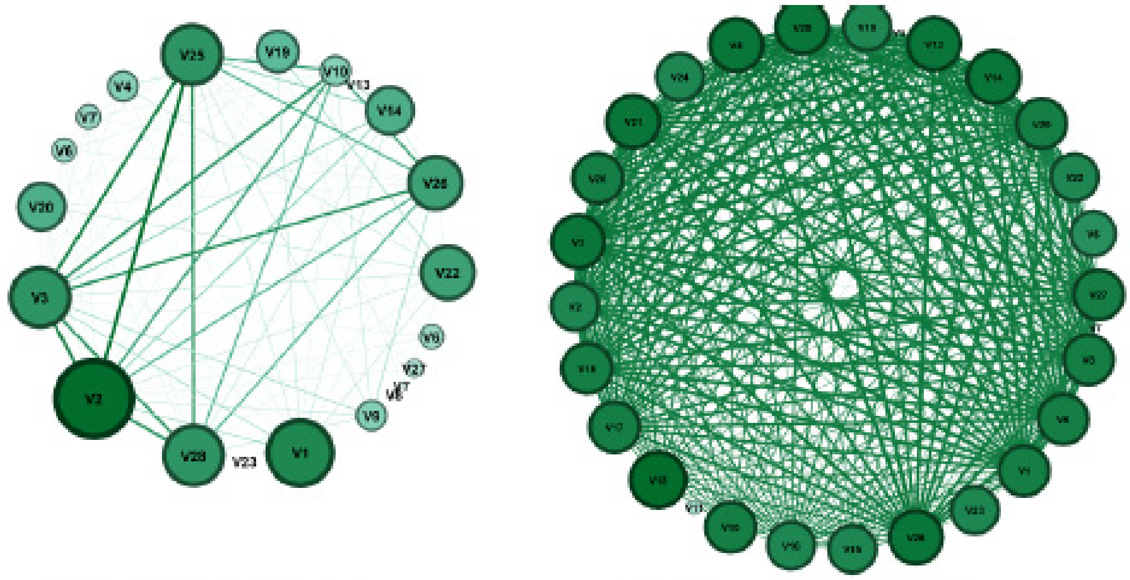


Fig. 2: Normalized score for each variable as per the matrix

(Resources), V2 (Organization experience), V25 (Project schedule), and V26 (Risk). Theoretically, they are the most prevalent variables mentioned in the literature. The differences between scores reveal the discrepancies between theoretical and simulation models that have been developed to date. These variables are V13 (Owner strictness), V18 (Bid time), V8 (Markup), V21 (Outsource quality), V17 (Bonds value), V27 (Design complexity), V4 (Bid price), V9 (Organization utilization). Hence, there is a lack of dynamic models for studying and simulating these variables. It is worth mentioning that variables such as V18 (Bid time) and V17 (Bonds value), despite their importance, have not been studied using SD models in any existing study.



(a) Social Network for Dynamic studies

(b) Social Network for NOT Dynamic studies

Fig. 3: Social network for SD and non-SD studies

II. Social network analysis

Figure 3 reveals that the non-SD network has a higher degree of centrality than the SD network. This indicates that the literature emphasizes the importance of investigating dynamic variables in conjunction rather than separately, the simulation models developed have tended to focus on specific variables. Figure 4 quantifies this observation, where the variables with the highest normalized score in both networks can be considered the most prominent variables in construction project management. These variables are V1 (Organization Cash), V3 (Resources), V22 (Number of bidders), V25 (Project schedule), and V26 (Risk). In both networks, these variables have a normalized degree greater than 0.8, i.e., the simulation models developed to agree with what has been advocated theoretically in the literature.

The difference in density between the two networks shown in Fig. 3 indicates that the variables are linked and have been considered in expert mental models, but have not garnered a sufficient amount of attention in terms of modeling analysis. Both the conventional analysis and the SNA show that the greatest disparity is concerning variable V13 (Owner strictness). “Owner strictness” is a critical variable influencing project success, it has been underrepresented in the simulation models developed to date. The second-largest gap is V23 (Price feasibility). This variable has not received sufficient attention from

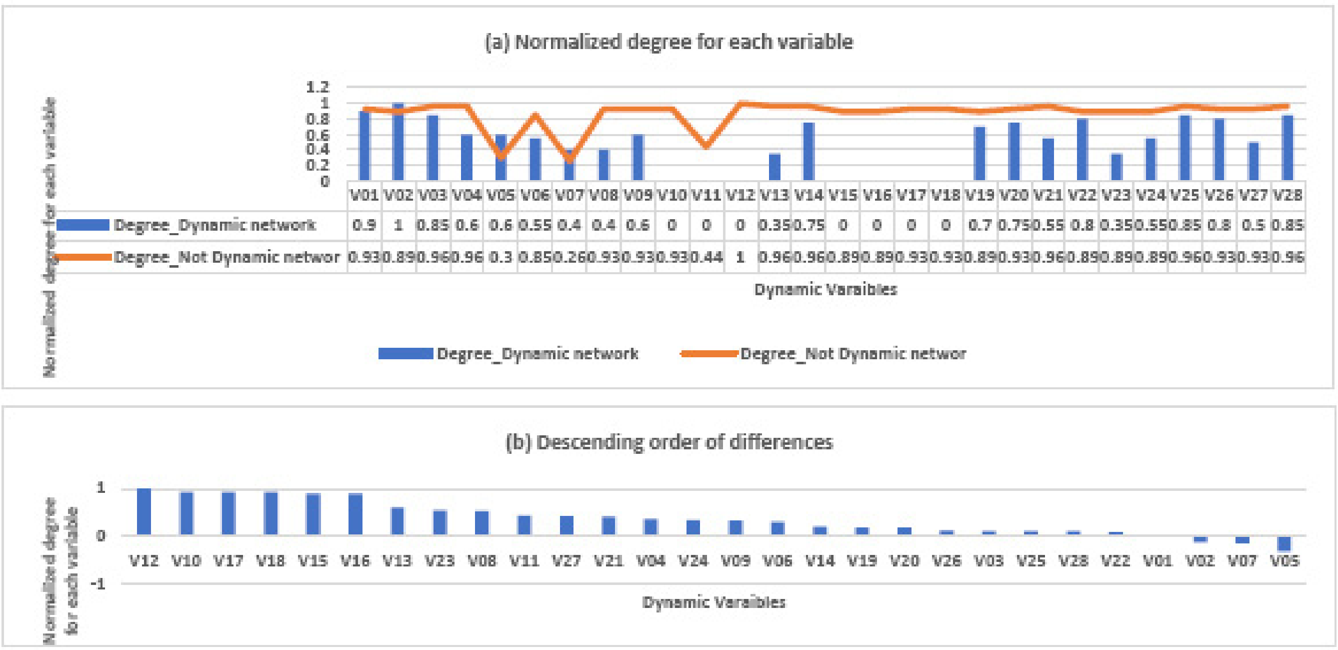


Fig. 4: Normalized degree score per variable for each network

the dynamic analysis perspective, as shown in Fig. 4. Moreover, the analysis reveals that no model among the studies reviewed accounts for all 28 dynamic variables. Among the models reviewed, none is capable of modeling more than 10 variables at once.

The identified 28 dynamic variables can cover a wide range of project aspects such as risk, productivity, resources, outsourcing, project scope changes, and others as mentioned in Table 2. Moreover, these variables can represent safety using the variables: overhead cost, rework, and risk. The

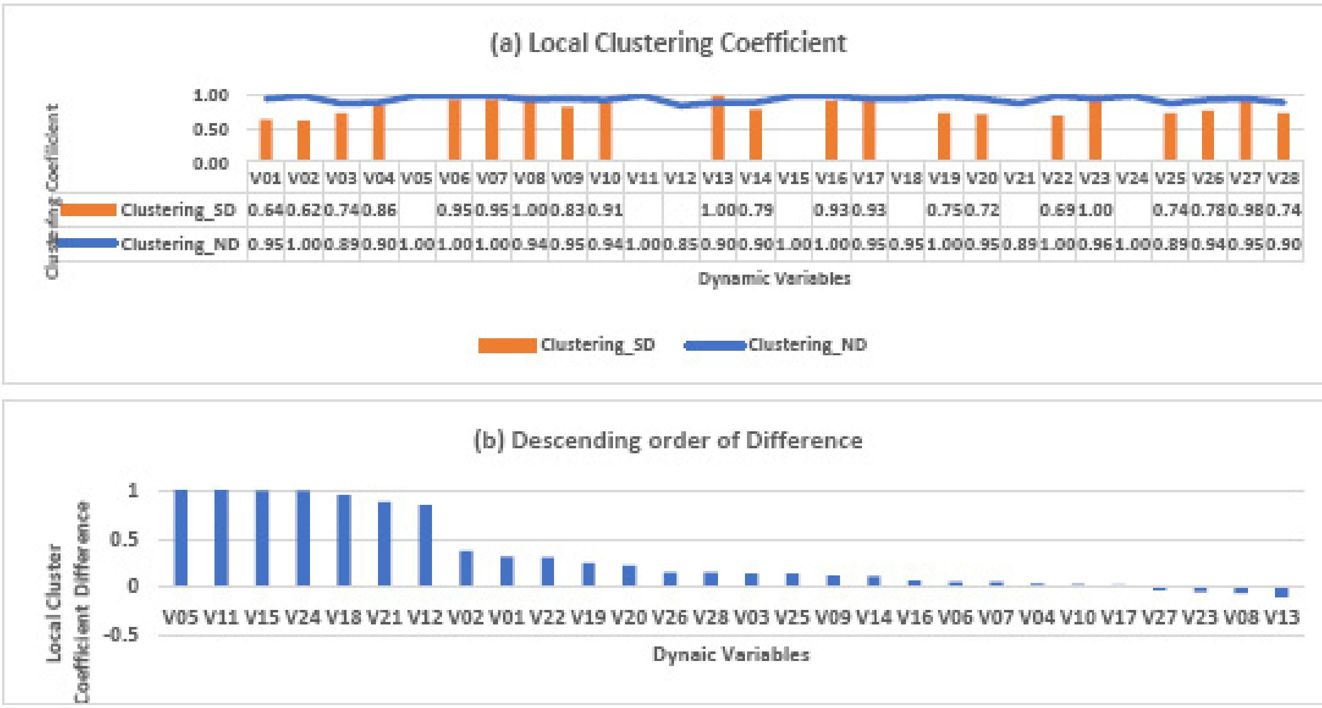


Fig. 5: Normalized local clustering coefficient per variable for each network

organization's technology level can be represented by the productivity, and rework variables. The schedule pressure can be represented by the difference between the project schedule and the project time. Overtime can be represented by productivity and cost. In other words, the 28 dynamic variables can be reconfigurable to represent almost the project aspects.

Social networks are inherently transitive. Transitivity is a local attribute of a node's neighborhood that reflects the amount of cohesiveness amongst the node's neighbors. A clustering coefficient is used to measure the transitivity attribute. The local clustering coefficient is calculated for each node and is shown in Fig. 5

The difference between the local clustering coefficient calculated from the Dynamic network and the Non-Dynamic network highlights the gap between what is required as represented by experts' suggestions and the dynamic models available. It also stresses the same variables identified by the degree of node measurements.

6. CONCLUSIONS

This study utilizes the systematic literature review approach to identify causes that affect the PBO workload fluctuation and understand their interaction. The goal of this study is threefold, address the absence of a systematic evaluation and content analysis of existing studies on workload changes in construction, identify factors influencing construction projects and contracting organizations, and recommend future research possibilities. Accordingly, a systematic analysis of prior studies is carried out to identify the dynamic variables that affect the project and the PBO's performance. Then, conventional analysis and SNA are utilized to quantify any variable that has received little to no attention in the available literature.

The analysis reveals that no model among the articles reviewed is capable of accounting for all 28 dynamic variables, as the most variables in reviewed models simulated are 10. This establishes a compelling argument for the development of an SD model that incorporates all 28 variables to realize more holistic PBO and project management. This step fills the gap between mental models linking these variables and the applied dynamic models revealed from SNA.

7. REFERENCES

[1] R. Turner and M. Miterev, "The Organizational Design of the Project-Based Organization," Proj. Manag. J., vol. 50, no. 4, pp. 487–498, Aug. 2019, doi: 10.11778756972819859746/.

[2] D. J. Lowe and J. Parvar, "A logistic regression approach to modelling the contractor's decision to bid," Constr. Manag. Econ., vol. 22, no. 6, pp. 643–653, Jul. 2004, doi: 10.108001446190310001649056/.

[3] G. Polat, B. N. Bingol, and E. Uysalol, "Modeling Bid/No Bid Decision Using Adaptive Neuro Fuzzy Inference System (ANFIS): A Case Study," pp. 1083–1092, May 2014, doi: 10.10619780784413517.111/.

[4] H. M. Al-Humaidi, "Construction Projects Bid or Not Bid Approach Using the Fuzzy Technique for Order Preference by Similarity FTOPSIS Method," J. Constr. Eng. Manag., vol. 142, no. 12, p. 04016068, Dec. 2016, doi: 10.1061/(ASCE)CO.19437862.0001180-.

[5] J. Van Der Meer, A. Hartmann, A. Van Der Horst, and G. Dewulf, "Multi-criteria decision analysis and quality of design decisions in infrastructure tenders: a contractor's perspective," Constr. Manag. Econ., vol. 38, no. 2, pp. 172–188, Feb. 2020, doi: 10.108001446193.2019.1577559/.

[6] A. Jerbrant, "A maturation model for project-based organisations - with uncertainty management as an ever-present multi-project management focus," South Afr. J. Econ. Manag. Sci., vol. 17, no. 1, pp. 33–51, Jan. 2014, doi: 10.10520/EJC148769.

[7] X.-X. Yuan, "A correlated bidding model for markup size decisions," Constr. Manag. Econ., vol. 29, no. 11, pp. 1101–1119, Nov. 2011, doi: 10.108001446193.2011.637568/.

[8] S.-S. Leu, P. V. Hong Son, and P. T. Hong Nhung, "Optimize negotiation price in construction procurement using Bayesian Fuzzy Game Model," KSCE J. Civ. Eng., vol. 19, no. 6, pp. 1566–1572, Sep.

2015, doi: 10.1007/s122052-0522-014-.
[9] M. K. Nasir and B. H. W. Hadikusumo, "System Dynamics Model of Contractual Relationships between Owner and Contractor in Construction Projects," J. Manag. Eng., vol. 35, no. 1, p. 04018052, Jan. 2019, doi: 10.1061/(ASCE)ME.19435479.0000666-.
[10] N. Semaan and M. Salem, "A deterministic contractor selection decision support system for competitive bidding," Eng. Constr. Archit. Manag., vol. 24, no. 1, pp. 61–77, Jan. 2017, doi: 10.1108/ECAM-06-0094-2015.
[11] D. Singh and R. L. K. Tiong, "A Fuzzy Decision Framework for Contractor Selection," J. Constr. Eng. Manag., vol. 131, no. 1, pp. 62–70, Jan. 2005, doi: 10.1061/(ASCE)073362)131:1(2005)9364-).
[12] P. Jaskowski, S. Biruk, and R. Bucon, "Assessing contractor selection criteria weights with fuzzy AHP method application in group decision environment," Autom. Constr., vol. 19, no. 2, pp. 120–126, Mar. 2010, doi: 10.1016/j.autcon.2009.12.014.
[13] C. P. Killen, K. Jugdev, N. Drouin, and Y. Petit, "Advancing project and portfolio management research: Applying strategic management theories," Int. J. Proj. Manag., vol. 30, no. 5, pp. 525–538, Jul. 2012, doi: 10.1016/j.ijproman.2011.12.004.
[14] M. Martinsuo, "Project portfolio management in practice and in context," Int. J. Proj. Manag., vol. 31, no. 6, pp. 794–803, Aug. 2013, doi: 10.1016/j.ijproman.2012.10.013.
[15] A. Mahdavi, N. Naderpajouh, J. Choi, A. Ketabi, M. Hastak, and Q. Cui, "Dynamics of project selection and growth in project-based organizations," Int. J. Constr. Manag., vol. 21, pp. 1200–1217, Dec. 2021, doi: 10.108015623599.2019.1604307/.
[16] C. Wolf and S. W. Floyd, "Strategic Planning Research: Toward a Theory-Driven Agenda," J. Manag., vol. 43, no. 6, pp. 1754–1788, Jul. 2017, doi: 10.11770149206313478185/.
[17] E. G. Too and P. Weaver, "The management of project management: A conceptual framework for project governance," Int. J. Proj. Manag., vol. 32, no. 8, pp. 1382–1394, Nov. 2014, doi: 10.1016/j.ijproman.2013.07.006.
[18] L. Wang, M. Kunc, and S. Bai, "Realizing value from project implementation under uncertainty: An exploratory study using system dynamics," Int. J. Proj. Manag., vol. 35, no. 3, pp. 341–352, Apr. 2017, doi: 10.1016/j.ijproman.2017.01.009.
[19] F. Cosenz and G. Noto, "A dynamic business modelling approach to design and experiment new business venture strategies," Long Range Plann., vol. 51, no. 1, pp. 127–140, Feb. 2018, doi: 10.1016/j.lrp.2017.07.001.
[20] M. Martinsuo and J. Geraldi, "Management of project portfolios: Relationships of project portfolios with their contexts," Int. J. Proj. Manag., vol. 38, no. 7, pp. 441–453, Oct. 2020, doi: 10.1016/j.ijproman.2020.02.002.
[21] F. Cosenz, "Supporting start-up business model design through system dynamics modelling," Manag. Decis., vol. 55, no. 1, pp. 57–80, Jan. 2017, doi: 10.1108/MD-060395-2016-.
[22] "Systems thinking: Critical thinking skills for the 1990s and beyond - Richmond - 1993 - System Dynamics Review - Wiley Online Library." https://onlinelibrary.wiley.com/doi/abs/10.1002/sdr.4260090203 (accessed Jun. 19, 2023).
[23] L. B. Sweeney and J. D. Sterman, "Bathtub dynamics: initial results of a systems thinking inventory," Syst. Dyn. Rev., vol. 16, no. 4, pp. 249–286, 2000, doi: 10.1002/sdr.198.
[24] K. Stave and M. Hopper, "What Constitutes Systems Thinking? A Proposed Taxonomy," Jan. 2007.
[25] S. Dabirian, S. Abbaspour, M. Khanzadi, and M. Ahmadi, "Dynamic modelling of human resource allocation in construction projects," Int. J. Constr. Manag., vol. 22, no. 2, pp. 182–191, Jan. 2022, doi: 10.108015623599.2019.1616411/.
[26] M. Shafieezadeh, M. Kalantar Hormozi, E. Hassannayebi, L. Ahmadi, M. Soleymani, and A. Gholizad, "A system dynamics simulation model to evaluate project planning policies," Int. J. Model. Simul., vol. 40, no. 3, pp. 201–216, May 2020, doi: 10.108002286203.2019.1596779/.
[27] W. Lo, C. L. Lin, and M. R. Yan, "Contractor's Opportunistic Bidding Behavior and Equilibrium Price Level in the Construction Market," J. Constr. Eng. Manag., vol. 133, no. 6, pp. 409–416, Jun. 2007, doi: 10.1061/(ASCE)0733409)133:6(2007)9364-).
[28] A. Martín-Martín, M. Thelwall, E. Orduna-Malea, and E. Delgado López-Cózar, "Google Scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations' COCI: a multidisciplinary comparison of coverage via citations," Scientometrics, vol. 126, no. 1, pp. 871–906, Jan. 2021, doi: 10.1007/s111924-03690-020-.
[29] A. Bajracharya, S. O. Ogunlana, and N. L. Bach, "Effective organizational infrastructure for training activities: a case study of the Nepalese construction sector," Syst. Dyn. Rev., vol. 16, no. 2, pp. 91–112, 2000, doi: 10.100291>16:2(200022)1727-1099/::AID-SDR190>3.0.CO;2-D.
[30] Y. H. Tang and S. O. Ogunlana, "Modelling the dynamic performance of a construction organization," Constr. Manag. Econ., vol. 21, no. 2, pp. 127–136, Feb. 2003, doi: 10.10800144619032000079699/.
[31] T. R. B. Taylor and D. N. Ford, "Managing Tipping Point Dynamics in Complex Construction Projects," Jun. 2008, Accessed: Jun. 20, 2023. [Online]. Available: http://localhost:8080/xmlui/handle/yetl/28431
[32] M. Egemen and A. Mohamed, "SCBMD: A knowledge-based system software for strategically correct bid/no bid and mark-up size decisions," Autom. Constr., vol. 17, no. 7, pp. 864–872, Oct. 2008, doi: 10.1016/j.autcon.2008.02.013.
[33] A. S. Bageis and C. Fortune, "Factors affecting the bid/no bid decision in the Saudi Arabian construction contractors," Constr. Manag. Econ., vol. 27, no. 1, pp. 53–71, Jan. 2009, doi: 10.108001446190802596220/.
[34] Q. Cui, M. Hastak, and D. Halpin, "Systems analysis of project cash flow management strategies," Constr. Manag. Econ., vol. 28, no. 4, pp. 361–376, Apr. 2010, doi: 10.108001446191003702484/.
[35] B. Dangerfield, S. Green, and S. Austin, "Understanding construction competitiveness: the contribution of system dynamics," Constr. Innov., vol. 10, no. 4, pp. 408–420, Oct. 2010, doi: 10.110814714171011083579/.
[36] A. Enshassi, S. Mohamed, and A. El Karriri, "Factors affecting the bid/no bid decision in the Palestinian construction industry," J. Financ. Manag. Prop. Constr., vol. 15, no. 2, pp. 118–142, Aug. 2010, doi: 10.110813664381011063421/.
[37] A. Alvanchi, S. Lee, and S. AbouRizk, "Modeling Framework and Architecture of Hybrid System Dynamics and Discrete Event Simulation for Construction," Comput.-Aided Civ. Infrastruct. Eng., vol. 26, no. 2, pp. 77–91, 2011, doi: 10.1111/j.14678667.2010.00650-.x.
[38] "System Dynamics Applied to Outsourcing Engineering.pdf." Accessed: Jun. 20, 2023. [Online]. Available: https://www.cmaanet.org/sites/default/files/resource/System%20Dynamics%20Applied%20to%20Outsourcing%20Engineering.pdf
[39] A. Alvanchi, S. Lee, and S. AbouRizk, "Dynamics of Working Hours in Construction," J. Constr. Eng. Manag., vol. 138, no. 1, pp. 66–77, Jan. 2012, doi: 10.1061/(ASCE)CO.19437862.0000384-.
[40] M. S. El-Mashaleh, "Empirical Framework for Making the Bid/No-Bid Decision," J. Manag. Eng., vol. 29, no. 3, pp. 200–205, Jul. 2013, doi: 10.1061/(ASCE)ME.19435479.0000147-.
[41] A. M. Jarkas, "Primary factors influencing bid mark-up size decisions of general contractors in Kuwait," J. Financ. Manag. Prop. Constr., vol. 18, no. 1, pp. 53–75, Jan. 2013, doi: 10.110813664381311305078/.
[42] Y. Li and T. R. B. Taylor, "Modeling the Impact of Design Rework on Transportation Infrastructure Construction Project Performance," J. Constr. Eng. Manag., vol. 140, no. 9, p. 04014044, Sep. 2014, doi: 10.1061/(ASCE)CO.19437862.0000878-.
[43] A. M. Jarkas, S. Mubarak, and C. Y. Kadri, "Critical factors determining bid/no bid decisions of contractors in Qatar," Jul. 2014, Accessed: Jun. 20, 2023. [Online]. Available: http://qspace.qu.edu.qa/handle/105764190/
[44] K. Ye, L. Shen, B. Xia, and B. Li, "Key attributes underpinning different markup decision between public and private projects: A China study," Int. J. Proj. Manag., vol. 32, no. 3, pp. 461–472, Apr. 2014, doi: 10.1016/j.ijproman.2013.06.001.
[45] M.-R. Yan, "Project-Based Market Competition and Policy Implications for Sustainable Developments in Building and Construction Sectors," Sustainability, vol. 7, no. 11, Art. no. 11, Nov. 2015, doi: 10.3390/su71115423.
[46] A. Leśniak and E. Plebankiewicz, "Modeling the Decision-Making Process Concerning Participation in Construction Bidding," J. Manag. Eng., vol. 31, no. 2, p. 04014032, Mar. 2015, doi: 10.1061/(ASCE)ME.19435479.0000237-.
[47] M. Shokri-Ghasabeh and N. Chileshe, "Critical factors influencing the bid/no bid decision in the Australian construction industry," Constr. Innov., vol. 16, no. 2, pp. 127–157, Jan. 2016, doi: 10.1108/CI-04-2015-0021.
[48] I. O. Aje, T. O. Oladinrin, and A. N. C. Nwaole, "Factors influencing success rate of contractors in competitive bidding for construction works in South-East, Nigeria," 2016, doi: 10.21315/jcdc2016.21.1.2.
[49] M. A. Wibowo, I. N. Y. Astana, and H. A. Rusdi, "Dynamic Modelling of the Relation between Bidding Strategy and Construction

Project Performance," Procedia Eng., vol. 171, pp. 341–347, 2017, doi: 10.1016/j.proeng.2017.01.342.
[50] M. L. Chisala, "Quantitative Bid or No-Bid Decision-Support Model for Contractors," J. Constr. Eng. Manag., vol. 143, no. 12, p. 04017088, Dec. 2017, doi: 10.1061/(ASCE)CO.19437862.0001407-.
[51] B. Aznar, E. Pellicer, S. Davis, and P. Ballesteros-Pérez, "Factors affecting contractor's bidding success for international infrastructure projects in Australia," J. Civ. Eng. Manag., vol. 23, no. 7, pp. 880–889, Oct. 2017, doi: 10.384613923730.2017.1341955/.
[52] O. A. Olatunji, O. I. Aje, and S. Makanjuola, "Bid or no-bid decision factors of indigenous contractors in Nigeria," Eng. Constr. Archit. Manag., vol. 24, no. 3, pp. 378–392, Jan. 2017, doi: 10.1108/ECAM-01-0029-2016.
[53] Y. Li, L. Jiang, T. R. B. Taylor, and D. N. Ford, "Impact of Labour Controls on Tipping Point Dynamics in Large Complex Projects," Syst. Res. Behav. Sci., vol. 35, no. 6, pp. 605–618, 2018.
[54] F. Nasirzadeh, M. Khanzadi, and M. Mir, "A hybrid simulation framework for modelling construction projects using agent-based modelling and system dynamics: an application to model construction workers' safety behavior," Int. J. Constr. Manag., vol. 18, no. 2, pp. 132–143, Mar. 2018, doi: 10.108015623599.2017.1285485/.
[55] I. S. Abotaleb and I. H. El-adaway, "Managing Construction Projects through Dynamic Modeling: Reviewing the Existing Body of Knowledge and Deriving Future Research Directions," J. Manag. Eng., vol. 34, no. 6, p. 04018033, Nov. 2018, doi: 10.1061/(ASCE)ME.19435479.0000633-.
[56] M. Marzouk and E. Mohamed, "Modeling bid/no bid decisions using fuzzy fault tree," Constr. Innov., vol. 18, no. 1, pp. 90–108, Jan. 2017, doi: 10.1108/CI-110060-2016-.
[57] S. Abbaspour and S. Dabirian, "Evaluation of labor hiring policies in construction projects performance using system dynamics," Int. J. Product. Perform. Manag., vol. 69, no. 1, pp. 22–43, Jan. 2019, doi: 10.1108/IJPPM-030134-2019-.
[58]A. Oke, A. Omoraka, and A. Olatunbode, "Appraisal of factors affecting bidding decisions in Nigeria," Int. J. Constr. Manag., vol. 20, no. 2, pp. 169–175, Mar. 2020, doi: 10.108015623599.2018.1484846/.
[59]G. Li, G. Zhang, C. Chen, and I. Martek, "Empirical Bid or No Bid Decision Process in International Construction Projects: Structural Equation Modeling Framework," J. Constr. Eng. Manag., vol. 146, no. 6, p. 04020050, Jun. 2020, doi: 10.1061/(ASCE)CO.19437862.0001830-.
[60]Z. G. Al-Kofahi, A. Mahdavian, and A. Oloufa, "System dynamics modeling approach to quantify change orders impact on labor productivity 1: principles and model development comparative study," Int. J. Constr. Manag., vol. 22, no. 7, pp. 1355–1366, May 2022, doi: 10.108015623599.2020.1711494/.
[61]J. Scott and P. J. Carrington, The SAGE Handbook of Social Network Analysis. SAGE, 2011.
[62]R. A. Hanneman and M. Riddle, "Introduction to Social Network Methods: Table of Contents".