DEVELOPMENT OF AN INTERDEPENDENCY NETWORK MODEL FOR ANALYZING CONSTRUCTION CONTRACTOR PAYMENT RISKS IN KENYA: A CASE OF DESIGN-BID-BUILD PROCUREMENT SYSTEM

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(Construction Engineering and Management)

JOMO KENYATTA UNIVERSITY

OF

AGRICULTURE AND TECHNOLOGY

2023

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A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Construction Engineering and Management of the Jomo Kenyatta University of Agriculture and Technology

2023

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University:

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DEDICATION

This thesis is dedicated to my wife, Divina, and our four children, Gloria, Carson, Einstein and Euler. Their tolerance and understanding allowed me to concentrate on my doctoral studies. I also dedicate this dissertation to my late mother, Agnes Kerubo, who died of cancer during my Ph.D. studies. Despite her lack of education beyond primary school, she instilled in me values that allowed me to maintain focus and discipline throughout my Ph.D. journey. My greatest regret is that she did not live to see the results of her hard work. Last but not least, I would like to dedicate this thesis to my father, Kenyatta Abuta, who repeatedly told me while I attended Kisii High School that a good education was the best gift he could give me.

ACKNOWLEDGEMENT

Even though the Ph.D. process took more than six years, it was one of my most intriguing endeavors. During this time, I acquired two new fields, which I used in this thesis. One prominent discipline is network science, which encompasses the subfield of Social Network Analysis (SNA). The second is the new institutional economics (NIE) with its subfields of transaction cost economics, principal agency, and property rights. Using the NIE principles, it was possible to identify the strategic components of the systems used to procure construction projects. This thesis serves as an example of how ideas from the two disciplines have been combined.

However, during the course of my Ph.D. journey, I received valuable encouragement and assistance from several individuals who deserve acknowledgment. The Almighty God deserves special recognition for his grace, health, and wisdom. Second, I want to thank Dr. Gwaya, Prof. Masu, and Dr. Eng. Ajwang, who served as my supervisors and gave me constructive input. In addition, they facilitated the development of creativity and critical thinking, which played a pivotal role in shaping the present thesis.

Thirdly, I would like to thank the editorial staff and anonymous peer reviewers of *SAGE publishing* and *Journal of Strategic Contracting and Negotiation*, who reviewed my articles and provided feedback. In addition to the published articles, their contributions have shaped this thesis. The Journal of *Construction Management and Economics* reviewers whose comments enhanced the theoretical portion of this thesis are also acknowledged.

Fourthly, I appreciate Kenya Law Review's provision of a public portal from which the payment dispute cases were obtained. Similarly, the subject matter experts who participated in the study are acknowledged. The empirical component of this study was supported by the two data sources, and along with the theoretical section, the study was able to offer findings that contributed to theory and practice.

Fifthly, I would like to thank Dr. Abwunza for his assistance with EndNote X9 and NVIVO, as well as my wife Divina for introducing me to the proofreading software.

Prof. Stephen P. Borgatti, the creator of the UCINET software, and his wife Roberta Borgatti of Analytic Technologies deserve special recognition for waiving the software's fee. It has been used for modeling and analysis.

Finally, I would like to express my gratitude and appreciation to the Jomo Kenyatta University of Agriculture and Technology for their generous decision to exempt me from paying tuition fees. Additionally, I would like to extend my thanks to the esteemed panelists of the SMARTEC seminars for their valuable and constructive criticism. I am also appreciative of Dr. Eng. Kabubo, the director of SMARTEC and the dean of the School of Civil, Environmental, and Geospatial Engineering, for entrusting me with the responsibility of teaching the MSc. in Construction Engineering and Management programme during my tenure as a student. Similarly, I would like to express my gratitude to Dr. Eng. Mdondo, the chairman of the Civil, Construction, and Environmental Engineering department, for granting me the opportunity to teach MSc Civil Engineering despite being a Ph.D. candidate. These opportunities significantly enhanced my confidence in conducting Ph.D. research and furthered my whole academic experience.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

AHP	Analytical hierarchy process
CD	Contextual Determinants
D-B-B	Design Bid Build
FIDIC	International Federation of Consulting Engineers
ISM	Interpretive Structural Modeling
JBC	Joint Building Council
NIE	New Institutional Economics
SMARTEC	Sustainable materials, Research & Technology Centre
MM	Market Mix Theory
TCE	Transaction Cost Economics
P	Practices
PAT	Principal Agency Theory
PPOA	Public Procurement Oversight Authority
PPROA	Public Procurement Regulatory Authority
SBP	Speculative Building Procurement
SDM	Systems dynamic modeling
SEM	Structural Equation Modeling
SNA	Social Network Analysis

ABSTRACT

One of the most important components of systems used to procure construction projects is payment to construction contractors. It is connected to the owner's financial obligations in the design-bid-build D-B-B system. For the owner, paying late, paying insufficiently, or not paying at all portend a favorable risk consequence, as evidenced by incurring a lower realization cost than actual. On the other hand, it portends a risk consequence that is undesirable. To better comprehend how contractor payment risks are initiated and propagated, it is necessary to analyze the interconnectedness nature. However, the connections between various payment risk causes are scarcely accounted for in prior literature. Secondly, little attention has been paid to the influence of contextual determinants on occurrence of payment dispute risks. Thirdly, literature has ignored the connections between application of incompatible procurement practices and occurrence of payment risks. In addressing these gaps, three objectives were tackled. First, the study assessed the influence of contextual factors on the co-occurrence of payment disputes. The second objective determined of compatibility of D-B-B practices and their influence on occurrence of payment risks. The third objective developed an interdependency network model for analyzing contractor payment risks. In tackling the first objective, contextual determinants were gathered from the literature. These were then tested with 29 and 22 payment dispute cases in the private and public sectors, respectively. Using social network analysis (SNA) techniques, such as degree, eigenvector, and Bonacich centralities, and structural hole measures, the results were quantitatively analyzed. In the second objective, incompatible practices were gathered through qualitative synthesis and then rated by 12 subject matter experts. This output was subsequently analyzed using SNA techniques including hierarchical clustering, structural equivalence, and Euclidean distance. In the third objective, incompatible practices were used to generate 12 propositions, which were then evaluated by 12 SME. This output was then used to develop an interdependency network model, which was analyzed using SNA techniques such as one-mode matrix, eigenvector and eigenvalue, and Labda partitioning. A major finding as pertains objective one was that site asset specificity reflected by the practice of separating legal ownership from contractual possession propagates most of the payment dispute cases. As a result, the study recommends an evaluation of the effectiveness of current payment default remedies in addressing the challenge of the inseparability of the site from the final product in order to protect the rights of contractors who have not been paid. A key finding from the second objective was that the linkages between certain D-B-B procurement practices and the owner’s cost saving strategies contributed to most contractor payment risks. As a result, the study recommends adoption equitable risk sharing practices such as social capital. Analysis of the interdependency network model revealed that 20% of the risk practices cause and propagate 80% of payment risks. To effectively reduce the majority of these risks, the study recommends adoption of Social Network Analysis (SNA) methods in identifying and determining the most significant payment risk causes from an interconnected perspective. The study focused on payment risks within the D-B-B procurement system. Therefore, there is need for future studies to explore occurrence of payment risks in other construction procurement systems.

Key words: Contractual practices, design-bid-build procurement system, social network analysis, payment risks, vulnerability assessment

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Without a doubt, the construction industry and associated projects are a significant contributor to economic growth in a variety of economies (Elhag et al., 2019). In Kenya, Giti et al. (2020) have correlated the sector with urban growth and development. Therefore, improved performance can be achieved by gaining a deeper understanding of the underlying causes of underperformance, such as payment defaults in the form of late, insufficient, and nonpayment to contractors (Mbachu, 2011; Mewomo, 2016; Tran & Carmichael, 2013). Also attributed to these causes are the effects of integrating independently owned resources based on inequitable procurement systems (Chakra & Ashi, 2019; Shabani & Nik-Bakht, 2021). One thing they all have in common is that they all exhibit an interconnected characteristic. This trait reflects a context of many interdependent elements and/or processes (Gao et al., 2018). In systems and network thinking (Pryke, 2017), interdependence is a crucial indicator (Davies & Mackenzie, 2014). Therefore, a better comprehension of complexity can provide an approach for managing the sources of underperformance issues, such as payment risks.

In the context of construction project procurement, "complexity" is characterized by structural interconnectedness and uncertainty (Qazi et al., 2016). First, the structure relates to the degree of fragmentation(Fellows & Liu, 2012), which refers to the significantly greater number and diversity of the system's components (Gao et al., 2018). Secondly, uncertainty is a measurement of the unknown information relative to the information available for decision-making during the realization process (Sha, 2011). This uncertainty exhibits a dynamic behavior in that it is greatest during the initial phases, gradually decreases throughout the realization sequence, and reaches zero at the final point (Winch, 2001). Therefore, indicators of complexity and the occurrence of payment risks are linked (Osipova, 2015). To better comprehend the problem of payment risks, it is necessary to first model its interdependent components.

Focusing on the interconnectedness characteristic is crucial because it enables the profiling of interdependencies as pathways between entities (Chinowsky et al., 2011; Zhang, 2016). In addition, the capacity to identify interdependencies can be used to determine the vulnerability status of a system (Guo et al., 2020a). Evaluation of a target's susceptibility to exploitation is crucial because it can reveal the level of susceptibility (West, 2014). Similarly, it can show how a loss for one side is a win for the other (Wu et al., 2011b). In contracting, procurement systems such as design-bid-build D-B-B are useful for revealing how one party's financial loss is another's financial gain (Naoum & Egbu, 2016). This study paid special attention to the D-B-B because it is the most prevalent (Elhag et al., 2019), but also the least efficient (Rajeh et al., 2015).

A construction procurement system can be conceptualized as an approach for integrating disparate resource owners through contractual arrangements that delineate responsibilities and liabilities, encompassing diverse processes and payment structures (Osipova & Eriksson, 2011). The D-B-B method, as described by Mehany et al. (2018), is considered the earliest approach and is sometimes referred to as traditional. One notable characteristic of this approach is separation between the design and the construction phases (Shabani & Nik-Bakht, 2021). Consequently, this necessitates the establishment of two distinct contracts between the project owner and the involved teams. As a result, the D-B-B approach is often linked to several indications of underperformance, such as cost and schedule overruns, quality nonconformance, and disagreements, mostly due to the absence of distinct role separations during the realization process (Elhag et al., 2019). Given the prevalence of payment dispute risks (Viswanathan et al., 2020), it is imperative to investigate the influence of D-B-B-associated practices on the occurrence of contractor payment risks.

One reason why the D-B-B is less inefficient than other procurement systems, such as design and build (Osipova & Eriksson, 2011), is that it allows one party to benefit at the expense of others. This research conceptualizes a financial profit or loss as an indicator of risk. Thus, the contractor payment risks of being paid late, receiving an insufficient amount, or not being paid at all indicate a financial loss for the contractor

(Mbachu, 2011) and a financial gain for the project owner (Wu et al., 2011b). In fact, the owner's primary objective is to acquire the constructed facility at a price that is less than the market value (Chang & Ive, 2002). To better comprehend the interdependence of the two risk sides, it is necessary to consider the interconnectedness context within which payment is embedded.

1.2 Rationale for the Study

First, the need for a deeper understanding of payment risks is predicated on the fact that they are interconnected with widely accepted project performance evaluation criteria (Griffiths et al., 2017). Indeed, the timeliness and completeness of payments to contractors are related to the cost parameters and, in turn, the financial obligations of the parties (Mbachu, 2011), as well as the quality and timeliness of the project's completion. This connectivity is also supported by studies of contractual disputes (Barman & Charoenngam, 2017). This is due to the fact that, in the absence of an advance payment method (Mewomo, 2016), prompt and complete payments are crucial to ensuring that the contractor's costs are reimbursed in full (Tran & Carmichael, 2013). Any delay, incompleteness, or nonpayment is related to the project's performance and, by extension, the industry level. Therefore, it is helpful to examine payment risks from a holistic viewpoint in order to gain a more comprehensive understanding.

Second, due to a relatively higher degree of fragmentation, construction procurement systems exhibit a state of interconnectedness. In fact, a system like the D-B-B includes payment subsystems. Nevertheless, the D-B-B’s components and contractual practices were borrowed from the standard product market system, which is characterized by manufacturing principles (Skitmore & Smyth, 2007). Consequently, assessing the degree of incompatibility between theoretical principles and practices can be used to identify incompatible practices. However, the existing payment literature, neither accounts for the connectedness nor determines the suitability of the borrowed logic.

Abdul-Malak et al. (2019); Andalib et al. (2018); Mbachu (2011); Peters et al. (2019); Zayed and Liu (2014), investigated various payment risk empirical aspects.

However, interdependencies between factors, processes, and elements, which is a critical contextual aspect has been ignored. Instead, they presume independency between entities. This assumption of independence is reflected in their methodologies. This is exemplified by Peters et al. (2019), who extracted the causes of late and non-payment concerns from the literature and then framed them as if they existed independently of one another. Consequently, it is challenging to deduce the causal paths. As interdependencies between entities (Zhou & Irizarry, 2016), for instance, they are crucial tools for identifying and linking causes to their effects (Wang et al., 2017). The inability to effectively link causes and effects can, for instance, increase the frequency of dispute cases.

This is demonstrated by five payment delay cycles and their corresponding FIDIC red book role versus obligation structures (Abdul-Malak et al., 2019). Multiple flowcharts were used to illustrate the connection between the actions of the employer, his contract administrator, and the contractor and the payment default. This suggests that the payment defaults were the result of a combination of various actions and/or inactions on the part of the involved parties. However, the used flow diagram technique has limitations, such as the inability to clearly establish cause-and-effect relationships (Pryke, 2012). As a result of this limitation, there are numerous interpretations regarding the allocation of liability. This is evidenced by the progression of decisions from lower forums of dispute resolution to higher forums such as arbitration and the courts (Barman & Charoenngam, 2017).

Thirdly, the existing literature on payment suggests a lack of connection between theoretical principles and the selection and application of contractual practices. This limitation is reflected in the inability to detect how the selection of particular procurement practices facilitates strategies such as deliberate payment defaults (Wu et al., 2011a). Such connections are the basis for the cost-saving practices that are masked by tactics such as late, underpaid, and non-payment. In fact, transaction cost economics determinants were used to link intentional payments with the owner's cost-saving strategies (Wu et al., 2011a; Wu et al., 2011b). For instance, the practice of determining the contract price prior to the start of construction assumes certainty (Malatesta & Smith, 2011). Nonetheless, the constructed facility did not exist at the time of contract signing. As a result of this misalignment, contractors are frequently held accountable for variances between the estimated and actual costs. Therefore, proper connections between the theoretical framework and practice can better explain payment risks.

In conclusion, the existing payment literature rarely explains the effect of combining agency and neutral roles on payment risks. In the case of the D-B-B, the engineering agent combines design, supervision, and contract administration and acts as a mediator between the owner and the contractor in the event of a dispute (Besaiso et al., 2018). The agent carries out the first two roles on behalf of the project owner, while the final two roles are assumed to be neutral (Zhu & Cheung, 2020). Nonetheless, this overlap typically contributes to a number of disputes, including those involving payment risks (Demachkieh & Abdul-Malak, 2019). As a result, there is no way to determine why some of the proposed payment default remedies are ineffective. For instance, it is unclear how the role of intermediaries can be characterized in the proposed blockchain decentralization payment default remedy (Hamledari & Fischer, 2021). To encourage the use of such remedies, it is necessary to illustrate a method of profiling the intermediary roles.

1.3 Statement of the Problem

The central problem addressed by this research is that there is an insufficient understanding as to how the interactions between contextual determinants and incompatible practices contribute to the payment risk problem to contractors. Contractual payments are a good example of this because prior research haven't paid much attention to their interconnectedness. This constraint can be seen in several ways. In the case of D-B-B (Sha, 2011), for example, the various payment mechanisms are incorporated within systems of integrating separately held resources into a construction project. Because of this, existing literature tends to investigate the payment issue as though it exists apart from its interconnected components, among other things.

As a result of inadequate understanding, how occurrence of payment risks is linked to other project performance parameters such as the cost, time, and quality tends to be ignored (Barman & Charoenngam, 2017). As a result, there is persistence of underperformance challenges related to cost and time overruns (Adam et al., 2017), quality nonconformance (Love & Matthews, 2020) and construction disputes (Cheung & Pang, 2014). However, these challenges can be reduced if interdependencies with payment risks are better understood.

The concept of contractual payments to contractors is linked to cost because it implies a cost expenditure to the owner. However, ignoring the linkage between payment practices and cost parameter has tended to obscure the two-sided viewpoints associated with risk consequences. The first side emphasizes the financial duties of the owners/clients. Consequently, it also reflects the right of suppliers like designers and contractors to be paid. As a consequence, it should come as no surprise that nonpayment is a significant contributor to cost overruns (Ahiaga-Dagbui et al., 2017). As a result of payment risks, time overruns are also common (Kazaz et al., 2012). Additionally, payment-related factors contribute to non-conformance in the quality of the product (Ye et al., 2014). Therefore, taking into account the interconnectedness among things would help us obtain a better understanding and in turn a reduction in cost, quality and time related consequences.

Ignorance of the interconnectedness character also contributed to the persistence of consequences of late, underpayments and nonpayment problem such as construction disputes (On Cheung et al., 2018). As a result, techniques of assessing contractor vulnerability to payment risks have remained ineffective. Vulnerability, as a state produced by a lack of adequate adjustment to fluctuations caused by the interactions of its interconnected elements (Fidan et al., 2011), enables the identification of consequences. In a procurement systems such as the D-B-B (Chang & Ive, 2002), vulnerability assessment demonstrates the extent to which its entities are compatible or not. Indeed, Ruparathna and Hewage (2015) observe that the lowest cost factor is the most frequently used criterion for contract award. However, failing to balance, for example, the desire to incur the lowest cost with the liability for variances between actual cost outcomes and those predicted ahead of schedule frequently results in a two-sided yet mutually inclusive consequence.

On the one hand, it exposes contractors to defaults in the form of late, incomplete, or non-payments (Wu et al., 2011a). Indeed, when payment defaulters, such as the project owner, pay late, pay less than due, or fail to pay at all, they earn an economic benefit in the form of lower procurement expenses. As a result, there is a link between the degree to which a system is interconnected and its susceptibility, as indicated by the mutual co-occurrence of multiple states. However, the failure to consider the interconnected character has hindered a more accurate analysis and thus a more complete understanding.

Despite the critical nature of connectedness, existing payment-related research follows a disconnected approach. For example, Abdul-Rahman et al. (2014) presuppose mutual exclusivity between payment default causes, impacts, and mitigation strategies. As a result, an in-depth understanding of how vulnerabilities in an interconnected system initiate and propagate payment defaults is neglected. As a result, ineffective planning and control techniques such as protocols and process maps are used. Indeed, protocols are the result of futuristic planning assumptions, whereas process maps are the result of diagnostic assumptions (Pryke, 2012). These assumptions are also included in other techniques, such as critical path analysis and its variants, and earned value analysis.

However, applications, such as Demachkieh and Abdul-Malak (2019), indicate that the interactions between the indicated contractual conditions and the events resulting in unpaid contractors shows a rather subjective analysis. Due to a lack of sequencing, the causal diagrams used to depict the contractual conditions and their consequences illustrate ambiguous grouping. As a consequence, their interdependence is not readily apparent. As a result, the decisions as pertains liability apportionment are subject to misinterpretation (Schenck & Goss, 2015). Consequently, it's unsurprising that the numerous payment-related dispute decisions made by, for example, the contract administration unit are subject to challenge in arbitration and ultimately in court forums (Barman & Charoenngam, 2017).

Another consequence is that the failure to recognize the interconnected nature of payment, contributes to the misalignment of perceived ineffective practices or strategies with effective ones, or vice versa. For example, Hamledari and Fischer (2021) study on payment blockchains is predicated on their potential to decentralize intermediary functions, hence mitigating payment defaults. However, their solution is based on earned value techniques (Hamledari et al., 2017), which presuppose linear functions. As a result, it lacks a mechanism for profiling intermediary roles. This situation has contributed to the application of less optimal payment risk mitigation measures, which in turn also reflects in consequences such as persistence of construction disputes (Abwunza et al., 2019) and quality nonconformance (Demachkieh & Abdul-Malak, 2019).

1.4 Objectives of the Study

1.4.1 The Overall Objective

The overall research objective is to develop an interdependency network model for identifying and analyzing construction contractor payment risks in the Kenyan construction industry.

1.4.2 The Specific Objectives

In addressing the overall objective, three specific objectives were formulated. Namely;

1. To assess the influence of contextual determinant on co-occurrences of construction contractor payment disputes, in terms of their lateness, underpayment and non-payment.
2. To evaluate the extent of misalignment between the standard product practices and design-bid-build construction procurement system settings and the resultant influence on contractor payment risks.
3. To develop an interdependency network model for identifying and analysing construction contractor payment risk vulnerabilities.

One thing that all three objectives have in common is that they are linked to each other. Practices were thought to be a byproduct of contextual determinants. Consequently, the second objective assessed the degree of incompatibility between practices and their connection to payment risks. The degree of incompatibility suggested their capacity to cause payment risks. Therefore, the third objective utilized the practices to construct a model of an interdependency network in order to identify and analyze construction contractor payment risk vulnerabilities.

1.5 Research Questions

Table 1.1 presents outlines the research questions and shows how they are linked with the objectives. It shows that each objective one is associated with five research questions, while objectives two and three are associated with four questions. Chapter four presents the result for these questions.

Table 1.1: Linking Research Questions to Objectives

Objective	Research questions
1. To assess the influence of contextual determinants on construction contractor payment risks.	1. How can the interconnectedness between contextual determinants be represented? 2. Which practices are linked to the contextual determinants? 3. How does the co-occurrence of payment disputes in the private sector compare with the public sector? 4. To what extend does the interconnectedness impact payment disputes? 5. Which contextual determinant propagates most payment disputes?
2. To evaluate the extent of misalignment between the standard product practices and design-bid-build construction procurement system settings and the resultant influence on contractor payment risks	1. To what extent does the standard product market and the D-B-B construction procurement practices dissimilar? 2. How are the dissimilarities between practices linked to contractor payment risks? 3. Which dissimilarity index initiates and controls most payment risks? 4. How can the incompatibilities between practices be re-aligned?
3. To develop an interdependency network model for identifying and analysing contractor payment vulnerabilities	1. How can the interdependencies between risk practices be represented? 2. Which mechanisms does the topological properties of the interdependency network model reveal? 3. Which interdependency initiates and transmits most payment risks 4. To what extent are contractors exposed to payment risks?

Source: Own formulation

1.6 Justification of the Study

This study is important due to its contributions to theory, methodology, policy, and practice. Each of these contributions is discussed briefly.

1.6.1 Contribution to Theory

The study contributed to the theory by bridging the research gap regarding an insufficient understanding of how the interconnectedness between contextual determinants leads to the co-occurrence of payment risks. It accomplished this by incorporating and contributing to the market mix MM, transaction cost economics TCE, principal agency PAT, and complexity theories of interdependence.

First, it emphasized the interdependence of the place, product, price, and promotion elements of the market mix. Due to the fact that this theory was developed for the standard product market system, the research revealed that its application to the procurement of construction projects tends to generate incompatibilities. These incompatibilities were identified by comparing the practices associated with contextual novelty interactions in the case of design-bid-build project procurement. The comparison uncovered eleven incompatible practices whose implementation increases payment risks. In construction procurement, for instance, it was discovered that the product and its site are inseparable. However, they are distinct in the standard product market system.

The study also drew from and contributed to transaction cost economics. This was demonstrated by conceptualizing transaction cost economic factors as contextual determinants, which was then validated by payment dispute cases. As a result, it became apparent, for instance, that practices associated with site and process asset specificity were associated with the highest frequency of payment disputes. In this way, the validation of how the site and process particularities contribute to the TCE is demonstrated.

Thirdly, the research drew from and contributed to the theory of principal agency. It did so by deriving contextual determinants from the asymmetric information dimensions of adverse selections, moral hazard, and hold-up. These factors were then utilized to derive, test, and evaluate incompatible practices. For instance, the design-bid-build FIDIC engineer's practice of combining agency and neutral roles revealed associations with the contractor's susceptibility to payment risks. In contrast to the PAT's premise that agents are more informed than principals, this study illustrated a situation in which the principal is more informed than the contractor (agent).

Lastly, the study drew from and contributed to the theory of interdependency-based complexity. It relied on the serial, pooled, and reciprocated dimensions of interdependence to demonstrate links with payment risks. Consequently, it became apparent, for instance, that the practices associated with these dimensions were related to the strategic actions of the project owner.

1.6.2 Contribution to Methodology

The study made two methodological contributions by addressing the inability of payment studies to assess the influence of interconnectedness on payment risk.

In the first place, it demonstrated that social network analysis and systems dynamic modeling methods SDM are complementary. This is due to the absence of standardized measurement metrics in SDM. This was demonstrated by Xie et al. (2019), who combined SDM with structural equation modeling techniques. This study demonstrated how SNA metrics such as the eigenvector, maximum flow betweenness, and Euclidian distances, to name a few, can be utilized to identify interconnected systems.

The study also contributed to modeling payment risk methodology. This was a response to the insufficient recognition of the interconnectedness context in previous studies related to payment risk modeling. This was demonstrated through the use of a three-step methodology. This methodology described and analyzed the interrelationships between the variables that influence payment risk.

1.6.3 Contribution to Policy and Practice

By addressing the gaps outlined in chapter two, this study contributes six policy and practical implications. These contributions are detailed in chapter five. In conclusion, the first is that it illustrates the link between strategies and practice selection. Second, the study establishes a connection between payment risk mitigation measures and the root causes of the issue. It also illustrates a method for rationalizing construction contracts. Fourthly, it illustrates a connection between proactive and reactive construction market positions and contractual inequality. Fifthly, the study demonstrates a less ambiguous method for identifying the interdependencies between causes and effects. The study concludes by demonstrating how the proposed blockchain decentralization measures can be complementary.

1.7 Significance of the Study

As a result of addressing the research objective, at least six benefits are demonstrated by this study.

1. The study demonstrates how to link practices and strategies by combining various theoretical concepts. Although Wu et al. (2011a) made an effort in this direction, their framework is limited to linear conceptualizations. By enlarging it, it is possible to expose an entire networked system, which explains why, for instance, the procuring side frequently prefers the D-B-B over other options. Practitioners can use this output to improve the quality of advice their contracting sides.
2. The study allows the profiling of associated strategies by determining the degree of incompatibility between practices. It is within this context that current payment default remedies can be evaluated. Indeed, Skaik (2017) suggests that various policy interventions such as mandatory payment statutes remain unachieved. This output can guide policy makers in assessing the efficacy of their solutions.
3. Another benefit is that this study illuminates the rationale for contract negotiations, which can be used to assess current contract practices. Although parties are free to contract according to their terms (Hughes,

2006), it asserts that role separation can help alleviate payment risks (Besaiso et al., 2018). Based on this output, contractors have a basis for negotiating certain contractual aspects.

4. The study also demonstrates how some contracting principles can deviate from the norm. For example, contractual privity is undermined by the FIDIC red book (Ndekugri et al., 2007), in which the engineer acts as the owner’s agent and an impartial role holder. Based on this output, contract designers can be able to evaluate appropriateness of some practices
5. The study illustrates a less ambiguous method of tracking and allocating liability by conceptualizing the interconnectedness of payment risk in terms of its causes and effects. Therefore, if applied, it can reduce the amount of subjective analysis reported by researchers such as (Abdul-Malak et al., 2019).
6. Finally, this study demonstrates that, in contrast to the procurement side's proactive posture, the contractor's reactive posture facilitates exploitation through payment defaults under D-B-B contracting. Both sides can use this information when making decisions.

1.8 Scope and Limitations of the Study

The scope of this research is outlined under the domain of investigation, theoretical, methodological and geographical coverage.

1.8.1 Scope of the Study

1.8.1.1 The Domain of Investigation

This study focuses on the risks associated with lateness, incompleteness, and underpayment in the construction industry. However, due to its greater interconnectedness compared to other industries (On Cheung et al., 2018), contextual factors and practices that reflect the role of owners and their consulting agents are also taken into account. The primary objective was therefore to model the resulting dependencies and use the results to determine how the problem originated and spread.

In comparison to other procurement systems, such as design and build (DB), the Design-Bid-Build (D-B-B) option is emphasized more in this study. It has been determined that the D-B-B is relatively inefficient (Rajeh et al., 2015), despite being the most prevalent procurement strategy (Naoum & Egbu, 2016). The inefficiency aspect is illustrated by obstacles such as adversarial tendencies and the ensuing conflicts (Sarhan et al., 2017). Indeed, payment-related defaults are significant contributors in both instances (Barman & Charoenngam, 2017). The observed frequency highlights the tensions between the negative and positive aspects of the risk outcome, as their occurrences indicate mutual inclusion rather than exclusion. For example, by incurring a lower price than the actual, the defaulting owner accrues a positive benefit, while the unpaid contractor suffers negative risk consequences. Consequently, the recognition of these paradoxical interdependencies provides analytical models.

1.8.1.2 The Theoretical Scope

This research is limited to a combination of concepts and arguments associated with transaction cost economics (TCE), principal agency theory (PAT), marketing mix theory (MM), complexity by interdependence theories, and network theories. There are variations among these theories, but their greatest benefit is that they provide an interconnected framework for modeling and analyzing contractor payment risk aspects. Their combinations were used to derive and explain contextual variables and incompatible practices. These were then utilized to establish various modeling entities and interpret the results. These deliverables demonstrated the application of explanatory and descriptive elements to the subject of payment risks. In addition, network concepts and metrics provided the required quantitative modeling and analysis tools.

1.8.1.3 The Methodological Scope

First, in terms of philosophical assumptions, this study is restricted to critical realist premises. According to critical realists, the reality is concealed within its contextual framework. Modeling is therefore one method for conceptualizing and revealing it. Such models provide a means for describing and analyzing the interconnections between system components. To that end, the study investigated, modeled, and analyzed payment risks from an interconnected standpoint.

In terms of research strategy, the study is limited to a combination of qualitative and quantitative approaches. In general, qualitative methods such as thematic synthesis and SNA quantitative methods were utilized. The SNA methods were further divided into micro-level and macro-level network measures, including degree, Bonacich, and eigenvector centralities, in addition to structural hole measures. In addition, partitioning metrics such as hierarchical clustering, structural equivalence, Euclidean distance, and Lambda methods are utilized.

The research employed a three-step methodology. The first was based on a case study approach and examined the impact of contextual determinants. These were validated using data from cases of payment dispute. In this research design, it became apparent that the interactions between contextual determinants produce practices that are not fully aligned with systems for procuring construction projects, such as the D-B-B. A comparative design revealed that the contextual determinants were created for the standard product market. As a result, in the second phase, the degree of their incompatibility was evaluated. Because the degree of incompatibility suggested a connection with payment risks, the third phase created an interdependency network model for analyzing payment risks.

The unit of analysis is an additional crucial parameter. In this investigation, it varied across the three phases. In the first phase of the research, the focus was on analyzing the private and public contextual sub-networks derived from payment dispute case data. In the second phase, the unit of analysis was a network of incompatible practices constructed using data from subject matter experts. In the third phase, interdependencies were the unit of analysis. Similarly, this was developed using data from subject matter experts.

1.8.1.4 The Geographical Coverage

This study was limited to the geographical boundaries of Kenya. The first data set was selected from a public portal case list at http://kenyalaw.org/kl/ that contains information on commercial disputes. It has unrestricted access and is therefore publicly accessible. The second and third data sets were collected from arbitrators of construction payment disputes within the geographical boundaries of Kenya. An important implication is that the findings of the study may not apply outside of Kenya.

1.8.2 Limitations of the Study

First, the scope of the study is restricted to its area of inquiry. As a result, emphasis was placed on developing an interdependency network model for analyzing the payment risks of construction contractors in Kenya. The model included interdependencies between risk organizational practices. The practices were derived from the observed interconnectedness of contextual determinants in the design-bid-build procurement system. The contextual determinants are not completely compatible with the D-B-B because they were created for the standard product market. Even though incompatible practices have been successfully identified, the level of compatibility with other procurement systems may yield different results.

Second, the geographic scope of the study is restricted to Kenya. In fact, the initial data set used to construct the model was derived from payment dispute cases found on the Kenya Law Review website. Similarly, the second and third data sets were obtained from the https://ciarbkenya.org/dispute-resolvers/ portal and provided by subject matter experts. This scope does not invalidate the findings, but they may not be applicable in other jurisdictions.

Third, the current investigation has certain methodological limitations. The study, for instance, utilized a combination of the typical and comparative case study research designs. This method enabled the identification and analysis of interdependencies between contextual determinants and incompatible practices. Despite the fact that the approach has increased comprehension compared to previous payment studies, it did not allow for statistical generalizations. Instead, the findings of this study were analytically generalized to the theories that guided the research. In addition, the utilized SNA technique provided an evaluation strategy for the modeling and analysis of interdependencies between node variables, which were identified beforehand (Solis et al., 2013). This therefore implies that it lacks a predictive perspective. To address this deficiency, an a priori theoretical framework was developed and then employed to identify contextual determinants and practices model variables.

Lastly, the payment dispute and the used subject matter data sets may differ from the actual payment records. Although the National Construction Authority's project registration records are a suitable source, actual payment information is subject to confidentiality restrictions. On the one hand, the constraints can be attributed to intentional payment risks, which point to a cost-cutting strategy used by clients and their consultants. Due to the fact that such a strategy can also reveal unfair contractual practices, it is possible to obtain realistic disclosure in payment dispute forums. Although records from arbitration could have provided the most relevant source, that forum is subject to confidentiality restrictions. On the other hand, due to the need for continuous workload, it may not be in the best interests of the contractor to disclose litigation history. Overall, the data set utilized in this study supported the findings.

1.9 Study Assumptions

This study was guided by five assumptions.

1. First, it assumes the co-occurrence of a risk dimension with two sides. This suggests that their co-occurrence is the result of uncertain events with both positive and negative outcomes. The downside is represented by the risks of late payments, underpayments, and non-payment. As a result of their occurrences, it is possible to acquire the manufactured product for less than its actual price. This risk translates into a financial benefit for the construction owner or client, and thus represents the positive aspect.
2. It is assumed that the interdependence of contextual determinants influences the co-occurrence of payment risks. These determinants were derived from the principal-agent, transaction cost economics, and interdependency theories. The payment dispute cases then validated their co-occurrences.

3. It is assumed that interactions between contractual practices cause payment risks. Consequently, there is a connection between practices and contextual determinants. In this context, practices are the result of interactions between contextual determinants.
4. It is assumed that the design-bid-build D-B-B construction procurement system is associated with a greater frequency of payment risk occurrences than other procurement systems. In addition, it is assumed that the practices associated with this system are not fully aligned with it because they were designed for the standard product market setting. Consequently, contractor vulnerability interdependencies are defined by the degree of incompatibility.
5. Lastly, it is assumed that the application of the mechanism of a contract administrator, who combines agency and neutral roles in the D-B-B, results in a project owner/client who is better informed than his contractors. Therefore, the influence of a contractor who was more knowledgeable than the owner was disregarded.

1.10 Definition of Key Terms

The terms used in this study carry the indicated meaning.

Asymmetric information: Due to the unequal distribution of information, one of the parties to a contract is more informed than the others (Xiang et al., 2015).

Blockchain: A method for illustrating a digital ledger that records all approved information exchanges (Abrishami & Elghaish, 2019). In the context of procuring a construction project, boundary objects and spanners are commonly used to facilitate information exchange between parties (Fellows & Liu, 2012). The contract document is an example of an object, while the spanners represent the contract administration roles.

Construction procurement: The acquiring of construction related inputs from suppliers in an appropriate quantity, at the best possible price, time and place (Ruparathna & Hewage, 2015).

Construction project: The process of transforming separately owned resources into a constructed facility (Chang & Ive, 2002).

Construction procurement system: An interconnected organizational representation between roles and obligations amongst project elements such as processes, procedures and practices (Ahn et al., 2017).

Interdependency: Refers to the connections or paths between node entities (West, 2014).

Independently owned resources: The term illustrates the process of integrating critical inputs such as the site, design and construction into a construction because they exist as legally and economically separable entities (Alashwal & Fong, 2015).

Network: a mathematical and graphical object, which comprises interdependencies between nodes (Borgatti & Halgin, 2011).

Project complexity: The term refers to the structural and contextual characteristics of a construction project. The structural dimension describes the interconnectedness between many and differentiated elements, while the contextual dimension refers to the dynamic uncertainty associated with the process of transforming inputs into outputs.

Practices: Refers to the activities and methods that emerge from the interdependence of contractual roles and theoretical principles (Austin et al., 2016).

Risk: Occurrence of an uncertain event, which is indicated by a financial gain to one side and a financial loss to the other (Qazi et al., 2020a).

Social capital: The concept refers to resources that are embedded within and across networks of individual actors and derived through elements such as reciprocation and trustworthiness (Gao et al., 2013). The relationships between actors is important because it can provide access to various opportunities.

Structural interconnectedness: It refers to the connections between variable or elements of a network or system (Easley & Kleinberg, 2010).

Transaction cost economics: A transaction is presumed to have taken place if a good or a service crosses a technologically separable interface (Winch, 2001). A technology refers to the production mode used for transforming inputs into outputs (Williamson, 1998). The interdependencies between the separated parts is determined by transaction frequency, uncertainty, asset specificity, opportunism and bounded rationality (On Cheung et al., 2018).

Uncertainty: Refers to the differences between the available information to make a decision and the available information (Sha, 2011).

Vulnerability assessment: This concept refers to the characteristics that describes a systems susceptibility to failure or inability to perform optimally (Fidan et al., 2011).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the literature. This is arranged under the main concepts the study setting, the payments sub-systems and the payment concept from an interconnected perspective. Other areas are a rationale for the new institutional economics thinking, an integrated theoretical framework, a review of the payment model related studies and the need for linking latent with patent factors with payment risks. It also frames the contextual determinants and incompatible practices. A section on the social network analysis perspective is also provided. Finally, it summarizes the knowledge gaps and presents a conceptual framework.

2.2 The Concepts Related to Payment Risks

2.2.1 Project Governance

Within the context of construction contracting, the term "governance" refers to the process of controlling interactions between project participants through the application of institutionalized practices (Winch, 2008). Due to their fragmented nature, divergent interests frequently pose a barrier to integration (Bygballe et al., 2013). Thus, forming a temporary project coalition is one method of reconciling conflicting interests. In a typical project coalition, the construction buyer acts as the client/owner and collaborates with a diverse group of suppliers (Pryke, 2017). While there are numerous procurement systems, in the design-bid-build option, the designer and contractor are the primary supply units (Winch, 2014). Thus, the purpose of such a structure is to control the interactions of differing interests.

With the need to control divergent interactions, one of the critical principles is that parties are expected to fulfill their contractual obligations in an appropriate manner (Hughes, 2006). This implies that the fulfillment of these obligations is inseparably linked to their liabilities. For instance, because the owner's responsibilities include providing the construction site and funding, they are inseparably linked to how suppliers such as contractors are compensated (Arditi et al., 2008). Payment certification in the D-B-B system is handled by the contract administrator (Ndekugri et al., 2007). However, the administrator is also responsible for design and serves as the first point of contact for resolving disputes between the owner and the contractor (Besaiso et al., 2018). This combination is paradoxical, as it frequently results in difficulties such as disagreements (Zhu & Cheung, 2020), which reflect misaligned interests. Given that the contractor's primary obligation is to construct and, as a result, to be paid, this type of governance structure tends to shift risk allocation mechanisms to the contractor's disadvantage.

As an illustration, interest divergence is associated with the economic autonomy of the parties (Haloush, 2020), who must nonetheless interact during the integration process (Bygballe et al., 2013). According to Rajeh et al. (2015), the misalignment is greater with the D-B-B than with other governance structures, such as design-build. The D-B-B system, on the other hand, is the most widely used (Chakra & Ashi, 2019). Chang and Ive (2002) attributed the D-B-B structure's paradoxical popularity to its ability to provide price certainty to the procuring side. This is reflected in the approaches, such as contract price determination prior to construction (Malatesta & Smith, 2011). This implies that the use of mechanisms such as fixed pricing presupposes the existence of a completed product. However, because the product does not exist at the time the contract is signed, Osipova (2015) observe a tendency for contractors to bear the risk of price variation. Indeed, Wu et al. (2011b) argue that owners use late, under, and non-payments as cost-cutting measures. Thus, the contractor's loss is the owner's gain, implying that the procurement structure chosen reflects the owner's strategic intentions. To better understand how payment is linked to strategies or measures, it is important to look at how the governance structure is designed first.

2.2.2 Construction Procurement System

The construction industry uses various procurement systems to integrate the fragmented units (Oyegoke et al., 2009). However, the concept means different things to different authors (Ruparathna & Hewage, 2015). This can be attributed to the recognition that it borrows its assumptions and practices from the interactions between the market and the manufacturing or production firm (Hobday, 1998; Winch, 2003). Because it thus combines practices of both the market and the firm, the resultant hybrid system is therefore subject to varied understandings (Sarhan et al., 2017). Moreover, a notable idea is that the practices are interconnected with their assumptions, and therefore a misalignment results to a two-sided rather than a single outcome. For instance, in the standard product market, the price provides a suitable governance mechanism (Winch, 2008). However, the adoption of the standard market price determination approaches has a potential of exposing the contractor to vulnerabilities such as payment defaults. On the other hand, such defaults portend cost saving strategies for the owner (Chang & Ive, 2002). However, as Motawa and Kaka (2009) observe, the pricing approaches and other components such as the payment methods are part of a procurement system. Thus, a better understanding is possible if the components are explicated within their sub-system and systems.

2.2.3 Structure and Functions

From a network thinking perspective, the structure can also refer to a network (Freeman, 2004). It is a mathematical and graphical object composed of points and their connections (Lee et al., 2018). Connections are typically denoted by lines, whereas points denote nodes or vertices. As Pryke (2017) notes, a critical concept is that a network is a representation of a system in which the lines specify the functions or roles of the structure or system. While roles and functions are synonymous, their interactions result in the formation of a structure, such as the D-B-B. Njie et al. (2005) demonstrate how the interdependence of various subsystems and other elements can help illustrate the contracting parties' distinct roles. For example, the owner, also known as the client or construction buyer, provides the construction site and financing, whereas the consulting unit is in charge of design and other intermediary functions such as payment certification (Besaiso et al., 2018). Additionally, the contractor is accountable for construction. This implies that the causes for payment defaults reflect the distinct yet interdependent roles. It has been noted that such contexts contribute to ambiguity in such areas as cause-effect attribution. However, a network of practice-related roles can be used to identify cause-effect relationships, which can also reveal payment risk vulnerabilities.

2.2.4 Vulnerability

A critical function of an interconnected structure is to facilitate vulnerability analysis (Guo et al., 2020a). Thus, vulnerability analysis is conditional on the system's interconnectedness (Lam et al., 2013). Payment is, in fact, a byproduct of the various processes and actions undertaken by the parties involved. The term "vulnerability" is frequently used in this context to refer to a two-sided outcome. To begin, it reflects the system's vulnerability and, consequently, its susceptibility to risks (Zhu & Mostafavi, 2017). Second, it acts as a proxy for resilience or robustness, terms that refer to a system's capacity to survive a disruption (Jiwei et al., 2019). Thus, observations such as the contractor's exposure to payment risks imply disruption of the contractor's payment flow and thus susceptibility. Chang and Ive (2002) argue that the D-B-B system is guided by decisions made by the owner and design agent, but not by decisions made by the contractor. Due to the interdependence of the systems, the result includes a cost-saving benefit for the owner, which serves as an indicator of robustness. For instance, the interdependence of elements such as fixed price tends to facilitate the owner's cost-cutting efforts, illustrating the owner's strategy of price certainty. Similarly, this interdependence demonstrates the contractor's vulnerability to payment risks. To gain a better understanding of payment risk exposure, it is necessary to identify system elements such as incompatible practices.

Skitmore and Smyth (2007) for example, used six distinct characteristics to compare the design-bid-build, design-build, and speculative building procurement systems. They noted, among other things, that the most critical factors were the pricing methodologies. This is because the difference between the cost of inputs and the price paid by buyers determines profitability or lose channels. Similarly, Chang and Ive (2002) investigated the effects of nine variables on the decision to use D-B-B, D-B, or other procurement systems. Cost/price certainty was rated as the most important factor because it influences the owner's procurement structure. Owusu-

Manu et al. (2018) discovered that payment administration processes contribute to the vulnerability of construction projects to corrupt practices during their procurement. This means that the vulnerability channels are determined by the system elements' selection and configuration. As a result, it is critical to be aware of interdependencies that could result in system vulnerability.

Additionally, Chang and Ive (2002); (Skitmore & Smyth, 2007), demonstrate that the most critical factor in selecting a procurement system is cost or price. They do not, however, take into account the impact of interconnectedness. For example, Chang and Ive (2002), assert that the quality parameter is unconnected to the cost and time parameters. By contrast, Pollack et al. (2018) demonstrate the "iron triangle" concept by observing that the connections between cost, time, and quality are inseparably linked. Indeed, Paton-Cole and Aibinu (2021) argue that disagreements over liability for quality nonconformance stem from a variety of factors, including deficiencies in design and contract administration. The D-B-B structure allows for the identification of cost variances between projected and actual costs through the design and its budgeted estimates. However, cause-and-effect methods are incapable of recognizing the interconnections between the various causes (Schenck & Goss, 2015). As a result, aspects such as disconnections, how they are bridged by intermediary roles and the influence of flow of payments is not sufficiently understood.

2.2.5 Practices

The concept of "practice" refers to the activities and methods that emerge from the interdependence of contractual roles and theoretical principles (Austin et al., 2016). This reflects formal and informal contracting rules (Sha, 2011). Formal means express, while informal means implicit. Express terms include the owner's obligation to make interim payments to the contractor upon certification (Walsh, 2017). An example of an implied norm is the owner's expectation that his consulting agent will not disclose confidential information such as financing deficiencies as a result of doubling in design and certification. In conclusion, the concept of practices is crucial because their interdependencies can determine whether a system is vulnerable or robust (Walsh, 2017).

2.2.6 Blockchain as a Technique for Mitigating Payment Risks

Multiple studies suggest that the concept of blockchain is applicable to the fields of construction engineering and management. They consider the term "blockchain" to be a method for illustrating a digital ledger that records all approved transactions (Abrishami & Elghaish, 2019). Consequently, each block is connected to the one that came before it, which is in turn connected to the genesis block (Hileman & Rauchs). As a result of this interconnectedness, a blockchain serves as an autonomous platform for the storage of data between divergent exchange participants. In the context of integrating independently owned resources into a construction project, boundary objects and spanners are commonly used to facilitate information exchange between parties (Fellows & Liu, 2012). The contract document is an example of an object, while the spanners represent the contract administration roles. However, in the D-B-B system, the documents are supplied by the designer, who also administers payments (Besaiso et al., 2018). This combination results in frequent conflicts of interest (Zhu & Cheung, 2020), which undermines the reliability of intermediary roles. Therefore, the blockchain concept is touted as a potential method for decentralizing the links, which exposes contractors to payment risks.

On a broad level, various studies have emphasized that there is a rationale for implementing the blockchain concept in the construction field. Specifically, Prakash and Ambekar (2020) note that the unequal information distribution and lack of trust associated with lump sum and lowest price considerations can be mitigated by adopting the blockchain concept. They attribute this development to greater transparency and traceability. In addition, since intermediaries such as contract administrators cannot be relied upon completely (Vivar et al., 2020), automating contracts with blockchain technology can ensure verifiability and reduce the likelihood of manipulation. Consequently, liability can be linked with the proper cause. According toAbrishami and Elghaish (2019), the use of blockchain technology can increase transparency, security, and control, thereby facilitating the tracking of financial transactions. Even though these arguments are persuasive, the adoption of blockchain technology could be accelerated by demonstrating a method for identifying and analyzing interdependencies. However, this is rarely the case in existing payment literature.

From the standpoint of contractual payments, the necessity of adopting the blockchain concept has been outlined. According toAhmadisheykhsarmast and Sonmez (2020), using blockchain technology to automate construction contracts can reduce payment defaults between payers and payees. They argue that the method can reduce mistrust and payment insecurity. As a solution to the unreliability of contract documents and contract administrators, Hamledari and Fischer (2021) advocate the use of blockchain technology in the payment system. It achieves this by ensuring contractual performance, minimizing intentional and unintentional errors, and relocating intermediaries to the periphery. This enhances observability, verifiability, and confidentiality. The observability property ensures that no party suffers or benefits from information imbalances. The verifiability feature provides an auditable evidence trail, which enhances the precision of dispute resolution. The confidentiality feature is designed to protect contracting parties from interference by agencies such as the FIDIC controlling engineer (Ndekugri et al., 2007). However, Hamledari and Fischer (2021) methodology is based on linear techniques that are incapable of establishing parallel and reciprocal interdependencies. The result is an incomplete understanding of the connection between intermediaries and payment defaults. Therefore, a better strategy should be explored.

2.3 Payment Sub-systems

From an interconnected perspective, payment is a subsystem within the larger procurement system, as opposed to a single entity. As a result, it includes payment mechanisms and methods (Njie et al., 2005). The selection of these elements is significant because it determines the type of procurement system (Sha, 2011). While Motawa and Kaka (2009) also reiterated this conceptualization, their conceptualization tends to disregard the underlying assumptions and interconnected nature. The assumptions are significant indicators of the mediating events(Fidan et al., 2011), and, among other things, useful for identifying system vulnerabilities. This can reveal the underlying strategies and effectiveness of the mitigation measures. For these reasons, it is essential to comprehend how and why the interconnectedness of the payment subsystem's components contributes to problems such as payment defaults.

2.3.1 Payment Mechanisms

The payment mechanism provides a means for pricing the product or service (Sherif & Kaka, 2003). This implies that it reflects the payment terms, whose purpose is to allocate responsibility for the difference between the contracted and actual project costs (Osipova & Eriksson, 2011). Consequently, the selection of a pricing strategy affects the allocation of risks between the owner and his contractors. Since contractors are not involved in pre-contract activities under the D-B-B system, unequal risk distribution is possible. By failing to make payments, paying late or underpaying, Chang and Ive (2007b) demonstrate that the owner can acquire the constructed facility at the lowest possible price, which exposes the contractor to risks such as payment risks. Thus, there is a connection between the selection of a pricing strategy, the procurement structure, and the owner's strategic objective.

In practice, a number of payment methods are available. However, the application by Motawa et al. (2008), tends to follow a continuum, with fixed price at one end and cost-plus at the other. However, the prior payment literature neglected at least two interrelated aspects. First, there is a limited effort to identify the theoretical principles upon which the mechanisms are based. Consequently, the compatibility of payment mechanisms with the context of construction contracting interactions is rarely evaluated. In addition, the effect of interconnectedness with other system components on the flow of payments was overlooked. In light of the outlined issues, it is necessary to investigate the payment mechanisms.

(a) Fixed Price/Lumpsum Contract

The fixed price, also known as the lump sum contract, emphasizes an approach in which the product price is assumed to be fully determined prior to construction (Malatesta & Smith, 2011). While Ruparathna and Hewage (2015) find that it is a central aspect of the D-B-B type of procurement system, it is based on unrealistic assumptions. For instance, it is contingent upon contractual completeness in terms of the advance availability of all information that will affect performance conditions (Chang & Ive, 2002). However, this assumption reflects the market for standard products. In such circumstances, the fixed price mechanism is appropriate because it can effectively coordinate the interactions between producers/sellers and their buyers (Crespin-Mazet & Ghauri, 2007). However, it contrasts with the interactions associated with the construction project procurement, particularly under the D-B-B option (Skitmore & Smyth, 2007). Consequently, such conditions allow the owner to shift the responsibility for cost variations to the contractors (Osipova, 2015). Thus, it is essential to identify and analyze how such vulnerabilities contribute to payment risks.

Eybpoosh et al. (2011); Qazi et al. (2020a) for instance, illustrate how the paths between risk causes and their triggers represent the channels for conveying a win or loss strategy. Winning in such strategies implies that the other player will lose (Wu et al., 2011b). Since the fixed price is a central component of the D-B-B procurement system (Ruparathna & Hewage, 2015), its prevalence among owners and their agents indicates its capacity to generate benefits for one of the parties. In the D-B-B option, the formulation of procurement components excludes contractors(Chang & Ive, 2002). Consequently, their design is anticipated to provide benefits to owners rather than contractors. In fact, Chang and Ive (2007a) demonstrated that disputes over liability for cost variations were linked to payment defaults to contractors. Chang and Ive (2007b) also demonstrated how some payment defaults by the owner reflect strategies for shifting liability for variations to contractors. The ability to transfer cost variation risks makes the fixed price mechanism a crucial component of the D-B-B option, which explains why it is the most preferred.

(b) Cost-plus

The key characteristic of the cost-plus method of payment is that the contractor is reimbursed for actual costs incurred plus a fee (Shabani & Nik-Bakht, 2021). The cost relates to the production inputs of materials, labor, and plant/equipment (Skitmore et al., 2006). On the other hand, the fee covers overheads, profit, and management, and it includes various mechanisms such as fixed, percentage, and gain/loss share (Turner, 2004). While the total cost is therefore the sum of the cost and the fee, an important premise of this method is that the cost cannot be precisely estimated prior to construction (Malatesta & Smith, 2011). This is based on the assumption that the future product does not exist at the time the contract is formed. Consequently, the variation risk should be borne by the project owner or buyer. However, the use of fee mechanisms such as gain or pain share tends to shift the risk of cost variation to the contractor. Due to these interdependencies, the contractor's susceptibility to payment risks is sometimes common.

As a result, the cost-plus mechanism is more aligned with standard product market features than D-B-B construction contracting. In the first scenario, the producer is responsible for the difference between the cost of inputs and the price paid by consumers (Malatesta & Smith, 2011). From a strategic standpoint pertaining to the owner's action plan (Eriksson & Westerberg, 2011), it indicates the path to profit or loss. In construction, speculative building procurement best reflects the use of the cost-plus mechanism (Skitmore & Smyth, 2007). A distinguishing characteristic of SB is that the developer owns the construction site. This feature assumes asset specificity in terms of the irreversibility of product inputs and the inseparability of the final product from its site. With these advantages, the owner is in a better position than the contractor to assume cost variation risks. Thus, the approach is suitable for cooperative-related procurement systems (Eriksson & Lind, 2016), in which relational attributes such as repeat business are deemed significant. However, the cost-plus mechanism is rarely used when the strategy is to avoid cost variation-related risks, as is common with the D-B-B option (Mehany et al., 2018).

(c) Measurement Mechanisms

The measurement or re-measurement mechanism is a hybrid between the fixed price and cost-plus mechanisms. The measurement mechanism is also known as unit price contract (Hyari et al., 2017). In contrast to cost-plus, the rates for each work item are established before the contract is signed (Turner, 2004). This is accomplished through the use of the bill of quantities, drawings with a schedule of rates, and bills of materials. In certain instances, these methods are frequently combined. While the combination provides some measurement flexibility, it enables the contract price to be determined precisely after a portion of the work has been completed or upon completion of the project (Davis et al., 2008).

The practice of paying for partial performance is crucial since it permits the contractor to be paid at different intervals (Vagadia, 2007). This contrasts with the standard market, where payment for the product is reliant on full rather than partial performance (Ive & Chang, 2007). As a result, exchange on the standard product market is instantaneous, whereas the construction process requires longer durations. Although the final payment method is designed to satisfy the entire performance requirement, the practice of progress payments suggests that the contractor is not selling a finished product that includes the site. Therefore, it is essential to adequately align these differences. A misalignment, on the other hand, portends consequences such as contractor cash flow issues (Peters et al., 2019), and hence portends shifting of contractual obligations and liabilities of the parties. For instance, if the contractor is not paid on time, is underpaid, or is refused payment entirely, this indicates that he has inherited the project funding obligation. Understanding this dependency is crucial for rationalizing contractual procedures and determining how they are linked to strategies or mitigation measures.

Another important aspect of the measurement mechanism is that the quantities determined at the time of contract signing are an estimate rather than an exact representation of the contract sum (Hyari et al., 2017). In other words, rates are frequently fixed while quantities are subject to re-measurement. While adjustment of rates through fluctuation clauses can be agreed upon in advance, the D-B-B procurement system frequently uses the measurement mechanism concurrently with the fixed price (Davis et al., 2008). Despite the combination, the approach is frequently misaligned with the uniqueness of construction transactions, as it assumes certainty rather than uncertainty (Malatesta & Smith, 2011). Consequently, various challenges, such as disputes over the value of work (Barman & Charoenngam, 2017), suggest that the context is inadequately understood. Therefore, assessing the compatibility of the payment mechanisms and recognizing how the variables are interconnected can lead to a deeper comprehension.

Due to the misalignment, the D-B-B system case demonstrates that measurement and certification are contract administration functions. This implies that the pre-contract role of measuring quantities cannot be separated from the post-contract certification of work done (Abdul-Malak et al., 2019). Due to the fact that quantity measurement is a part of the design function, the approach tends to contribute to risks such as cost variations (Steininger et al., 2020). This results in issues such as ambiguities in the allocation of liability as it relates to the precise cause and effect (Schenck & Goss, 2015). For instance, the engineer or any other lead consultant is responsible for the D-B-B design, specification, and determination of the tender quantities, which indicate the client's budget estimate. Flyvbjerg (2009) notes that the problem exemplifies the concept of strategic misrepresentation, in which actual quantities are purposefully understated. Consequently, the budget estimate before the project is initiated differs from the actual costs (Ahiaga-Dagbui & Smith, 2014). Therefore, the practice of combining design and certification portends ambiguity in the allocation of liability for cost variations.

Furthermore, combining the post-contract certification function with the pre-contract roles of design, specification, and contract quantities under the consulting unit undermines the impartiality assumption. This is because the consulting unit also acts as a mediator between the owner and the contractor (Besaiso et al., 2018). As a result, Ndekugri et al. (2007)note that the presumed impartiality is implausible. One reason for this is that the project owner or client hires and pays the consultant (Winch, 2001). Accordingly, his duty in this regard is to protect the owner before the contractor. Therefore, such incompatibilities will generate interdependencies between the owner's strategies and a susceptibility to contractor payment defaults.

2.3.2 Payment Methods

The payment methods are important components because they provide the procedures and methods for making payments. Three payment methods are widely utilized (Davis et al., 2008; Hyari et al., 2017; Odeyinka & Kaka, 2005). These include advance, interim or stage/milestone, and final payments, which include retention funds. These are characterized by interconnected procedures, such as how to seek payment and evaluation steps. Moreover, these processes are supported by numerous interconnected theoretical principles. El-Adaway et al. (2017a) illustrated how, from the FIDIC red book perspective, the application for payment is linked to the issuance of the payment certificate and, in turn, the payment due date. However, the demonstrated interconnectedness only illustrated the serial type of interdependence, ignoring the reciprocal and pooled typologies. Bygballe et al. (2013) suggest that a thorough evaluation of these typologies can be a valuable tool for assessing the appropriateness of adopted methods and associated practices. Due to an insufficient focus on interconnectedness, however, the current payment literature lacks a tool for evaluating the effectiveness of adopted payment methods and associated practices.

For example, one common approach in the standard product market is to determine the product price after production (Hobday, 2000). However, its application in construction contracting portends numerous incompatibilities. Other than the advance payment method, the other payment methods, such as interim and final payments, tend to reflect the standard market practices. However, because they are not fully aligned with the construction transaction principles (On Cheung et al., 2018), suppliers such as the contractor may be unaware of how vulnerable they are to defaults such as late payments, underpayments, and non-payment. In order to gain a better understanding, it is necessary to assess the suitability of existing payment methods within the context of the interconnectedness of their theoretical principles.

(a) Advance Payments

In the advance payment method, the contractor is paid prior to actual performance (Shash & Qarra, 2018). Specifically, this method of payment aims to finance the costs that contractors will incur for a specific contract (Motawa & Kaka, 2009). Indeed, Zhu and Cheung (2020) discovered that its application reduces the contractor's financial risk-bearing capacity. As a result, Shash and Qarra (2018) found that it also improves the contractor's cash flow profile. In the absence of cofinancing arrangements, the owner/client is responsible for financing the project. However, its purpose is frequently defeated when it is contingent on the contractor providing an advance payment guarantee bond from a financial institution (Motawa et al., 2008). On the one hand, the bonding requirement is significant because it protects the owner/payer against the possibility of the contractor's nonperformance (Shash & Qarra, 2018). Therefore, it is a crucial exchange mechanism.

In contrast, sometimes owners are required to issue payment bonds to contractors (Wu et al., 2008). However, given the nature of the construction industry, this is uncommon. This is the case, among other reasons, because there are typically more contractors/bidders than projects at any given time (Skitmore et al., 2006). Consequently, certain contractors are vulnerable to contracts that favor owners (Abdul-Malak et al., 2019). In the D-B-B system, contractors are required to respond to terms established by the owner (Crespin-Mazet & Ghauri, 2007), including the exclusion of advance payments. This implies that contractors must work before receiving payment. In contrast to producers and sellers of standard products, contractors sell construction services that cannot be separated from finished products (Arditi et al., 2008). This is because, with the exception of situations in which the contractor is also the site owner, as Chang and Ive (2007a) explain, the product cannot be separated from the site on which it was built. Understanding this context, despite its scarcity in the current payment literature, can provide a foundation for rationalizing contracting practices and procedures.

(b) Interim/Progress Payments

The interim or progress payment is a method by which the contractor is compensated for having completed a portion of the contract work (Fawzy et al., 2019). The method stipulates how periodic payments will be made contingent on the fulfillment of certain contract requirements. It is crucial because it accounts for the vast majority of payment dispute cases (Ramachandra & Rotimi, 2015b). Moreover, it is a significant source of cash flow for the contractor (Andalib et al., 2018), thereby determining the contractor's rate of performance and financial status. Consequently, the greater the magnitude, the greater the financing risks (Fidan et al., 2011), which also reflect the degree of cost savings or vulnerability. Therefore, it is necessary to gain a better understanding of how to receive interim payments or not.

According to the FIDIC red book, the contractor is required to submit a formal application to the engineer (El-Adaway et al., 2017a). The engineer is required to determine the amount payable and issue a payment certificate upon receiving the request. The employer/owner is obligated to pay the contractor within 28 days of receiving the payment certificate. These processes are noteworthy for their interconnectedness. However, the interconnectedness also implies separation and combination of roles. By supplying a design, for instance, the engineer demonstrates a pre-contract awareness of factors such as the owner's financial capacity. Furthermore, during the post-contract stage, the same engineer is in charge of payment certification and resolving disputes between the owner and the contractor (Besaiso et al., 2018). However, , the combination of agency and neutral roles tends to undermine the impartiality assumption (Ndekugri et al., 2007). Consequently, the interdependencies between outcomes such as payment defaults are typically obscured.

For instance, Abdul-Rahman et al. (2014) identified numerous causes of payment default, which, as Mbachu (2011) conceptualizes, are synonymous with risks. However, Peters et al. (2019) noted that the complexity of the causes was not sufficiently understood. Complexity is, among other things, defined by the degree to which system elements are interconnected (Davies & Mackenzie, 2014). In contrast, Peters et al. (2019) conceptualize variables as disconnected. For example, complex bureaucratic procedures, a slow approval process for variations, the cascading effect of economic changes, and ineffective process implementation were cited as the leading causes of payment defaults. However, this finding suggests that payment default is not due to a single cause but rather to interdependencies between the stated causes. Therefore, the clear default paths can be identified by understanding the process of making interim payments from an interconnected perspective.

(c) Final Payments

The final payment is a method whereby the contractor is paid balance payments upon achieving full performance or upon the termination of the contract. In addition, it is usual for full or partial retention funds to be processed with the final payments (Andalib et al., 2018). Because they are tied to the process of terminating contractual relationships, it is assumed that the two payment methods are final. Therefore, the final payment signifies the completion of a project or the replacement of the contractor. Despite being less important than interim payments, Ramachandra and Rotimi (2015b) assert that final payments are the second most important factor in payment-related disputes. Shash and Qarra (2018) established that it is also the most significant contributor to the contractor's negative cash flow. In fact, until the final payment is received, the cash flow of the majority of contractors is typically negative (Zayed & Liu, 2014). A failure to make the final payment can also result in delayed completion, diminished profit margins, capital constraints, and insolvencies (Omopariola et al., 2020). Therefore, these repercussions suggest that the failure to make a final payment is connected to a variety of outcomes. However, their severity can be reduced if the link between final payment risks is better understood.

In addition, the method of final payments provides a method for adjusting the actual outcome to the contract price (Fawzy et al., 2018). The application of the final payment therefore signifies the transfer of ownership rights. While this is comparable to practices in the standard product market (Skitmore et al., 2006), its application in its entirety to the context of construction contracting suggests some incompatibilities. For instance, since the constructed output cannot be separated from its site without adequate compensation, the completed work cannot be undone. Consequently, the practice of paying only after satisfactory performance can expose contractors to payment risks (Chang & Ive, 2007b). Payment based on satisfactory performance is feasible on the standard product market, among other reasons, because the boundaries between producers/sellers and buyers are distinct. In construction, however, production is contingent upon the buyer's or project owner's custom order (Ive & Chang, 2007). Due to the buyer's legal ownership of the site, contractors cannot deploy their contributions to another buyer/client. With this knowledge, existing and prospective payment default remedies should be matched to the characteristics of the construction transaction.

The connection between how progress and final payments are administered and pre-construction pricing approaches also has an impact on contractor payment risks. Common practice in fixed-price contracts is to determine the contract price prior to construction (Malatesta & Smith, 2011). Nonetheless, the practice often assumes that the final price will not deviate from what was promised when the contract was signed. The significance of this practice is highlighted by the emphasis on the unilateral use of protective measures, such as the procurement side not providing payment guarantees while requiring contractors to submit performance bonds(Sarhan et al., 2017). Employing a certifier who will first protect the owner's financial interests is also employed occasionally to guarantee that the contract price is not exceeded.

Skitmore and Smyth (2007) argue that the practice of tying future performance to owner-predetermined prices is not compatible with construction transactions, particularly when the D-B-B option is utilized. This method presupposes standard product market conditions in which buyer pays for existing products (Maher, 1997). Due to the fact that the product does not exist at the time of contract signing, Malatesta and Smith (2011) suggest that pricing approaches for construction should be rationalized with conditions such as uncertainty. On the other hand, assuming certainty conditions as reflected by the standard product market portends variation risks (Fidan et al., 2011) and disagreements over the value of work done (Mbachu, 2011). In light of these considerations, payment methods should be adapted to deal with uncertainty.

2.4 Conceptualizing the Payment Concept from an Interconnectedness Perspective

Although the payment concept is multifaceted, its nature cannot be divorced from its surrounding setting. To begin, it demonstrates from a basic contracting law perspective that promises between parties become valid only when a consideration in the form of payments is included in the exchange relationship (Hughes, 2006). Thus, consideration payments have an impact on the execution of other contractual aspects and, consequently, on the entire contractual relationship. As a result of the payment element's interconnection with other elements, it requires appropriate conceptualization.

The manufacturing or marketing perspective also illustrates the concept of interconnectedness. An emphasis is placed on the transformation of raw materials, such as land and labor, into finished products (Lai et al., 2008). Clients (buyers) are now required to pay suppliers (sellers) for factor inputs for this transformation. In this way, the system of exchanging independently owned resources is intertwined with the payment of the price (Arditi et al., 2008). Infrastructure and buildings are in fact built using a complex system of independently held resources, including land, design and construction (Fellows & Liu, 2012). It is however important to understand that the interactions involved are distinct from those found in a typical product market (Skitmore & Smyth, 2007). A variety of issues arise because of the interplay between assumptions and associated practices, including payment defaults. While in the standard market, prices are set after production, when it comes to construction, prices are set before work even begins. In order to understand why and how defaults happen, interconnected thinking is essential.

Interconnectedness is also demonstrated by the iron triangle of cost, time, and quality parameters (Pollack et al., 2018). In the shape of a triadic graph, it depicts the link between the three project metrics of cost, time, and quality (Heravi & Faeghi, 2014). One of its assumptions is that if one of the parameters changes, then everything else changes as well (Pryke, 2017) . When it comes to practice, this principle is often overlooked despite its obvious influence. Failure to pay attention to the influence of interconnectedness has led to a rise in issues such as cost overruns (Memon et al., 2012), delays in completion (Steininger et al., 2020), and unsatisfactory quality (Abas et al., 2015). For instance, that cost variations are a two-dimensional parameter that on the one hand refer to project owner/client expenditure and thus financial responsibilities (Love et al., 2015). When it comes to contractor expenses, however, an incorrect reimbursement of the cost parameter indicates a problem with the contractor's financial situation. As a result, the contractor's and the client's cash flow are intertwined because of the way payments are processed. Similarly, Love et al. (2016) found that financial or payment-related factors contributed to a delay in completion as a result of a time overrun. Funding and/or payment-related issues may also contribute to noncompliance with quality requirements (Ye et al., 2014). To put it another way, projects and the construction industry could be improved if better understanding of their interconnectedness is gained.

Additionally, underperformance issues such as construction disputes and risks are a manifestation of the interconnected nature of the industry. For example, Barman and Charoenngam (2017) find that many types of disputes are intertwined and a result of numerous factors joining together. Disputes over payments were the most frequent as well. Cheung and Pang (2014) created an anatomical diagram to show how disputes propagate contractual risks. Without upfront payments, financial risks are uneven, as shown, among other things, by the contractor's cash flow constraints (Zayed & Liu, 2014). Despite the fact that Mbachu (2011) linked risks to the contractor's cash flow, the major source of risk was determined to be the owners/clients. In this finding, the disagreement over who is liable for quality non-conformance was a significant factor. It is possible to gain a more thorough comprehension if the interconnectedness character is taken into account.

2.5 The Need for the New Institutional Economic (NIE) Thinking

The New Institutional Economics (NIE) is a multidisciplinary perspective that has not yet reached a consensus on its definition. However, it incorporates principles from economics, law, sociology, and organizational science (Joskow, 2008). Additionally, it clarifies institutional drivers, their linkages, and their effects on economic activity performance (Alberti, 2019) . These facets stem from research on the linkages between firms (Coase, 1937) and their interactions with other firms (Coase, 1960). With these concepts in mind, the NIE was developed to compare interactions inside firms and relationships with other firms in the market. Institutions, as a set of agreed-upon regulations, strive to contain the actions of people who represent their firms in order to control these interrelationships (Furubotn & Richter, 2008). Thus, NIE is not a theory but a framework for theoretical assumptions based on relationships.

Though there are variants such as behavioral economics (Gulati et al., 2005) and organizational economics (Mahoney & Qian, 2013) that address aspects of the NIE, both North (1991) and Williamson (1998) agree that it aims to evaluate institutions within the constraints of conventional or neo-classical economics, with some modifications. The adjustments are necessary since neoclassical assumptions did not take interaction determinants into account (Coase, 1998). Due to the neo-classical theory's inability to uncover interface determinants, certain institutionalized activities and associated procedures remained unexplained. The determinants are intricately tied to theoretical assumptions, practices, and strategies. As a result, NIE develops explanations that facilitate the comprehension of practices and strategies.

Within the sphere of construction economics and management, a mix of neo-classical and NIE assumptions has been used. Crespin-Mazet and Ghauri (2007) and Skitmore and Smyth (2007) demonstrate how the combination of neo-classical market mix (MM) theory and some NIE aspects is well-suited for investigating non-standard product market interactions. Those investigations demonstrate, among other things, that the execution of construction projects is an example of a non-standard system of interactions. As a result, a holistic implementation of MM without proper alignment with NIE-based interface determinants portends plenty of incompatibility issues. The use of NIE determinants such as asset specificity and hold-up by Chang and Ive (2007a), suggests that such issues are reflected in payment-related challenges. In this sense, fusing aspects of NIE with neo-classical assumptions enables the development of a comprehensive framework for studying the payment default problem.

2.6 The Quest for an Integrated Theoretical Framework

To adequately describe interrelationships, a comprehensive theoretical framework should be developed. Ngulube et al. (2015) explains that it entails combining concepts from diverse logics. As depicted in Fig.2.1, there are three interconnected institutional levels and a variety of theoretical principles whose objective it is to derive and explain relationship-based determinants and associated actions. Unlike

Williamson (2000), institutional levels, the longitudinal evolution over time elements are eased. Additionally, Williamson's fourth level is merged with the third level, as well as various parts of the marketing mix and resource dependency theories. Because the payment default problem is also multifaceted, the theoretical multiplicity approach is important. It represents economics (Chang, 2013), organizational structure in terms of procurement systems (Sha, 2011), and engineering as manifested in manufacturing practices (Bygballe et al., 2013).

of the construction procurement context entails a plethora of autonomous yet interconnected actors, including clients or owners/buyers of construction inputs, designers and contract administrators, and contractors, to name a few (Fellows & Liu, 2012). While the associated divergent roles portend difficulties such as competing economic interests, the payment phenomenon is also intertwined to the triadic parameters of cost, time, and quality (Ahiaga-Dagbui & Smith, 2014). This interconnection reflects additional consequences, including disputes (Viswanathan et al., 2020) and risks (Mbachu, 2011). With this backdrop in mind, payment phenomena must be viewed via a multidisciplinary lens, with underlying principles gathered and incorporated.

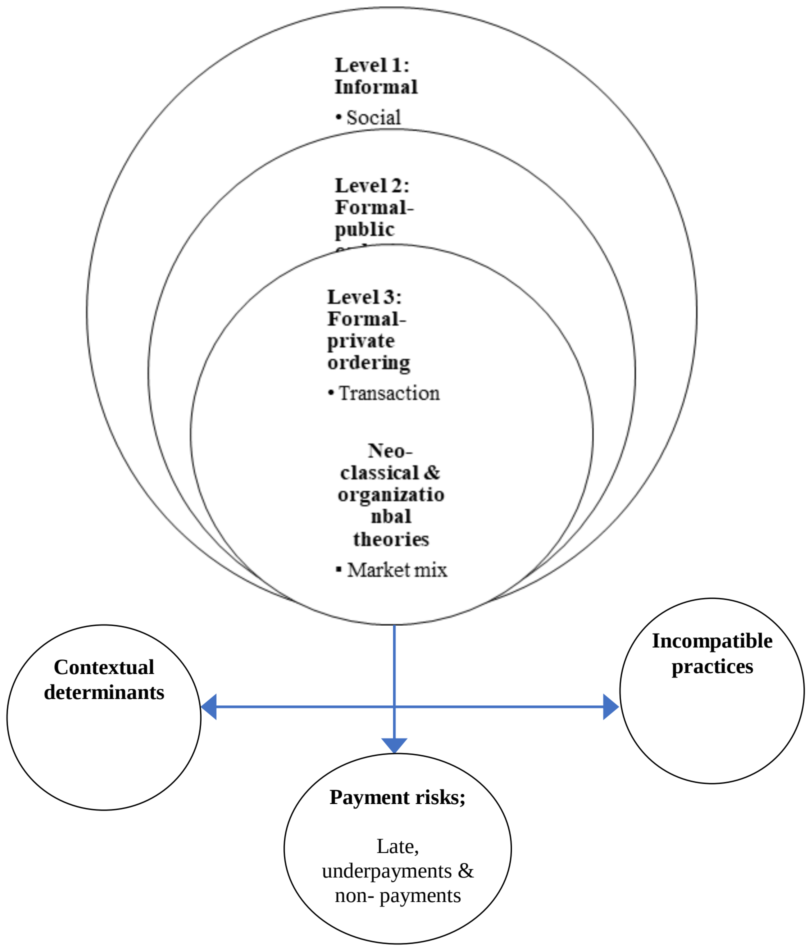


Figure 2.1: An Integrated Theoretical Framework

Source: adopted with modifications from Winch (2009)

The interrelated nature of the system is demonstrated in Fig.2.1. However, regardless of their perceived status, the three levels and their theoretical concepts are not static and exert influence on one another. Payment for construction work done under any of the realization systems is an institutionalized practice (Winch, 2009) and is thus a result of contracting relations. As a result, the payment default problem can be better explained by the aspects depicted in Fig.2.1. This is due to the relationships between the three institutions and their participants, as reflected by their respective theoretical principles. While these principles underpin practices such as contract price determination before the construction process (Malatesta & Smith, 2011), they also influence strategies as evidenced by payment default issues. Indeed, Chang and Ive

(2007a) revealed a link between the desire to incur the lowest possible costs and defaults such as late or underpayments. Additionally, the arrows show that the four levels of theories exert influence on payment risks, which are as a result of interactions between contextual determinants and contractual practices.

2.6.1 Informal Institutions and the Social Factors

In line with Williamson (2000), the 1st level embodies informal rules in the form of aspects such as taboos and customs whose mechanisms include trust (Tywoniak et al., 2007), and among other things depends on frequency of interactions. However, because construction transactions usually occur infrequently, the informal mechanisms from the social exchange theory have not been able to sufficiently moderate the self-maximizing utility assumptions of those involved (Steinle et al., 2014). But, Laan et al. (2011) find that higher levels of trust correlates with an increase in social capital that is useful in determining whether players can rely on the repeat business promises. Fu et al. (2015) also suggest that the social part of exchange relations can mitigate against the self-maximizing economic assumptions. In particular, Wang et al. (2018) find that a better fit between informal and formal institutions under an effective delivery system leads to better performance. An important commonality among these studies is that the transaction frequencies is a key moderating factor. On the contrary, Wu et al. (2011a) correlate the unreliability of future promises with the vulnerability of contractors to payment related defaults. Therefore, failure to appropriately align the contextual features with the informal institutions contributes to challenges such as payment defaults.

2.6.2 The Marketing Mix Theory

McCarthy (1960) developed the original marketing mix theory, which consists of elements such as place, product, price, and promotion. Among its distinguishing characteristics is that it was developed by manufacturers/sellers of standard market products. Thus, as a sales tool, its primary objective is to maximize sales (Arditi et al., 2008). Due to the fact that this context is distinct from that of procuring construction projects, Hobday (1998) suggests that appropriate adjustments be made. However, as a result of various misalignments, it frequently results in incompatibilities. As a result, contractors working under the D-B-B option face risks related to payment defaults. There is thus a connection between the extent to which contractors are exposed to payment risks and the marketing mix theory's incompatibility.

The MM has been applied in a variety of contexts, including the evaluation of construction procurement systems (Skitmore & Smyth, 2007), as well as the assessment of the extent of contractor marketing strategies (Arditi et al., 2008; Polat & Donmez, 2010). The common denominator among these studies is that the theoretical objectives are distinct from those of construction contracting. The primary objective of MM is for the producer to configure associated practices in such a way that the product remains competitive, as demonstrated by a positive margin (Skitmore & Smyth, 2007). The margin is a powerful strategic tool because it accurately reflects the difference between the product's price and the cost of inputs (Chang & Ive, 2007b). However, such a strategy is determined by the assumptions' interdependence. As a result, there are interdependencies among place, product, price, and promotion in MM (Polat & Donmez, 2010). Interdependences, on the other hand, act as vulnerability paths in the event of a misalignment.

To begin, place refers to the geographical space in which producers interact with their buyers (Skitmore & Smyth, 2007). Standard market producers and sellers can make distribution channel decisions based on this context. However, in construction transactions, the focus is on procurement routes or structures, and their suitability is determined by buyers of design and construction inputs, not sellers (Chang & Ive, 2007b). Failure to adjust for these differences can expose contractors to risks such as payment defaults.

Second, a product is a good or service that producers or sellers provide in response to market demand (Crespin-Mazet & Ghauri, 2007). In comparison, contractors (sellers) propose to construct futuristic products (construction projects) on the buyer's immovable property. Among other things, these distinctions imply a doubling of buying and selling on both sides. However, because the product is inextricably linked to its site, the situation has frequently been associated with power asymmetry (Zhu &

Cheung, 2020). As a result, control is skewed in favor of the legal site owner. Indeed, Abdul-Malak et al. (2019) attribute the contractor's vulnerability to payment defaults to a greater degree of owner control.

Thirdly, because the future product does not exist at the time of contract award, it portends a source of post-contract uncertainty on a variety of dimensions (Sha, 2011). Contracting uncertainty is one such dimension, and it reflects the difference between the actual outturn price and the tender price (Winch, 1989). As a result, payment of the price, which represents the actual value paid in exchange for the transfer of ownership, cannot be guaranteed (Skitmore et al., 2006). There is therefore a link between future performance and risks such as payments.

Finally, promotion in the market mix refers to the networked relationships between producers, suppliers, and buyers in the market (Crespin-Mazet & Ghauri, 2007). As a result, its strategies are designed to serve the producer's interests rather than those of the seller. This contrasts with construction promotion practices in terms of their buyer-determined procurement systems, the nature of which is mediated by the immovability of the site (Chang & Ive, 2007b). Taken together, Table 2.2 and 2.3 illustrates how these assumptions' interdependence results in incompatible practices.

2.6.3 The Role of Transaction Cost Economics

Coase (1937) proposed the transaction cost economics theory, which was later expanded by(Williamson, 1985). Its central argument is that, in addition to production costs, transaction costs—the costs associated with interactions between sellers and buyers—are also significant. If a good or service passes through a technologically separable interface, a transaction is presumed to have occurred (Winch, 2001). This premise is notable in that it emphasizes the importance of considering the effect of interdependence between exchange entities (Furubotn & Richter, 2008).

TCE frequently conceptualizes interdependence through the lens of transaction frequency, asset specificity, uncertainty, bounded rationality, and opportunism (Li et al., 2013). The first three reflect the transaction's properties, while the final two reflect the transacting parties' behavior. Rajeh et al. (2015) discovered that, when compared to other procurement systems, the D-B-B has the highest transaction costs, implying inefficiencies. Thus, by conceptualizing interdependence from a TCE perspective, one can gain a better understanding of consequences such as vulnerability to payment risks.

To begin, Winch (2001) defines uncertainty as the difference between the information that is required and the information that is available. As a result, the deviation implies that the characteristics of construction project procurement are distinct from those of standard market interactions (Skitmore & Smyth, 2007). For example, transactions in the former case are typically continuous, whereas in the latter, they reflect discontinuity (Chang & Ive, 2007b). Thus, the uncertainty link can be used to explain interaction frequency. To fully understand the effect of such deviations, it is necessary to take into account the interaction of various uncertainty dimensions and uncertainty with other TCE factors.

For instance, Winch (1989) dimensions uncertainty in terms of task, natural, organizational, and contracting uncertainty. The task dimension emphasizes the uncertainties inherent in continuous versus discontinuous production. Due to the reliability of historical data (Sarhan et al., 2017), it is possible to forecast the risks associated with the former with a reasonable degree of accuracy. However, due to the seasonality of their infrequent interactions, transactions in the D-B-B tend to have a one-off character (Skitmore & Smyth, 2007). This condition partially explains why certain contractors are vulnerable to accepting inequitable terms (Abdul-Malak et al., 2019). Natural uncertainty refers to the risks that come with the inability to obtain accurate weather and geological data. This explains why a structure such as the D-B-B, where design and construction are separated, is a significant source of variation (Mehany et al., 2018). Contractual uncertainty reflects the degree to which dissimilar entities which comprise the project organization are economically separated. This dimension explains why the D-B-B structure has a higher transactional cost than the design-build structure (Rajeh et al., 2015). Finally, contracting uncertainty demonstrates the impact of contractual incompleteness on the variances between the contract price and the actual outcome (Skitmore et al., 2006). This dimension explains the distinctions in approaches to price determination prior to and after production. However, the D-B-B approach ignores such distinctions and thus creates a vulnerability to payment risks.

Similarly, Barman and Charoenngam (2017) connected payment-related disputes to dimensions of decisional uncertainty based on the parties' behaviors. The term "decisional" categorizes disputes into substantive, strategic, and institutional dimensions based on the concept of "bounded rationality" and "opportunism's" interdependence. On the substantive level, available information is subjected to divergent interpretations, resulting in disagreements. Strategic uncertainty entails deception tactics and is thus one of the sources of variation risk (Flyvbjerg, 2009). Institutional uncertainty is a term that refers to divergent backgrounds that contribute to a lack of common understanding. Significantly, the various dimensions are intertwined and exist as a result of the interaction of transactional and behavioral factors. This means that, rather than assuming a single causality concept, payment default causations must be viewed as interconnected. Indeed, Peters et al. (2019) make the assumption that the causes, effects, and mitigation measures of payment default are unconnected. However, in order to accurately establish causal connections, it is important to realize that all of these factors are interconnected.

Second, the asset specificity principle is critical because it demonstrates the transformative effect of process interdependence (De Vita et al., 2011). For instance, before the contract is signed, the parties have the option of contracting with whomever they wish, as they exist as distinct fragments (Fellows & Liu, 2012). However, as evidenced by its integrative nature, the construction process demonstrates a transformational process. The contractor's resources are transformed into a constructed output during this transformation. The output is irreversible and inseparable from its site, as it is legally owned by the construction owner/client (Chang & Ive, 2007b). This is reinforced further by MM, which uses the term "site" to refer to the owner-defined procurement structure (Skitmore & Smyth, 2007). This aspect enables the owner to craft a contract that protects his economic interests, indicating his opportunistic nature. However, employing practices such as "work first and get paid later" presupposes an owner who is not opportunistic. Indeed, Wu et al.

(2011b) argue that without countermeasures such as advance payment practices, transformed inputs can be exploited as indicated by payment defaults.

Thirdly, TCE asserts that bounded rationality and opportunism can also have an effect on interdependence. Bounded rationality is a concept that recognizes that human agents are limited in terms of their cognitive, analytical, and information processing abilities (Turner, 2004). The result as (Cheung & Pang, 2014) note is contractual incompleteness indicated by incomplete information, and the unreliability of historical data occur. Contract documents, for example, are frequently used to regulate the relationship between the owner and contractors (Fellows & Liu, 2012). However, the extent to which they are incomplete may present an opportunity for the owner to acquire the constructed output at a lower cost than the actual. The result includes exposure of contractors to payment risks (Xiang et al., 2012). These arguments can among other things, explain the link between owner's strategies and the choice for specific contractual practices.

Finally, opportunism is a term that refers to strategies employed in order to obtain unjustified gain (You et al., 2018). This behavior implies that each party acts solely for his or her own benefit. As a result, it emphasizes the critical nature of evaluating the integrator's behavior in relation to contractual outcomes (Fellows & Liu, 2012). Under the D-B-B FIDIC structure, the integrator is an engineer who is in charge of designing, supervising, certifying, and resolving disputes (Besaiso et al., 2018). This combination, however, implies a conflict between agency and neutral roles. As a result, it, for example, allows engineering agents to make decisions that expose contractors to payment risks (Zhu & Cheung, 2020). Indeed, decisions such as undervaluation and under certification imply a connection to the owner's financial difficulties, implying opportunistic behavior. However, because existing payment studies, such as Peters et al. (2019), frequently overlook the role of interdependence, it is not clear how, for example, the owner's strategies are related to payment risks.

2.6.4 The Principal-agency

Principal-agency theory (PAT) was first proposed independently by Ross (1973) and Mitnick (1973); Mitnick (1974). Despite their fragmented contributions, they agree that because of the inherent conflict of interest between principal and agent, the primary challenge is to separate ownership from control of resources. Separation occurs when the hiring party, known as the principal, relinquishes control to the hired party, known as the agent. As a result, the principal-agent relationship is structured around the concept of the contract (Hughes, 2006). Additionally, it is the contractual principles that bind the TCE and PAT together (Pryke, 2012). Indeed, PAT views organizational entities through the lens of a treaty of contracts (Winch, 2008), whereas TCE views them through the lens of "contractual men" (Williamson, 1985). This connection emphasizes their complementarity, which is also relevant to understanding contractor payments.

In a D-B-B contracting system, the principal is typically the project owner, also known as the client or construction buyer, while the main contractor is one of the agents. There is also another principal-agency relationship as a result of the contract between the owner and the project integrator, who may be an engineer, project manager, or architect (Besaiso et al., 2018). Likewise, when upper-tier entities delegate portions of their responsibilities to subcontractors, a new set of contracts is created. In this context, PAT assumes a problem of unequal information distribution and divergent interests (Steininger et al., 2020). As a result, it is presumed that the agent is more informed than the principal (Schieg, 2008). However, Eriksson and Lind (2016) demonstrate that the converse is also true. However, the existing payment literature does not adequately address the relationship between an information-advantaged owner and the contractor's exposure to payment risks. Examples of practices that advantage the owner includes right to choose the contract (Yao et al., 2020) and contractor noninvolvement during pre-tender stages (Mehany et al., 2018).

Due to the unequal distribution of information, PAT is based on the information asymmetry principle (Schieg, 2008). According to it, one of the parties to a contract is more informed than the others (Xiang et al., 2015). As a result, the vulnerable party is subject to adverse selection, moral hazard, and hold-up risks (Xiang et al., 2012).

Adverse selection refers to the characteristics of privately held or exclusive information that is thus unavailable before a decision is made (Owusu-Manu et al., 2018). As a result, incompatible contractual partners are chosen, exposing some parties to risk. This is demonstrated, for example, when an owner unknowingly awards a contract to a contractor who lacks the necessary qualifications (Forsythe et al., 2015). On the other hand, Xiang et al. (2012) consider the absence of complete information about the owner's payment capacity and reputation prior to contract signing to be a source of risk for contractors. Thus, when an owner fails to pay a contractor, a shift in financing risks occurs.

Moral hazard occurs after the contract is signed, and it indicates a lack of motivation to guard against risks when protected from their consequences (Osipova, 2015). It occurs when a less informed party is unable to observe the more informed party's concealed intentions and actions (Steinle et al., 2014). For instance, the owner's inability to detect a contractor's substandard work suggests that the contractor is compensated for unjustified gain (Forsythe et al., 2015). Indeed, owners occasionally incur rectification costs following the expiration of the defect liability period. On the other hand, Eriksson and Lind (2016) observe that deliberate payment delays, underpayment, and non-payment demonstrate the owner's moral hazard because the contractor, for example, cannot observe the owner's financial risk-shifting strategies However, the payment literature pays little attention to the connection between the owner's moral hazard and the efficacy of payment default remedies. This has a variety of consequences, including risk misallocation practices.

The hold-up problem occurs when an advantaged party withholds information from a disadvantaged party (Schieg, 2008). As a result, the vulnerable party is subjected to unreasonable demands by the privileged party (Chang & Ive, 2007a). Notably, the concept emphasizes the effect of interdependencies between processes, which highlights differences between roles. Design deficiencies and change orders are common sources of variation in the D-B-B contracting structure (Adam et al., 2017). However, for some contractors, this presents an opportunity to increase their marginal gains, illustrating a bottleneck situation (Forsythe et al., 2015). On the other hand, the consequences, such as nonpayment or failure to certify without justification

(Abdul-Rahman et al., 2014), portend a variety of negative consequences for the contractor. Because the contractor's progress is contingent upon the owner's timely and complete payment (Andalib et al., 2018), the consequences such as late completions demonstrate the hold-up effects. As a result, the hold-up concept emphasizes the importance of recognizing interdependencies between causes and effects.

2.7 The Concept of Complexity by Interdependency

Interdependence is one of the characteristics of a complex system (Baccarini, 1996). A complex system is characterized by the interconnectedness of numerous and diverse parts. In this regard, interdependency provides a means of recognizing patterns of ties or connections, between units or entities such as the project owner/client, consulting firm, and contractor (Bankvall et al., 2010). Such connections also exist between entities such as construction trades sharing space (Wambeke et al., 2014). However, the degree of consequences posed by interdependencies between entities differs from those posed by interdependencies between individual units (On Cheung et al., 2018). As a result, it provides a suitable method for measuring aspects such as the magnitude of differences between causes and, thus, an indicator of vulnerability pathways (Fidan et al., 2011). Therefore, it's critical to comprehend the interdependency concept more fully in light of this context.

Thompson (1967) suggested a method for describing interdependencies. This method has been used to investigate a variety of facets, including interaction determinants that compare the characteristics of differentiation and integration (Winch, 1989) and the identification of incompatible practices (Bankvall et al., 2010). In addition, the concept has been employed to evaluate the integration mechanisms between disintegrated firms (Davies & Mackenzie, 2014), and to model the misalignments that contribute to ineffective project performance (Chinowsky et al., 2011). In this way, understanding the concept is crucial for identifying, modeling variables and performing subsequent analysis.

Other applications involve interactions between risk factors (Yang et al., 2018), construction accident causes, (Eteifa & El-Adaway, 2018) and institutionalized practices (Pishdad-Bozorgi et al., 2017). These examples demonstrate the significance of the concept of interdependence in a context of interconnectedness. Due to the fact that the payment concept is embedded and thus reflected by aspects such as contractual risks (Chen et al., 2020), disputes (Jelodar et al., 2016), and cost variations (Steininger et al., 2020), the property can indicate exposure to payment risks.

Thompson (1967), asserts that the concept of interdependence can be subdivided into pooled, sequential, and reciprocated dimensions. Payment defaults are the result of interactions between contracting-related contextual factors and practices, as depicted in Fig. 2.2. In this view, payment defaults facilitate the interdependencies between contextual factors and associated practices. On the basis of this conceptualization, it is possible, for instance, to link variations with payment defaults.

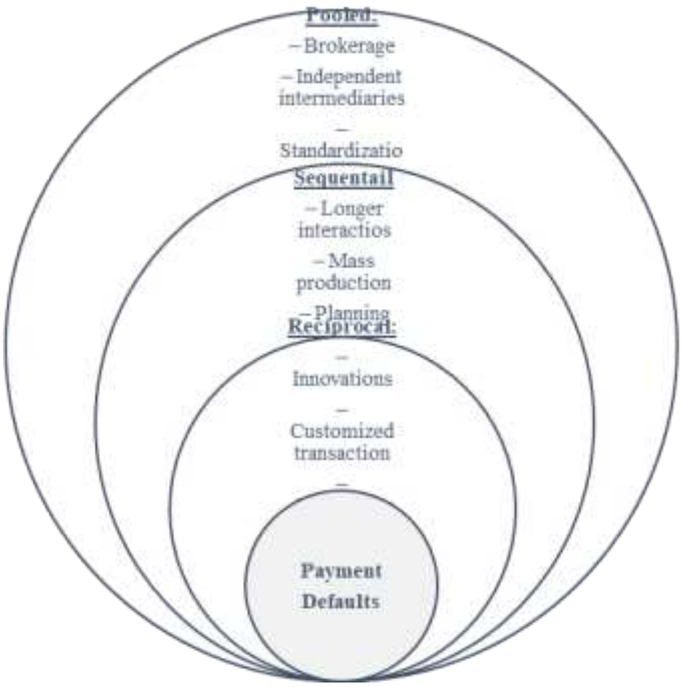


Figure 2.2: Interdependence Typologies Enabling and Being Enabled by Payment Defaults

2.7.1 Pooled Interdependencies

The pooled interdependence exists when there is interaction between independent units or entities that each contribute to a common goal (Davies & Mackenzie, 2014). Consequently, the concept of a "pool" implies an event that, among other things, permits concurrent activities or roles. A pool would be the realization of a construction project using systems such as design-bid-build. Due to the interactions between its components, it enables, for instance, the consulting unit to simultaneously provide design and contract administration services. This, in turn, establishes connections such as those between knowledge of owner financing strategies and payment defaults during and after construction. In such a co-concurrency, a feedback mechanism exists in which the forecasted cost plans are enabled by their design, which in turn enables the constructed outcome and thus determines whether payment will be administered late, underpaid, or denied. Although some sequential interactions are also involved, the observed duality of roles reflects a parallel approach to planning, whose implications include contractors' exposure to payment risks. The initiation and propagation of payment risks by the consulting unit, such as the designers, quantity surveyors, and project manager (Mbachu, 2011), can therefore be understood in terms of pooled interdependencies.

Consequently, practices such as combining pre-contract and post-contract phases reflect the concurrent planning mechanism. Nevertheless, their identification is supported by interactions between diverse theoretical assumptions. For example, the interdependencies between the project owner/client and contractor units are marked by competing economic interests (Ndekugri et al., 2007). In addition, the presumed neutrality of the contract administrator is not a reliable mechanism for mediating disputes. In cases such as the D-B-B, the owner's objective is to acquire the constructed facility at the lowest possible cost (Chang & Ive, 2002). In other words, the practice of combining design and payment administration suggests a connection with deliberate payment defaults.

The concept of boundary crossing is yet another example of pooled interdependence (Fellows & Liu, 2012). In this instance, boundary-spanning activities include the practice of contract and administration supply duplication. Here, the boundary activities between legally distinct entities function as a pool used to connect disconnected units. The mechanism for connecting disconnected entities is similar to that of a structural hole (Heng & Loosemore, 2013). For example, the concept has been used to describe the impact of bridging (connecting) roles as brokers on the process and outcomes (Di Marco et al., 2010). In addition, it has been used to develop a contractual model, which has been employed to analyze various contractual consequences (Chowdhury et al., 2011). Furthermore, by dimensioning structural holes into various positions, the involved risk initiating and transmitting roles, as well as their causes, can be profiled (Yang et al., 2020). These examples indicate a similarity between pooled interdependence, boundary-spanning activities, and the concept of a structural hole. The concept is therefore useful for profiling and explaining diverse outcomes, such as the initiation of payment default and transmission paths.

2.7.2 Sequential Interdependencies

Sequential interdependencies characterize situations involving directed interactions in which the output of one entity becomes the input of the corresponding entity (Bankvall et al., 2010). Where such entities are tasks between activities, the sequential interdependency reflects the concept of planning activities in advance of their construction (Chinowsky et al., 2011). Another example of sequential interdependencies is when the owner orders construction by first acquiring the site, then the design, and finally the construction (Bygballe & Jahre, 2009). The point is that one activity must conclude before the next can begin, which, among other things enables the identification of the shortest path. This principle serves as the foundation for common scheduling techniques such as the critical path method. Among other advantages, the application permits the identification of causes of delays between activities. This is illustrated in Abdul-Malak et al. (2019), in which flow diagrams are utilized to model and analyze the conditions that contribute to payment delays and underpayments. The concept of the shortest path corresponds to that of the shortest path length distance in studies based on the SNA.

The principles that underpin the concept of sequential planning are applicable in manufacturing settings (Bygballe & Jahre, 2009). This is due to the fact that they are characterized by interactions within the manufacturing organization, and their coordination can be achieved efficiently through the use of techniques such as process and protocol maps (Winch & Carr, 2001). These procedures entail converting input resources into output products based on their relative prices (Turner & Müller, 2003). Given the manufacturing organization's administrative rules, the production process is relatively predictable. As a result, changes in input prices can be adjusted to reflect the payable price by the buyer who is not involved in the production process configuration.

Consequently, the application of sequential planning principles enables the input/output to be configured and re-configured. This allows for the resultant margins to be controlled with greater precision. However, in contexts where uncertainty variability is relatively high, such as in the execution of construction projects, the implementation of sequential interdependence-based practices represents a formidable challenge. It impairs the ability to recognize, for instance, which causal combinations contributed to the cost variations. This circumstance portends difficulty due to the inability to identify the concurrent involvement of other types of interdependencies and their uncertainty variances. Therefore, it is necessary to explore a more comprehensive and context-sensitive methodology.

2.7.3 Reciprocal Interdependencies

The reciprocal type of interdependence depicts a situation in which each of the interacting entities, both enables and is enabled by the others, such that the output of each entity becomes the input for the others (Davies & Mackenzie, 2014). Despite the presence of pooled and sequential typologies, the context of integrating separated resource units into a construction project exhibits the greatest degree of reciprocal interdependence (Bygballe et al., 2013). In this context, advance and complete information are uncommon (Gulati et al., 2005), so a change in one component of a networked system is absorbed by the entire system through mutually adaptive response mechanisms (Ahn et al., 2017). From the perspective of the realization of a construction project, interactions exist between concurrent, sequential, and reciprocal interdependencies. As a result, it is ineffective to analyze each type separately. This is reflected, for instance, in the triadic network of cost/financing and quality factors that is typically used to describe the realization processes. This is also exemplified by the connection between the occurrence of consequences such as payment disputes and their overlapping with the cost, time, and quality parameters (Tabish & Jha, 2018). Therefore, it is essential to capture and represent the flows between entities based on their interdependencies network.

Recognizing the interconnectedness of the entire system is crucial because it provides a means of demonstrating how combinations of causes can initiate and transmit diverse outcomes. For instance, the SNA methodology was utilized to identify and analyze interdependencies that contributed to inefficiencies in the execution of construction projects (Chowdhury et al., 2011). As a result, it was feasible to realign the misaligned interdependencies through the implementation of appropriate actions. In addition, modeling a network of interdependencies can provide a means of specifying the sources of uncertainty at the system level as opposed to the individual level (Wang et al., 2015). Although the sequential interdependence-based principles are illustrated at the individual level, the actual execution of construction projects involves a variety of pooled, sequential, and reciprocal typologies (Bygballe & Jahre, 2009). Therefore, it is worthwhile to explore a context-sensitive approach.

2.8 Empirical Review and Isolation of Research Gaps

There is a great deal of empirical research pertaining to construction contractor payment risks. Mbachu (2011) utilized a multifactor method to evaluate the effect of payment risk causes on the cash flow of the contractor. The most significant influence, 24%, was attributed to the owner's responsibilities. Abdul-Rahman et al. (2014) and Ramachandra and Rotimi (2015a) evaluated the causes of payment risks and solutions using a ranking method and discovered that the owner's ability to pay contributed to the majority of risks. Peters et al. (2019) ranked the impact of late payments and determined that bureaucratic procedures have the greatest impact.

Using the Analytical Hierarchy Process, Zayed and Liu (2014) evaluated the effect of payment risk factors on the contractor's cash flow and found that paying late had the greatest impact. Omopariola et al. (2020) evaluated the causes of payment risks on the cash flow of the contractor and discovered that delayed payment was the most significant. This research also revealed that contractor capital lock-up was the most detrimental consequence.

The assessed studies have at least three significant limitations. First is the failure to evaluate the effect of the payment risk factors collectively. For instance, the role of the owner, which includes disagreements over the value of work performed and variations, is classified separately from the role of the Quantity surveyor, which includes the issuance of ambiguous contract documents (Mbachu, 2011). Nonetheless, variations are frequently the result of ambiguous contract documents (Viswanathan et al., 2020), indicating that the occurrence of a payment risk is due to the interdependencies of numerous factors. Therefore, it is impossible to determine the effect of the network on the occurrence of payment risks.

Another limitation is the failure to consider the role of the contextual principles underlying the adopted procurement strategy. Despite the fact that the selection of the construction procurement system has been linked to challenges such as project risks and disputes (Mehany et al., 2018), the existing empirical payment literature has not investigated the impact of the contextual factors underlying the occurrence of payment risks. Peters et al. (2019) identified bureaucratic procedures and slow approval of variations as the top causes of payment risks. Under the principle of information asymmetry (Eriksson & Lind, 2016), the two causes could be the result of the owner's concealed intentions of masking his financing insufficiencies, thereby demonstrating moral hazard. Understanding such strategies can be crucial for assessing the viability of proposed mitigation measures.

Thirdly, because a procurement system like the D-B-B incorporates the principles and practices of the standard market production system (Sarhan et al., 2017), the degree of their alignment or misalignment can contribute to project risks. For instance, determining the contract price prior to construction is consistent with the context of mass-market standard product production (Malatesta & Smith, 2011). Despite the fact that this is feasible because the exchange price is determined after production and is therefore characterized by certainty conditions, its application in the D-B-B construction system is not effective. This is reflected by effects such as claims and disputes (Omopariola et al., 2020), but their impact could be mitigated by reducing the degree of misalignment.

2.9 The deficiencies in the Existing Payment Model Related Studies

A model is a representation of reality that is typically expressed in text, visual, mathematical, or a combination of these forms (Ngulube et al., 2015). Using visual and mathematical network models, this study describes and analyzes the problem of payment default. It is believed that the concept of payment is embedded and, therefore, interconnected with other concepts. Concerns exist because the concepts associated with design-bid-build construction procurement systems are not fully compatible. As a result, the D-B-B procurement option is associated with more challenges, such as payment risks.

For instance, little consideration has been given to the impact of the presumed clear role separation between input suppliers and the final product on contractor payment risks. This is exemplified by the contractor selection practices, which are predicated, for instance, on interactions between the mass product manufacturer and input suppliers who are not part of the production organization (Elhag et al., 2019). In this context, the hierarchical producer is able to control, for instance, the prices of input supplies relative to the prices of the final product. This procedure aims to control the amount of returns from a profit or loss perspective. However, in the context of D-B-B, the application of this strategy in its entirety has numerous limitations (Osipova & Eriksson, 2011). Due to the fact that the constructed project does not exist at the time of contract signing, the practice of determining the product price prior to construction generates numerous incompatibilities and consequently risks such as late, incomplete, and non-payments. Therefore, there is a connection between the contractor's cash flow modeling and the problem of payment default.

In light of this context, Table 2.1 examines the nature of interdependencies in studies pertaining to existing payment models. This table shows that there are at least three drawbacks. One is that interdependencies are ambiguous and, as a result, not readily unrecognizable. The second issue is that the modeling of the identified interdependencies contains insufficient and unsystematic quantitative and qualitative operational details. Particularly lacking are the provision of an adequate level of description and the presentation of distinctions between interdependent entities. As a result, a review of the three aspects is provided below.

Table 2.1: Evaluation of the Previous Payment Modeling Related Studies

Empirical study	**Model input variables**	**Theoretical assumptions**	**Nature of interdependency**	**Analytical approach**	**Nature of key outputs**
(Andalib et al., 2018)	Planned and actual contract data	Uncertainty but which is unspecified	Independent, single-cause	Diagnosis of historical & simulations	Normally distributed and linear profiles
(Zayed & Liu, 2014a)	Payment default causes from literature	Uncertainty but which is unspecified	Independent, single-cause	Simulations & subject matter judgement	Normally distributed & linear profiles
(Motawa & Kaka, 2009)	Planned and actual contract data	Unspecified	Independent, single-cause	Simulations & historical data	Linear profiles
(Abdul-Malak et al., 2019)	Contractual payment conditions	Unspecified	Independent, single-cause & networked	Diagnostic	Flow chart profiles
(Carmichael & Balatbat, 2010; Tran & Carmichael, 2013)	Paid versus claimed amounts	Uncertainty but which is unspecified	Networked causalities	Diagnosis of historical & actual data	Clustered profiles
(Wu et al., 2011b)	Payment default causes from literature	Adverse selection & moral hazard	Independent, single-cause	Simulations & subject matter judgement	Tables of correlational analysis
(Xie et al., 2019)	Payment defaults cause effect	Uncertainty but which is unspecified	Interconnected feedback flow diagrams	Simulations, subject matter judgement & sensitivity analysis	Causal diagrams, linear & non-linear profiles
(Ahmadisheykhsarmast & Sonmez, 2020)	Planned and actual contract data	Integrator uncertainty but which is unspecified	Independent, single-cause	Simulations & subject matter judgement	Automated flow diagrams
(Chen et al., 2018)	Contract price data	Unspecified	Networked causalities	Diagnosis of historical data & simulations	Logarithms, visual networks & profiles

Source: Synthesized from the indicated sources

2.9.1 Unclear and Unrecognizable Interdependencies

The first observation derived from Table 2.1 is that interdependencies are unclear and unrecognizable in the majority of studies (Abdul-Malak et al., 2019; Ahmadisheykhsarmast & Sonmez, 2020; Motawa & Kaka, 2009). Notably, their method of presenting interdependencies relies on both process and protocol maps. From an engineering and business perspective, process mapping is a commonly employed technique for presenting product realization processes (Pryke, 2012). The approach describes the successive stages of the process. In the context of design-bid-build, these stages include pre-contract, construction, and post-construction. On the other hand, protocols are used to present simulations of future processes (Winch & Carr, 2001). The combination of process maps and protocols is an effective method for comparing what was planned with what actually occurred. In other words, it demonstrates a proactive and reactive diagnostic approach.

In practice, the use of process and protocol maps is demonstrated by planning, monitoring, and control techniques such as the critical path and earned value. This combination, in particular, enables predictive and corrective actions to be taken (Hazır, 2015). However, one of its major drawbacks is that the involved independent, but interdependent interfaces within and across organizational units are difficult to identify (Winch & Carr, 2001). As a result, the gain/loss enablers are not clearly visible along the leakage paths pertaining to intentional payment defaults. In other words, the intersections and channels that lead to defaults such as late payments, underpayments, and nonpayment are not easily identifiable.

As an example, a protocol of contractual conditions that affect payments was extracted from the FIDIC standard form of contract of the International Federation of Consulting Engineers (Abdul-Malak et al., 2019). The process flowcharts were used to correlate payment defaults with the actions or inactions of the parties involved. Additionally, Gantt flowcharts were used to present simulated scenarios from which conclusions were drawn. One noteworthy idea is that this approach underpins the sequential type of interdependence. It is, however, incapable of revealing the involved pooled and reciprocal interdependencies. In fact, the events described as contributing to the defaults indicate the presence of co-concurrencies and, by extension, pooled interdependencies. In addition, the use of a circular flow diagram to illustrate how each party contributed to the disputed payment scenarios highlights reciprocal interdependencies. Consequently, it is unclear how the interactions between contractual conditions and the listed actions and inactions contributed to the reported payment default scenarios (Abdul-Malak et al., 2019). To put it another way, the cause-and-effect interdependencies are not readily apparent.

Another example is the combination of an earned Value-Gantt-based technique and fuzzy techniques to demonstrate the interdependence of causes of disagreements over the value of work done (Demachkieh & Abdul-Malak, 2019). The fuzzy technique attempted to bridge the gap left by the earned value technique's inability to distinguish between the causes of payment defaults. In addition, a protocol map illustrating the factors that led to the payment withholding or set-off was presented. This method illustrated interdependencies by means of broken and unbroken lines (Demachkieh & Abdul-Malak, 2019). However, a significant limitation of this approach is that it is unclear whether the interdependencies between delayed inspection and defective work refer to pooled or sequential interdependencies. Furthermore, the reciprocal interdependencies in terms of which of the outlined variables resulted in the withholding or set-off are not apparent.

One of the justifications for a method that identifies a network of interdependencies in terms of their sequential, pooled, and reciprocal relationships is that it can reveal the influence of intermediary roles such as contract administration (Bygballe & Jahre, 2009). This realization has led to the development of payment risk mitigation techniques, such as blockchain technologies (Hamledari & Fischer, 2021). The method provides a means for decentralizing inefficient intermediaries. Notable about these studies is that they profile their modelling variables using time/cost-based process and protocol approaches. Nonetheless, this method can only provide an approximation of the sequential interdependence. The inability to decentralize inefficient intermediary practices stems from a failure to recognize pooled and reciprocal interdependencies.

A relatively higher level of subjectivity and opaqueness in terms of transparency, for instance, is a characteristic of ineffective practices (Hamledari & Fischer, 2021). In this context, confidentiality requirements can obscure the connection between pre-contract financial information and actual results (Andalib et al., 2018). This opaqueness, in turn, results in repercussions such as limited capacity to audit contractual data, non-observability and non-verifiability by third-party payment dispute resolvers (Chang & Ive, 2007a). As a result, the application of automated planning and progress tracking techniques is limited due to their reliance on the process and protocol map principles (Hamledari et al., 2017). In fact, their limitation is the inability to identify the full spectrum of operational interdependencies in a clear and unambiguous manner (Pryke, 2012).

To summarize, in order to effectively disperse intermediaries who, contribute to payment risks, their roles and interdependencies must be clearly traceable. Some studies show that a social network (SNA)-based approach is one of the most appropriate approaches (Chowdhury et al., 2011). Its primary advantage is its ability to illustrate how a process map and the protocol-based process can be represented as an interconnected system. A system like this is useful for identifying and analyzing interdependencies.

2.9.2 Unsystematic Grouping and Insufficient Description of Variables

Second, the existing payment model-related studies in Table 2.1 show that their method of grouping variables or entities makes presenting and identifying interdependencies difficult. This is due to the fact that they are based on conventional techniques such as process and protocol diagrams. This is reflected in the haphazard arrangement of subjects such as contractual conditions, as well as a level of analysis limited to a single causation. As a result, it is impractical, for instance, to model and analyze dissimilar interactions that occur when integrating separately owned resources for a construction project. Consequently, interactions between diverse project roles (Chowdhury et al., 2011) and the associated practices (Pishdad-Bozorgi et al., 2017) cannot be modeled and analyzed more effectively.

In addition, unsystematic grouping is linked to the inability to present cause-and-effect relationships beyond the dyadic level (Pryke, 2012). A dyad is the smallest analytical unit in a network structure, consisting of two entities linked by a functionally specified form of interdependencies (Lee et al., 2018). This implies that such an approach lacks the ability to capture the overall interconnectedness and consequently suffers from an unsystematic ordering of system entities. Eteifa and El-Adaway (2018) have for example overcome those limitations by relying on mathematical principles to present observed data in the form of matrices. It is now possible, for example, to systematically determine the default initiation and transmission patterns. However, this has not been possible with studies related to payment models, such asHamledari and Fischer (2021).

One of the consequences of inappropriate grouping and insufficient analytical level is overlap, which leads to less visible interdependencies. These limitations result from a lack of systematic sequencing of the model input variables. An example is the use of a cause-and-effect diagram to present and analyze the actions that resulted in the stated payment defaults (Abdul-Malak et al., 2019). In this method, it is difficult to determine, for instance, which of the five reported defaults occurred first and what the associated causal paths were. Specifically, the observed contractual conditions and their presented reasons for earned value deductions are unsystematically grouped and lack clear sequencing (Demachkieh & Abdul-Malak, 2019). Consequently, the associated findings are susceptible to diverse interpretations. In other words, payment dispute decisions that result from such an analysis tend to be subjective, which contributes to their rejection by certain parties. This would explain why some decisions made at lower levels of dispute resolution, such as arbitration, result in litigation (Barman & Charoenngam, 2017).

2.9.3 Scarcity of Theoretical Assumptions and Identification of their Linkages to Risk Practices

Thirdly, the payment model-related research presented in Table 2.1 hardly demonstrates the unreliability of future transactions. For instance, in the absence of advance payments, the work-first, get-paid-later practice implies that future payments are uncertain. However, with the exception of Wu et al. (2011b), the underlying theoretical assumptions have not been accounted for in the other payment model-related studies. Consequently, there is a mismatch between certain and uncertain practices and payment risks. This is reflected in the selection of inadequately effective mitigation measures (Skaik, 2017). Tables 2.2 and 2.3 suggest that one way to bridge this gap is to identify the connection between contextual determinants derived from theory and their incompatible practices. On the basis of such a connection, inappropriate contracting practices can be rationalized.

For example, Andalib et al. (2018)'s model utilizes historical and simulated data to predict the owner's bidding stage payment behavior. It aimed to predict the contractor's cash flow profile during the performance phases if the owner failed to make timely and complete payments. This model assumed that contractors have previous work experience with owners and are therefore able to access financial data. This implies that such a model is predicated on continuous interaction contexts, such as the speculative building procurement system (Skitmore & Smyth, 2007). In contrast, the design-bid-build procurement system is characterized by a context that is discontinuous or unique. Therefore, failure to align contextual assumptions with contractual practices can obscure risk pathways.

Furthermore, Andalib et al. (2018)'s model does not take into account a situation in which the project owner and the contractor are economically separate units. Such a context is characterized by self-interest and limited foresight (Sarhan et al., 2017), which highlights the unreliability of historical data to predict future outcomes. According to Table 2.2, such a limitation implies that future outcomes will be determined by factors such as institutional uncertainty. Inability to obtain the anticipated funds is therefore one of its indicators (Abdul-Rahman et al., 2014). However, this factor does not act alone, but in conjunction with others(Barman & Charoenngam, 2017). By identifying the interdependencies between contextual determinants and incompatible practices, it is possible to better explain the likelihood of payment risk co-occurrences.

In another instance, subject matter experts rated the factors deemed to contribute to payment defaults and then used those scores to develop a cash flow model (Zayed & Liu, 2014). Given variations in cash outflow and cash inflow, the model was able to simulate a variety of payment default effects. A significant limitation is that the factors were assumed to be independent of one another. In reality, payment risks are generated and transmitted as a result of the interdependencies of numerous factors. Consequently, it is difficult to determine which factor or link contributes the most variances to the cash inflow/outflow profile. In addition, the ranked factors are of a patent nature, so additional insight can be gained by uncovering their latent/contextual conditions. For instance, the most significant impact on the contractor's cash flow was attributed to a change in payment terms. Knowing whether this was a result of a hidden intent prior to the signing of the contract or an unintended type can help parties adapt to the situation. The contextual determinants outlined in Table 2.2 can bridge this gap.

Xie et al. (2019)'s models attempted to link late payment conditions with project progress status and, as a result, simulate appropriate interventions from a system thinking perspective. Their significant limitation is their inability to distinguish between manifest conditions and latent causes. Uncertainty regarding the owner's project funding sources is cited as one reason for payment delays (Abdul-Rahman et al., 2014). However, such information is not easily accessible due to asymmetrical risks (Xiang et al., 2015). Consequently, identifying contextual determinants can provide a means of matching the most effective risk mitigation measures with their underlying causes.

2.10 The Need to Profile Interdependencies between Latent and Patent Factors

In approaches to risk or defect causation analysis, the latent and manifest factors are typically profiled (Wang et al., 2021). Such profiling is essential because it enables the association of interdependencies between risk causes and their outcomes. Latent factors are distinguished by their propensity to remain inactive until activated by a network of other factors (Aljassmi et al., 2014). The trigger generates patent factors (Love et al., 2010b). This indicates that latent conditions have a concealed nature, whereas patent factors represent the observable effects of a problem. Such profiling can provide a more accurate analysis of cause and effect.

In the payment risk, causation scenario, numerous latent conditions are present. In the pre-contract phase, for instance, contractors are sometimes unaware of the project owner's financial capacity to meet his future performance obligations in terms of timely and complete payment (Xiang et al., 2012). This condition, however, tends to remain dormant until it manifests itself in consequences such as the owner's cash flow shortage (Abdul-Rahman et al., 2014). While such a connection suggests a type of sequential interdependence, the cash flow shortage is also related to other factors. This includes late certifications, under-valuations, and disagreements over the value of work done (Mbachu, 2011). In the case of design-bid-build, these factors reflect the responsibilities of a contract administrator. Pooled and reciprocated interdependencies are also involved because the administrator also supplies the design and is involved in the formulation of the contract documents. As a result, the approach of connecting a network of latent and patent factors suggests a method of attributing cause to its consequences.

In numerous construction-related studies, the latent-patent analytical approach stands out. It has been used, for instance, to profile the initiators and transmitters of construction defect generation mechanisms (Aljassmi et al., 2014) and accident causes in construction projects (Zhou & Irizarry, 2016). Additionally, the approach has been utilized to profile contractual risks and their vulnerabilities (Zhu & Mostafavi, 2017). A characteristic shared by these studies is the application of social network techniques to illustrate the interdependencies between latent and patent factors.

Other studies view contextual variables as latent conditions. For instance, Love et al. (2010a) connected transaction cost economics determinants to contractual disputes. They demonstrated, for example, how ambiguities associated with information differences between the parties prior to signing the construction contract led to post-contractual ambiguities. In another case, various uncertainty indicators were matched with their corresponding their patent causes (Zhu & Mostafavi, 2017). Consequently, contextual factors such as uncertainties are useful indicators of the latent factors associated with contractual practices, and this provides a method for identifying and analyzing the interdependencies with their patent factors.

However, previous payment literature has not paid a great deal of attention to the role of contextual factors nor considered their links to patent causes (Peters et al., 2019; Ramachandra & Rotimi, 2015a; Zayed & Liu, 2014). As a result, they frame payment risk analysis in an insufficiently clear manner. For instance, it is unclear why the project owner's inability to realize funding when sales projections are not met is an underlying sub-cause but the lack of capital to finance the project is not (Omopariola et al., 2020). Nonetheless, it is evident that the two are interconnected due to latent conditions such as adverse selection (Xiang et al., 2015) and the uncertainty associated with the unreliability of the project integrator's overlapping roles under the D-B-B procurement system (Ndekugri et al., 2007). Under adverse selection, the owner is able to conceal his financial insufficiencies, which is indicative of capacity misrepresentation. This implies that certain payment risks are initiated during the pre-contract phase and will manifest during the performance phases.

In addition, Peters et al. (2019)noted that payment default causes were as a result of insufficiently understood ambiguities relating to behavioral differences between the distinct but interdependent project parties. Consequently, they compiled 28 causal factors from the literature and ranked bureaucratic procedures as the most significant. This significance was attributed to the inadequate qualifications and diversity of the payment process administrators. However, one important drawback is their inability to identify the underlying behavioral uncertainties linked to bureaucratic factors. This shortcoming is demonstrated by the admission that future studies must take into account principal-agency related factors. In fact, the principal-agency theory characterizes latent conditions with elements such as moral hazard and integrating unit uncertainty (Pesek et al., 2019). The context of these contextual factors is provided in Table 2.2. In this sense, contextual determinants can provide a framework for conceptualizing the latent causes of payment risk.

2.10.1 A Framework of Contextual Determinants

Table 2.2 presents a framework of eleven contextual principles, their explanations, and corresponding indicators. Because of the dormancy character of their effects, the principles are classified as latent, whereas their indicators have patent conditions, which are more visible (Aljassmi et al., 2014). For example, moral hazard results from unequal information distribution between the project actors. As a result of this inequality, the information disadvantaged actor is exposed to contractual risks such as late and under payments. Unlike adverse selection related risks, moral hazard risks manifest during the construction stage and aim at extracting unmerited gain. However, main idea is that no contextual risk cause is independent from others. This implies that their likelihood of occurrence is characterized by a network behavior.

2.10.2 A Framework of Incompatible Practices

Table 2.3 presents a framework of incompatible practices. It compares the features of the standard product market and procuring of construction project under the design-bid-build system (Column 1 & 2). In the standard product market, the production process is for example continuous. This portends frequent interactions between input supplies, the hierarchical producer and the end-product buyers. However, on the other hand, the procurement of construction projects is characterized with discontinuous interactions. Because of contextual differences, the process and the end-product have divergent promotional strategies. Therefore, Column 5 shows that contextual differences are also linked to incompatible practices.

Table 2.2: A List of Contextual Determinants and their Constructs

Contextual/Latent determinant	Meaning within the construction contracting domain	Patent indicators	Sub-patent indicators
1. Moral hazard opportunism	Employment of tactics aimed at extracting unmerited gain from contractors during the performance stage	□ Late, underpayment or non-payment of duly completed work □ Demanding of kickbacks	□ Intentional misinterpretation and employment of the contract
2. Power asymmetry	The disproportionate process control in favor of owners owing to their dual role in production (selling) and buying functions	□ Underpayments	□ Disputes over unilateral deductions of value of work done due to alleged defective work □ Unfair termination allegations
3. Asset specificity	The irreversibility of the inputs incorporated into the end product because its ownership rights exclude non-owners even if they contributed to its construction	□ Work-first get paid later practices □ Disputes over the value of progress and final account payments	□ Project abandonment □ Bankruptcies of contractor firms □ Final account disputes
4. Substantive uncertainty	The inefficacy of payment remedies due to the misinterpretation of ambiguous and incomplete information	□ Ineffective payment remedies □ Lengthy and costly payment dispute resolution practices	□ Failure to comply with payment provisions
5. Hold-up	Ability of the owner or his agents to coerce the contactor into dropping its claims because the degree of its performance depends on timely and fullness of payments	□ Exclusion of advance payment terms □ Late and underpayments □ Slow progress by the contactor	□ Owner counter claims □ Failure to match progress with schedule □ Counterclaims over alleged delays
6. Institutional uncertainty	Failure to adapt to occurrence of unexpected events due to lack of shared understanding among the parties	□ Shortage of funding due to the unreliability of the projected cash-inflow sources such as poor sales of constructed units or withdrawal of some funding partners	□ Inaccurate owner forecasts, errors in design and contract quantities □ Inability by the owner to secure funding
7. Strategic/contract uncertainties	Contested liability for the differences between forecast contract price and the actual outturn price	□ Shifting of cost variation risks to contractors	□ Disputes over the liability for variations
8. Adverse selection opportunism	Misrepresentation of owner payment capacity due to unobservability of his true intentions during the contract formation stage	□ Non-disclosure of funding arrangements □ Large retention percentages	□ The nondisclosed intent that contractors will part finance the project □ Disagreements over the liability for abortive works
9. Integrator uncertainty	Unreliability of consulting agents owing to their doubling in design/cost planning and contract administration	□ Involvement of many and varied parties in the payment process □ Ambiguity of roles □ Incomplete contract document documentation	□ Disagreements over the liability for abortive works □ Delay in valuation and certification
10. Infrequent transactions in the construction market	The pre-contract contracting uncertainty caused by more potential contractors compared to the available tenders at any one given time	□ Unreliability of repeat business promises □ Low trust between contracting parties	□ Willingness to accept unfair payment terms □ Inability to learn from the past

Source: Synthesized from the indicated sources

Table 2.3: A Framework of Incompatible Practices

Mass product market	Construction project (D-B-B)	Latent event	Indicative consequences	Practice (P)
Column 1.	**Column 2.**	**Column 3.**	**Column 4.**	**Column 5.**
Continuous & voluminous production (Chang & Ive, 2007b)	Discontinuous production one-off production (Turner & Keegan, 2001)	LE1 LE2	Differences in product promotion strategies	1. Buyer/consultant resource allocation advantaged position 2. Buyer/consultant repeat business promotion technique disadvantages the contractor
The buyer and the producer are separate firms (Malatesta & Smith, 2011)	The buyer doubles as a co-producer and sellers also double in production (Crespin-Mazet & Ghauri, 2007)	LE3 LE4 LE5 LE6	A misaligned process control structure	3. Payment upon satisfactory performance endorses less contractor end-product control 4. The buyer co-production functions enable less contractor control of the process 5. Not matching output with sums paid enables payment defaults 6. Delimitation of site passion from its legal ownership weakens payment default remedies
The integration process is under unified ownership (Malatesta & Smith, 2011)	Supply and umpiring roles are blended (Turner & Keegan, 2001)	LE7 LE8 LE9	Integrator independence paradox	7. Deferring certification of work done exposes contractors to payment risks 8. Doubling in the supply of contract documents & certification 9. Centralizing communication under the consulting unit impedes flows
The production cost is a liability of the producer (Skitmore et al., 2006)	The tension between deterministic pricing diagnostic approaches (Skitmore & Smyth, 2007)	LE10 LE11	Inappropriate pricing approaches	10. Uncertainty avoidance 11. Visibility of fault depends on availability of symmetrical information

Source: Synthesized from the indicated sources

LE1 Adverse selection opportunism; LE2; Moral hazard opportunism LE3; Power asymmetry LE4; Asset specificity LE5 Substantive uncertainty; LE6 Hold-up; LE7 Institutional uncertainty; LE8 Contractual incompleteness; LE9 The opportunism of the integrator; LE10 Strategic misrepresentation E11 Boundary spanning

2.11 Interactions between Contextual Determinants and Practices as Interdependencies

As noted previously, vulnerability is measured through a system's interdependence. In a system, it is assumed that the sum of several entities is greater than the sum of their constituent parts (Fellows & Liu, 2012). Thus, a change in one entity results in a network effect (Herrera et al., 2020). These effects create system vulnerability or resilience, through interdependencies. In identifying interdependencies, the first step is to recognize the network entities as a system. In accordance with this, column 5 of Table 2.3 lists practices as network entities. These practices result from the incompatibilities between the mass market (Column 1) and the D-B-B (Column 2) contexts, which are mediated by the principles in Column 4. The resulting interdependencies are discussed in 11 thematic areas.

2.11.1 Adverse Selection vs Owner Resource Advantaged Position

To begin, Table 2.3 suggests that the incompatibility of continuous and discontinuous production is linked to contractor payment risks. Continuity reflects mass-production markets, while discontinuity reflects one-off nature of construction projects (Turner & Müller, 2003). Without adaptation, this variation results in fewer projects being put on tender than bidders(Skitmore et al., 2006). This imbalance is attributable, among other factors, to the adverse selection behavior that leads to the selection of contractors based on the undisclosed premise of their ability to cover the owner's funding shortfalls (Abdul-Rahman et al., 2014). This is reflected in unfair contract provisions, such as the lack of payment guarantees (El-Adaway et al., 2017a). Because of this market imbalance, contractors are in a disadvantaged resource position, which can expose them to payment risks.

2.11.2 Moral Hazard vs the Repeat Business Strategy

Second, Wu et al. (2011a) suggest a link between pre-contract trading imbalances and the contractor's willingness to accept unfair terms in exchange for repeat business. However, because some owners may wish to obtain the built product at the lowest possible cost (Chang & Ive, 2007b), the future promise may prove unreliable.

In addition to the owner's moral hazard, the need for work can also contribute to contractor risks (Skitmore et al., 2006).

2.11.3 Power Asymmetry vs Payment Upon Satisfactory Performance

Third, in the standard product market structure, the roles of producers and buyers are distinct (Malatesta & Smith, 2011). Nevertheless, some design-bid-build practices imply ambiguity. For instance, despite the owner's obligation to finance the project, working before receiving payment implies a transfer of financing responsibility to the contractor. This results in power imbalances between the parties (Zhu & Cheung, 2020). The notion of power is opposition provided by party A to counter the influence of party B (Richard & Emerson, 1976). Power indicators include sanctions, whose effects reflect a shift in bargaining positions(Chang & Ive, 2007b). For instance, the exclusion of advance payment while retaining the ability to determine the amount to be paid implies greater owner control over the final product. Therefore, less control over the final product makes the contractor more vulnerable to payment defaults.

2.11.4 Asset Specificity vs Doubling in Buying and Co-production

Fourthly, in addition to end-product control rights imbalances, Crespin-Mazet and Ghauri (2007)suggest that the doubling of production and purchasing tends to result in process control imbalances. This imbalance stems from site ownership. Thus, the transformation of the contractor's resources into a project owner-owned site creates irreversibility, which is consistent with the effect of asset specificity (On Cheung et al., 2018). This is reflected in outcomes such as unjustified contractor termination and replacement (Chang & Ive, 2007a), which suggest a connection with financing burden reduction strategies. Therefore, the doubling of production and buying through a combination of site ownership and financing suggests unbalanced process control, with contractor exposure to payment risks.

2.11.5 Substantive Uncertainty vs not Matching Sums Paid with the Actual Outturn

Fifth, payment defaults are sometimes used to shift variation liability when product and process rights are concentrated with the owner (Chang & Ive, 2007b). Consequently, contractors frequently face cash flow difficulties (Shash & Qarra, 2018). As a result of missed contractual deadlines, a connection is typically established between lack of diligent progress and performance breach (El-Adaway et al., 2017a). However, since some contracts prohibit remedies such as decreasing the rate of work, substantive uncertainty tends to make contractors vulnerable(Barman & Charoenngam, 2017). This concept demonstrates how a skewed interpretation of contractual terms can lead to liability misallocation and, consequently, payment risk.

2.11.6 Hold-up vs Delimiting Site Possession from its Legal Ownership

Sixth, in addition to the vulnerability due to the link with end-product and inseparability from its site, there is also a connection with the practice of separating site possession from legal ownership. Typically, the owner of the construction retains legal title, whereas the contractor retains possession. However, contractual possession does not grant legal ownership to a contractor. Therefore, if the contract is terminated, the unpaid contractor is at risk. The level of exposure is determined by the presence of the hold-up condition, which is defined as the level of irreversibility indicated by the amount of unpaid sum and opportunism (Chang & Ive, 2007a). As a hostage-taking tactic, it explains how process imbalance affects payment default remedies. As a result, other than the mechanic lien (El-Adaway et al., 2017a), the current remedies for payment defaults are limited.

2.11.7 Institutional Uncertainty vs Deferred Certification

Seventh, the internal operations of mass market firms are typically governed by their intra-relationships (Xu, 2011). Because of administrative authority, the context is more cohesive, and thus there are fewer disputes. In contrast, D-B-B cross relationships suggest opposing economic interests (Winch, 2001), indicating a lack of similar understanding. For instance, the position of the engineering agent suggests a variety of paradoxical interdependences (Besaiso et al., 2018). For instance, the engineer is responsible for both design and certification. This combination creates unequal information distribution and opaqueness, which hinders common understanding(Ahn et al., 2017). This context is explained by institutional uncertainty (Barman & Charoenngam, 2017), which highlights contextual differences. Thus, ignorance of events like owner-related unanticipated variations and inaccurate cash flow forecasts (Abdul-Rahman et al., 2014) portends contradictory interpretations. As a result, suppliers such as contractors are frequently exposed to payment risks.

2.11.8 Contractual Completeness vs Doubling in Design and Certification

Eighth, the lack of consensus is also attributable to the belief that the design's cost estimates accurately reflect the final cost (Malatesta & Smith, 2011). Nevertheless, due to limitations such as imperfect foresight, which leads to contractual completeness (Turner, 2004), the accuracy of cost projections is occasionally overly optimistic. Imperfect foresight indicators include imprecise design specifications and inaccurate cost forecasts (Cheung & Pang, 2014), which are also linked to under-certifications (Fawzy et al., 2019). Therefore, these interconnections suggest a defense against liability for negligent advice and, as a result, contractor payment risks.

2.11.9 The Opportunism of the Integrator vs Impediment of Payment Flows

Ninth, there is another link between the contract documents and the engineering agent's certification (Besaiso et al., 2018). However, the opportunity principle states that agents will act in their own self-interest. Indeed, some construction projects provide engineering agents and contractors with opportunities to collude against owners (Le et al., 2014). However, contractors are often blackmailed because they don't fully cooperate with engineers, resulting in delayed certification and undervaluation (Shash & Qarra, 2018). These observations suggest that there is a link between the engineering agent's rent-seeking behavior and payment risks.

2.11.10 Strategic Misrepresentation vs Uncertainty Avoidance

Tenth, payment risks can be influenced by the pre-contract situation, in which the owner and engineering agency are more knowledgeable than the contractor. In fact, the engineering agent's primary responsibility is to safeguard the owner's best interests (Winch, 2001). As a result, anticipated costs are deliberately understated (Flyvbjerg, 2009). This is demonstrated by actions like under-certifications, which indicate manipulation to align work value with pre-contract strategy. This is illustrated by factors such as initiating projects without adequate funding (Tran & Carmichael, 2013) and opportunistic counterclaims against alleged substandard quality. This suggests a link between the procuring party's informational advantages and the contractors' exposure to payment risks.

2.11.11 Boundary Spanning vs Poor Visibility of Fault

Lastly, a payment risk connection is established when the engineering agent serves as a mediator between the owner and the contractor (Besaiso et al., 2018). Moreover, if the dispute cannot be settled, it is escalated to arbitration and court proceedings (Jagannathan & Delhi, 2020). However, the precision of the determination is contingent on the sufficiency and dependability of the submitted documents (Zhu & Cheung, 2020). In a D-B-B setting, the engineering agent holds these documents on behalf of the owner. However, due to the need to protect the owner's interests first (Winch, 2001), sensitive information may be withheld. Consequently, the (arbitrator or court's) ability to determine who is at fault is sometimes limited. Therefore, the bridging position of intermediary roles (Fellows & Liu, 2012), can reduce the quality of the third party's decision, thereby increasing the contractor's exposure to payment risks.

2.12. The social Network Analysis (SNA) Approach

This section presents the SNA approach. It is organized under the historical overview, the SNA concept, feasibility of SNA in the construction engineering and management field and an overview of the SNA metrics and concepts subsections.

2.12.1 Historical Overview

The perspective of social network analysis (SNA) has emerged as a multidisciplinary endeavor (Armstrong et al., 2013). This implies that it draws from a wide range of disciplines, including graph mathematics, physics, network science, and social sciences (Prell, 2012). As a result of this diversity, previous historical accounts have been organized according to considerations such as the geographical locations of authors and their institutions (Freeman, 2004), methodological advances (Scott, 2000), and the concepts and metrics that constitute SNA (Wasserman & Faust, 1994). Therefore, there is no point in reiterating similar accounts; instead, this section provides a brief overview of notable pioneers and a synopsis of subsequent developments.

The SNA can be traced back to a handful of influential pioneers. One of these pioneers was Leonhard Euler, who in 1941 used graphical mathematics to solve a practical problem from a network perspective (Perez & Germon, 2016). In this instance, Euler represented Königsberg, currently known in Russia as Kaliningrad, as a graph of seven bridges. Modeling the bridges as connections between nodes. In addition, the nodes represented land areas that are connected by bridges. In this manner, Euler was able to demonstrate that it was impossible to traverse the seven bridges without crossing at least one of them twice. In the 1930s, Jacob Moreno, another notable SNA pioneer, used graphs to illustrate relationships between human entities in a technique he termed sociometry (Freeman, 2004). His applications include capturing and analyzing interactions between classroom and workplace groups of people (Zhang, 2010). A common observation is that both Euler and Moreno utilized graphical mathematics to model and analyze problems. In fact, their approach to graphical mathematics is also referred to as a network.

Scott (2000) asserts that the evolution of SNA can be broken down into three main groups of researchers. These are the sociometric analysts, the researchers from Harvard, and the anthropologists from Manchester. As was previously stated, a significant contribution of the first group is the advancement of graph mathematics in network terms. The second group focused on interpersonal modeling and analysis based on the techniques of the subgroups. In the 1950s, the third group combined the ideas of the first two groups and used them to analyze the relationships between communities and villages (Prell, 2012). Formal application of SNA as a research methodology began in the 1970s and has since gained traction in a variety of fields (Chinowsky & Taylor, 2012).

Nevertheless, Loosemore's (1998) article presents the first application of SNA in the fields of construction engineering and management. Since then, its application has expanded, as evidenced by a wide range of topics, including risk and vulnerability assessment (Zhu & Mostafavi, 2017), construction accidents (Zhou & Irizarry, 2016), and procurement (Lee & Schaufelberger, 2014), to name a few. The notable exception is Chen et al. (2018), who model and analyze contractual payments using this method. Consequently, the SNA application in this study is an additional illustration of how it can be utilized in the field of construction contractual payments.

2.12.2 The Concept of Social Network Analysis

The social network analysis approach is a subfield of network science (Engel et al., 2021). As a science, it employs a variety of conventionally accepted techniques for observing, modeling, and analyzing data within a context of interconnectedness (Newman, 2010). The concept of interconnectedness refers to a property of a network's structure, which consists of two interdependent frameworks (Easley & Kleinberg, 2010). The first framework relates to the network structure level in the sense of a system in which all or some entities are interconnected. A network structure is represented in its fundamental form by points and lines (Borgatti & Halgin, 2011). The points are objects known as vertices or nodes, which can represent a number of different things. Such nodes can represent, among other things, geospatial locations (El-Adaway et al., 2017b), firms (West, 2014), human actors (Balfour & Alter, 2016), and causal factors (Eteifa & El-Adaway, 2018). The line entity, on the other hand, represents edges, connections, or interdependencies that serve to specify the functions of a network in terms of the things that flow between nodes (Freeman, 2004). Therefore, the SNA method provides a means of observing and analyzing a networked structure.

In the second framework, an interconnected network also refers to system-level effects (Easley & Kleinberg, 2010). This implies that the outcome of a networked system is contingent on the actions of its constituent entities. In other words, the point is that the behavior of independent entities differs from the behavior of interdependent system entities. This framework permits topological analysis and reasoning, among other things. As a result, it is possible, for instance, to examine the distribution of node degrees. Degree refers to the number of connections possessed by each node entity (Lee et al., 2018). Lin (2015) discovered, for instance, that the degree distribution in construction engineering networks exhibited a power law distribution when he examined them. Specifically, the decisions of a minority of engineers led to the majority of design errors. In this way, a SNA approach permits the evaluation of system-level effects.

Examining real-world network systems is another method for illustrating the connection between the concepts of systems and networks. Networks can be divided into three categories: technological, biological, and social. Internet, telephone networks, electrical systems, transportation, delivery, and distribution networks are examples of technological systems (Newman, 2010). The interactions between electronic components such as capacitors and resistors, for instance, affect the current flow in electrical circuits. Biochemical, neural, and ecological networks comprise the category of biological systems. The category of social networks includes interrelationships between individuals or groups. In terms of, for instance, friendship, kinship, religion, co-authorship, crime, and business, these interrelationships are used to define the purpose of a network (Herrera et al., 2020). One observable similarity between these categories is that their entities are not disconnected from one another. Because of this interconnectedness, structural and topological level aspects involving contractual payments can be effectively investigated using SNA methods.

In addition, the fundamental principles of a network articulated by Wasserman and Faust (1994) illustrate the similarities between the concepts of networks and systems. Consequently, the SNA is supported by four fundamental principles. That is to say,

a) Interdependence, rather than independence, exists between entities and their actions.
b) The connections or relationships between entities can be viewed as conduits for the transfer of material or immaterial resource flows.
c) When the entities are modelled as people or businesses, the networked context allows for the benefits and risks of a two-way outcome to be evaluated.
d) The relationship between the network structure and its functions is reciprocal

In fact, a comparison of the four principles and the characteristics of a complex system, such as those described by Anderson (1999) and Froese (2010), reveals a degree of similarity. In other words, there are striking parallels between the characteristics of a complex system and the underlying principles of a network. Because of the interconnectedness within which payment is embedded, the SNA methodology can provide a method for examining complex systems. The two approaches are complementary in this regard. Taken as a whole, SNA is an approach that provides a way to study contexts that are connected.

2.12.3 Feasibility of SNA within an Interconnected Context

The premise that physical and non-physical systems are interconnected in some manner necessitates a compatible modeling and analysis approach (Luke, 2015). The context of interconnectedness is important because it allows system elements to be viewed as components of a networked system (Freeman, 2004). As a result, it provides a method for observing, modeling, and analyzing a system's components. In this regard, an interconnected perspective influences how the research object is viewed and, consequently, the research findings. Because the payment concept cannot be separated from its context elements, such as payment mechanisms and methods (Njie et al., 2005), it is necessary to employ an appropriate presentation and analysis tool.

An essential characteristic of an interconnected perspective is the assumption of interdependence (Easley & Kleinberg, 2010). This assumption is significant because it is one of the essential characteristics of complex systems, as exemplified by various facets of the construction engineering and management field (Gao et al., 2018). A common example is the classical iron triangle concept (Tabish & Jha, 2018). This concept illustrates the interdependencies among the three primary project parameters of cost, quality, and time (Pollack et al., 2018). Consequently, it is a triadic network (Pryke, 2017). In this network, project parameters are the nodes and interdependencies are the links between them. It is essential to model and analyze such a network because the concept of payment is embedded in the project parameters. Therefore, an interconnectedness perspective is worthwhile if one wishes to gain a deeper understanding of, say, the causes of payment risk.

As an illustration, Fidan et al. (2011) find that cost variation-related risks result from the interdependencies between cost-varying causes, and their consequences are reflected in aspects such as late payments. However, such outcomes have a two-sided effect (Qazi et al., 2020b). For instance, the cost parameter indicates the financing function (Pollack et al., 2018a). Additionally, this function suggests a connection to the owner's strategy of acquiring the final product at the lowest possible price (Chang & Ive, 2002). In fact, late and short payments are two of the ways contractors are exposed to cost variation risks (Choudhry et al., 2014). This implies that the owner can obtain an economic benefit that reflects the positive side of the consequence of payment risk. In contrast, it corresponds to the contractor's economic loss, which reflects the negative side of the payment risk sequence. Consequently, adopting a suitable method for capturing the interdependence of the two outcomes has numerous implications. The SNA is recommended as one of the suitable approaches due to the interconnectedness between variables found in the construction engineering and management field. The justification is based on its capacity to overcome the inability to identify interdependencies between entities in an accurate manner (Pryke, 2004).

The independence assumption is a frequently used substitute for the interdependence assumption (Freeman, 2004). Common statistical approaches, in which the sampled items are assumed to be independent, reflect its application (Rai & Thapa, 2015). Structural equation modeling (SEM) is an example of a typical modeling technique (Sarstedt & Ringle, 2020). According to structural equation modeling, structure is the link between the unobserved (latent) and observed (patent) variables (Wasserman &

Faust, 1994). This indicates that its unit of analysis is the connection factor as opposed to a network of variables. In addition, since patent and latent variable are assumed to be independent (Sarstedt & Ringle, 2020), SEM is incapable of identifying actual interdependencies. Due to this limitation, it is incompatible with a context that is interconnected.

The assumption of independence is also reflected by linear regression analysis and its variants (Zuur et al., 2009). Consequently, they are unable to recognize and analyze interconnected systems. In construction contracting, for instance, the payment procedure is dependent on a number of factors (Njie et al., 2005). The FIDIC red book, for instance, demonstrates that the payment procedure involves a number of steps that are dependent on the actions or inactions of parties such as the contractor, the engineer, and the owner/client (El-Adaway et al., 2017a). Similarly, a payment default, as evidenced by repercussions such as payment dispute cases, can be traced to a combination of different causes (Cheung & Pang, 2013). Therefore, a network approach can aid in identifying the interdependencies between the causes and the attendant roles, thereby facilitating the allocation of responsibility. SNA is suggested in this context as one of the suitable modeling and analytical approaches (Lee et al., 2018).

Literature indicates that system dynamic modeling (SDM) is a suitable alternative technique (Ahiaga-Dagbui et al., 2017). It was, for example, used to model and study the effects of payment delays (Xie et al., 2019). The result was the identification of the interdependencies between the effects of payment delays. The identified interdependencies were then analyzed using the structural equation modeling approach. However, SEM is based on the assumption of independence and is therefore incompatible with the interdependencies identified by SDM. This indicates SDM lacks suitable operational metrics (Lee et al., 2018). In contrast, SNA is capable of visualizing and analyzing system interdependencies based on metrics such as eigenvector centrality (Pishdad-Bozorgi et al., 2017) and Euclidean distances (Li et al., 2011), to name a few. In light of these comparative advantages, the current study employs a SNA methodology.

2.12.5 Overview of SNA Metrics in Construction Engineering and Management

There are numerous SNA metrics and concepts. Those pertinent to the field of construction engineering and management have been reviewed, for instance, by (Lee et al., 2018). These authors evaluated and clarified 38 metrics based on the complex project management domains. In contrast, Lee et al. (2016) classify them by interconnectedness and density, centrality and power, and subgroup analysis. Zhang and Ashuri (2018) additionally, categorize them as macro-level, micro-level, and meso-level. The macro-level focuses on system-level analysis, the micro-level on nodal analysis, and the meso-level on network partitioning.Wasserman and Faust (1994), for example, have presented their manual mathematical notations. This mathematics has also been incorporated into software programs such as UCINET and its companion Netdraw (Borgatti et al., 2002). With the exception of simple illustrations, the three classifications are discussed without their mathematical notation.

2.12.6 Macro-level Metrics

The macro-level metrics can be categorized based on their purpose, which involves at least two things (Newman, 2003). The first category consists of techniques that describe the characteristics and methods of a networked system. The second relates to those mechanisms that characterize the driving and generative mechanisms of the network. Table 2.4 summarizes the metrics and concepts used to characterize the networked system. This summary's metrics and concepts are then synthesized and discussed in subsequent subsections.

Table 2.4: The Key Macro-level Concepts and Metrics

ID	Concept/metric	Description	Indicative reference
1.	Nodes	Nodes refer to the points or vertices. In this study they represent contextual determinants and incompatible practices and as illustrated by Fig. 2.3 they are indicated by (A1-A6).	(Fang et al., 2012)
2.	Edges	Edges are the lines that connect nodes, and according to Fig.2.3 they are for example indicated by A1-A2 and A1-A5. In the model developed in phase 3 of this study edges conceptualize payment risk vulnerability channels.	(Wambeke et al., 2014)
3.	Distance	The metric of "distance" refers to the number of edges that make a path	(El-Adaway et al., 2017b)
4.	Weighted network	A weighted network is one in which its connections have a value of more than 1. This contrasts with a binary network whose edges have a value of 1 or 0 indicating absence of an edge.	(Wambeke et al., 2012)
5.	Undirected network/ symmetric	A network in which the direction of influence is equal. In the context of risk network, the risk magnitude of sending and receiving nodes are equal.	(Woldesenbet et al., 2016)
6.	Diameter	Diameter is a measure of the longest path length between in the network. Thus, the larger the index, the less critical a node is.	(Zhang & Ashuri, 2018)
7.	Geodesic	Geodesic distance is the shortest distance between two nodes. Consequently, the smaller the index, the higher the risk transmission efficiency and hence the impact	(Eteifa & El-Adaway, 2018)
8.	Average path length	The average path length, or average geodesic, measures the average distance traveled along the shortest path possible in the entire network. Thus, the shorter the index, the more efficient the transmission.	(Zhou & Irizarry, 2016)
9.	Density	Density is the ratio of actual connections in a network compared with the maximum possible. The higher the density, the higher the diffusion of the flows in this case risks.	(Yang et al., 2020)
10.	Local clustering	A proportion of two connections that are close, hence indicates the extent to which nodes are similar or dissimilar	(Zhou & Irizarry, 2016)
11.	Global clustering	Global clustering is a parameter that quantifies a focal node's density in relation to its neighboring connections. A higher value indicates a greater propagation capacity, which is also an indicator of small worldliness.	(El-Adaway et al., 2017b)
12.	Small world	A network with small world properties has dense global clustering and shorter average path lengths. As a result, it suggests a higher transmission capacity.	(Lee et al., 2016)

Source: Synthesized from the indicated sources

(a) Nodes and Edges

A network is a structure comprised of an ordered set of points called nodes or vertices connected by lines called edges, links or connections. Nodes represent various entities such as people (Wambeke et al., 2012), project organizations

(El-Sheikh & Pryke, 2010), geospatial intersections (El-adaway et al., 2017b), risk causation factors (Eteifa & El-Adaway, 2018) or any other relevant unit of observation. A connector between at least two nodes is represented by a line (Fig. 2.3). Connections are used to define network functions such as contracting (Wang et al., 2018), communication (Hossain, 2009), payment or financial (Pryke & Pearson, 2006), just but to name a few.

(b) Binary and Weighted Networks

A network can be represented as either a matrix (Table 2.5) or a graphical object (Figure 2.3), or as both (De Nooy et al., 2018). This suggests that "network" and "graph" are interchangeable terms. A network may also be binary or weighted (Barabási, 2013). In a binary network, a value of 1 indicates the presence of a connection, while a value of 0 indicates the absence of a connection (Wasserman & Faust, 1994). For instance, there is a connection between A1 and A2, but not A1 and A3. This suggests that binary and unweighted networks are synonymous.

Table 2.5: An Illustrative Binary Matrix and its Properties

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**Deg**	**Distribution**
A1	0	1	0	0	1	0	2	2/5
A2	1	0	1	1	1	0	4	4/5
A3	0	1	0	1	0	0	2	2/5
A4	0	1	1	0	1	1	4	4/5
A5	1	1	0	1	0	0	3	3/5
A6	0	0	0	1	0	0	1	1/5
	2	4	2	4	3	1		

Source: Own formulation

In a weighted network, connections are denoted by a value greater than one (Newman, 2010). Therefore, the weight is a scale that conceptualizes the network flows. The weighting parameter can be used to model, among other things, effects on traffic intersections (El-Adaway et al., 2017b), causal magnitudes of construction defects (Aljassmi et al., 2014), effect of contracting practices (Pishdad-Bozorgi et al., 2017), exchange frequency on vulnerability to resource exploitation (West, 2014).

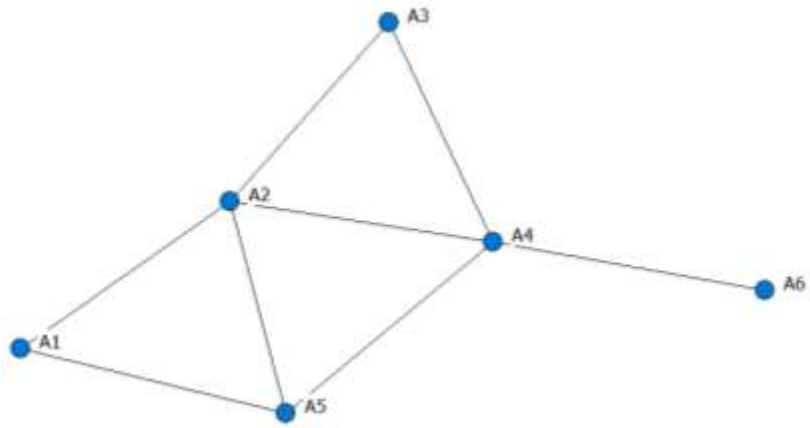


Figure 2.3: An Example of a Network as a Graph

Source: Own formulation

(c) Directed and Undirected/Symmetrical Networks

A directed network, also known as an asymmetric network, is one whose node connections are ordered by direction (Barabási, 2013). Variations between the values of incoming and outgoing connections determine the direction. The in-degree metric measures the value of incoming connections, while the out-degree metric measures the value of outgoing connections. According to Table 2.5, the column sums represent the in-degrees, while the raw sums represent the out-degrees. Due to the fact that the column sums equal the raw sums, the network is undirected and symmetrical. Overall, the concept of a directed network is significant because it provides a method for determining the order of influence (Mohammadfam et al., 2015). In the context of risk, a greater out-degree relative to other network nodes indicates the risk's origin (Li et al., 2016). In contrast, a lower out-degree relative to a higher in-degree is indicative of the recipient node's risk. Therefore, the direction property is helpful for determining the order of influence.

In contrast, an undirected network is one in which the in-degree and out-degree have the same value. Table 2.5 and Figure 2.3 illustrate this point. The metric of nodal degree, also known as all-degree, is an essential metric for networks that are undirected or symmetrical. Using the metric nodal degree, Fang et al. (2012) demonstrated that the risk propagation sequence did not have a significant impact.

(d) Network Density

The density metric measures the connectivity of the entire network (Zhang & Ashuri, 2018). In an unweighted network, it is calculated by dividing the sum of all connections by the maximum number of connections and is expressed as a percentage (Mohammadfam et al., 2015). A value of 1 indicates a network with all nodes connected, while a value of 0 indicates that all nodes are disconnected (Lee et al., 2018). In an unweighted network, density is calculated by dividing the sum of connection weights by the maximum number of possible connections (Eteifa & El-Adaway, 2018). A higher score indicates more connections and, consequently, a faster transmission capacity (Solis et al., 2013). A lower score indicates fewer connections and, consequently, a lower transmission capacity. For instance, Lee et al. (2016) discovered that a higher network density resulted from a greater number of interactions between risk causes. On the other hand, Yang et al. (2020) discovered that more effective risk mitigation measures lead to a decrease in network density. Therefore, the metric of network density can indicate both the overall risk severity and the degree of effectiveness of the mitigation measures.

(e) Degree Distribution

The concept of degree distribution captures the relationship between the degrees of individual nodes and their cumulative occurrence frequency throughout the entire network (Luke, 2015). The degree metric is computed using a simple frequency count and represents the number of connections between individual nodes (Newman, 2003). In this sense, the concept provides a method for evaluating the distribution of connections among the nodes. Examining, for instance, Table 2.5 and Figure 2.3 reveals that the degree of node A1 is 2/5, or 0.4. This is determined by dividing the node's connection count, which is 2, by the number of nodes in the network, minus one. The subtraction occurs because it is assumed that the node under consideration does not contain self-loops.

The pattern of degree distribution can be symmetrical or asymmetrical (Luke, 2015). Its impact is thus reflected in network structures that are balanced or imbalanced. Consequently, the implication of the degree distribution is significant because it provides a means of categorizing the network topology (Lin, 2015). "Topology" is a model property that is useful for explaining the mechanisms of network formation. Therefore, it is essential to conduct a thorough evaluation of the commonly utilized topological models.

(f) Two Mode Network

A two-mode matrix is a technique for storing two-dimensional data sets (Borgatti, 2009). This method is also known as a bipartite or affiliation network (Chowdhury et al., 2011). The term 'mode' refers to a data recording object of which there are two types (Luke, 2015). In this regard, the structure typically exhibits a dual mode. In this structure, the row dimension presents one type, while the column dimension stores the other type. In mathematics, a two-mode matrix is also referred to as an incidence matrix (Hanneman & Riddle, 2005). This rectangular matrix is commonly used to illustrate how data entities such as actors or variables are linked to groups, actions, events, and special locations (Luke, 2015). In this sense, a two-mode matrix is an effective method for relating outcomes to their contextual causes.

Indeed, literature is abundant with dual-mode examples. Wambeke et al. (2012), for instance, illustrated how incidents of sharing space between different construction trades can result in a two-mode network. This network was then converted into a single-mode network and used, for instance, to determine the frequency and magnitude of variation risk. In addition, El-Adaway et al. (2017b) developed a two-mode matrix of construction accident causes and occurrences. A one-mode matrix was computed and then utilized to illustrate connections between accident risk causes and their outcomes. Similarly, Chowdhury et al. (2011) constructed a two-mode matrix of agreements and the parties involved. The agreements depicted the consequences of participants' interactions. This two-mode matrix was then converted to a one-mode matrix and analyzed to determine the impact of project participants. Assaad and El-Adaway (2020) developed a two-mode matrix of causes and sources of construction business failure. This output was then converted into a one-mode matrix for analyzing the collective contribution to the failure of a construction business. One thing these examples have in common is that a two-mode matrix can be used to present risk dimensions.

2.12.7 Network Models

Three models are frequently employed to explain the properties that drive network formation (Newman, 2003). These models are random, small-world, and scale-free. This categorization suggests that the last two are distinguishable based on their nonrandom properties. These models are significant because they provide a method for examining the characteristics of empirical networks.

(a) Random Networks

A key assumption of a random network is that connections to nodes occur with equal probability (Newman, 2003). This premise suggests that the node entities will form connections regardless of the structure (Kereri & Harper, 2019). Consequently, this leads to a process of random formation characterized by unplanned connections and their patterns. Poisson's graph, which is based on the Poisson degree distribution, is a classic illustration of a random network (Newman, 2003). In the Poisson distribution, populations with higher and lower frequencies tend to form a smaller proportion than those with a medium degree of frequency (Sallaberry et al., 2013). Such an assumption of randomness implies the absence of a generative structure.

A structure reflects strategies and practices that restrict or enhance the position of nodes (Baum et al., 2003). The term "structure" in this context refers to the connections that define the characteristics of the nodes. Connections represent interactions between nodes in scenarios such as communication patterns resulting from meetings (Jackson & Rogers, 2007), construction market interactions (Badi et al., 2017), contractual relations (Chowdhury et al., 2011) and co-occurrence of construction defects (Aljassmi et al., 2014). These connections demonstrate that in the absence of interdependencies, there is no structure to control how random networks form.

Intuitively, the assumptions of random connections imply that the occurrence of certain outcomes is due to chance as opposed to deliberate design. Thus, the occurrence of problems such as payment disputes is coincidental. Nonetheless, Wu et al. (2011a) discovered that some payment defaults to contractors were unintentional while others were deliberate. The latter is reflected in the construction procurement structures' emphasis on particular practices. For instance, the practice of determining the contract price prior to construction aims to ensure that the actual outcome price is within the owner's or client's budget (Chang & Ive, 2007b). This strategy indicates a deliberate effort to replace uncertainty with certainty assumptions (Malatesta & Smith, 2011). The effects are reflected in occurrences such as disputes over cost variation liability. Due to the frequency of nonrandom occurrences, it is necessary to pay attention to nonrandom networks.

(b) Small-world Networks

The concept of a small world is a prevalent characteristic of nonrandom networks (Newman, 2003). The premise of the property is that the majority of connections between two nodes have a shorter path length or geodesic distance (Anderson et al., 2014). As a result, the clustering coefficient is typically employed to determine the presence of small-world properties. A score closer to 1 indicates that the distance between any two nodes is shorter (Zhou & Irizarry, 2016). Consequently, a small-world network topology is distinguished by a higher score than random networks (Kereri & Harper, 2019). A score closer to zero, on the other hand, indicates that other network nodes are only accessible via an intermediary. The small-world property can also be identified by the metric of shorter average path length (Jackson & Rogers, 2007), which enables non-neighboring nodes to communicate quickly.

The small-world property implies that a network is capable of performing complex tasks. In this regard, the small world property has been used to explain a variety of phenomena, including a faster flow of traffic (El-Adaway et al., 2017b), the diffusion of project innovations (Kastelle & Steen, 2010), and the propagation of risk more quickly (Zhou & Irizarry, 2016), to name a few. The point illustrated by these examples is that, due to small-world effects, the propagation of anything in a network will be accelerated. This property exhibits nonlinear behavior in that the spread tends to follow multiple channels, which makes it difficult to regulate.

Another significant feature of the small-world network is that distances between nodes are reduced due to the presence of intermediary nodes (Baum et al., 2003). A lower clustering coefficient also supports this conclusion. In applying this concept, Di Marco et al. (2012), for instance, discovered that a higher clustering coefficient indicated the capacity of intermediaries to resolve contractual disputes between teams. On the contrary, intermediary roles can also contribute to disunity (Heng & Loosemore, 2013). This implies that the intermediary can sometimes contribute to disagreements between dissimilar entities. Indeed, the role of contract administrators in escalating contractual disputes is common (Zhu & Cheung, 2020). In this context, the small-world properties can indicate the extent of payment default vulnerability.

(d) Truncated Scale-free Networks

A scale-free network is one whose degree distribution is consistent with the power law principle (Barabási, 2013). The graph lacks a scale because its head is skewed to the right and its tail is infinitely long (Stephen & Toubia, 2009). In a scale-free network, a few nodes have many connections, while the majority have few. Lin (2015) specifically states that;

1. On average 20% of the nodes will have 80% of the connections.
2. The nodes with the highest number of connections represent a hub in the network. This hub tends to assert the greatest control.
3. A random deletion of a number nodes has no effect on the extent of connectivity at the global level. However, fragmentation will occur if a small number of hubs is intentionally removed.

In the construction engineering and management literature, the application of the power law principle is evident. Liu et al. (2015), for instance, discovered that few contractors shared their project risks. Cao et al. (2017) found that few construction project organizations had a high number of collaborative connections. Similarly, few companies had contractual ties and, as a result, dominated the construction industry

(Lee et al., 2018). Lin (2015) discovered that technical consultants were more influential than the owner and contractors. In terms of risk, Guo et al. (2020a) discovered that a small number of factors contributed to the vast majority of construction accidents. These examples suggest that the formation of connections is driven by planned mechanisms, as opposed to random ones.

One of the common mechanisms is disassortative mixing or assortment diversity (Barabási, 2013). In disassortative mixing, entities with dissimilar characteristics tend to attract one another (Stephen & Toubia, 2009). For instance, Cao et al. (2017) found that the dominant contractors collaborated with architects, engineers, and project managers more frequently than with contractors offering similar services. Such actors serve as intermediaries or boundary spanners between project owners and contractors on the construction market (Fellows & Liu, 2012). Consequently, their position resembles that of a hub. This implies that there are more connections emanating from a hub than vice versa. Based on this strategy, a construction company has greater access to contracts than other contractors whose success depends on chance. As a result, a small number of prominent construction companies tend to dominate the construction industry.

Additionally, preferential attachment is a dominant mechanism (Lee et al., 2018). This mechanism is predicated on the notion that entities that control essential resources are more desirable and will therefore have more connections (Stephen & Toubia, 2009). For instance, project clients and their gatekeepers will attract connections from contractors. Typically, the construction market is characterized by a large number of contractors seeking work and a small number of projects up for bid (Skitmore et al., 2006). As a result, skewed procurement practices are favored. A prominent example is the prevalence of fixed price mechanisms (Ruparathna & Hewage, 2015). Due to the fact that the construction project does not exist at the time of contract signing, contractors are exposed to risks such as cost variations. In structures such as design-bid-build, the selection of terms is the foundation of owners' cost-cutting strategies (Osipova & Eriksson, 2011). Such strategies can therefore play a dominant role in the propagation of payment risk.

2.12.8 Micro-level Metrics

The centrality metrics are used to assess the individual elements of a network in terms of nodal analysis (Yang & Zou, 2014). Their purpose is to rank the importance of the nodes and in the network (Zhou & Irizarry, 2016). Because the level of importance tends to vary with the nodal position, a variety of metrics are usually employed. The common metrics include, degree centrality, Eigenvector, closeness and betweenness. These are discussed further.

(a)1 Degree Ccentrality

The degree centrality of a node is measured by a simple summation of its adjacent or direct connections. It determines the number of direct connections a node has, without considering their weight. The past applications of the degree centrality include identification of key trades in a construction site (Wambeke et al., 2012), determining the extent of interdependency between members of a design team (Zhang & Ashuri, 2018). Degree centrality was also used to determine the magnitude that a defect cause can exert on other causes (Wang et al., 2021). Similarly, Yang and Zou (2014) used in-degree and out-degree to identify the initiator and receiver type of risks among project stakeholders. These applications demonstrate at least two things. First that is that degree centrality is a useful measure of immediate influence, criticality and risk propagation capacity. Another aspect is that nodal analysis depends on the point of view.

The measure of degree centrality is constrained by at least two limitations (El-Adaway et al., 2017b). First, beyond the adjacent (neighboring) connections, it does not account for the influence of the non-neighboring nodes. It therefore does not provide a comprehensive picture. Secondly, degree centrality overlooks weighted connections and therefore assumes that all the connections have equal capacity (Pishdad-Bozorgi et al., 2017). As a result, it does not provide an objective way of prioritization, which in turn allows measures to be assigned to where it matters most. Therefore, it is important to explore more robust metrics.

(b) Eigenvector Centrality

The metric of eigenvector centrality considers the influence of all the adjacent and non-adjacent nodes and weighted connections (Pishdad-Bozorgi et al., 2017). It assigns relative scores, based on the premise is that connections to high scoring nodes have a higher influence than equal connection to low scoring nodes (West, 2014). In this sense, it combines the quantitative measurement in terms of the number of connections with the quality of the connections. Given these capabilities, the Eigenvector metrics is able to overcome the limitations of degree centrality.

Eigenvector metric has been applied to a variety of construction related topics. For example, Wambeke et al. (2012) used it to identify the trades to contributed to most project performance risks. From a contracting perspective, Chowdhury et al. (2011) used Eigenvector to profile roles according to whether they occupied a central or peripheral position, which indicated their relative contractual power. Akgul et al. (2017) use it to assess the market strategies and relative performance of construction firms. El-Adaway et al. (2017b) used it to identify the moist critical road intersections. It was also used to identify the most practice in terms of its capacity to trigger and being triggered by other practices (Pishdad-Bozorgi et al., 2017). Just like degree centrality, these examples demonstrate that Eigenvector centrality can be applied to a variety of construction topics. Additionally, compared to degree centrality it provides a better level of nodal analysis.

(c) Closeness Centrality

The metric of closeness centrality shows how close a node is to other network nodes (Hansen et al., 2020). It is computed by determining the distance between a pair of nodes. A mathematical way of doing this is to first calculate the farness which involves summation of all the lengths of the shortest paths for all the other nodes, that is, direct and indirect (Perez & Germon, 2016). The inverse of this output is the degree of closeness. This metric provide a means of assessing a node’s contribution to the whole network (Aljassmi et al., 2014).

The closeness centrality is applied in a variety of contexts. For example, Zhang and Ashuri (2018) used it to determine the degree of closeness among a team of designers. Buldyrev et al. (2010) also used it to assess the cascading effect of power transmission on the failure of the entire network. Wang et al. (2020) used closeness centrality to identify the risk factors that had the strongest influence on other factors. Similarly, Yang et al. (2018) used it to identify the most critical factors in the delivery of green buildings. These examples demonstrate that closeness centrality metric is relevant when determining those entities whose influence on others is relatively difficult to controllable.

(d) Betweenness Centrality

The metric of betweenness centrality measures the times a node falls on the shortest distance between other nodes (Hansen et al., 2020). The metric of the shortest distance is also similar to the geodesic distance (Perez & Germon, 2016). By revealing the extent, a node falls between other nodes, the metric of betweenness is able to identify relative node control capacities in the network (Wambeke et al., 2012). The metric is important because it shows the extent to which some nodes are acting as intermediaries (Badi & Diamantidou, 2017) and boundary bridging roles (Di Marco et al., 2010).

Similarly, Yang et al. (2020) also found that the node with the greatest betweenness were neither initiators nor ultimate recipients of risk in an engineering project, but hand the ability to manipulate the rate of flow Li et al. (2011) also used the metric of betweenness to establish the potential of a node to manipulate the flow of information and resources. Badi and Diamantidou (2017) noted that a relatively higher degree of betweenness indicated how design and cost management influences the roles of owners and their contractors. In this sense, the metric of betweenness offers a means of measuring the effect of controlling and intermediary functions. This approach is relevant to the contracting context because the practice of delegating controlling authority by the project owner to an agent is commonplace (Zhu & Cheung, 2020). In for example design-bid-build FIDIC red book, the roles of such agents include design, supervision, certification and dispute resolution(Haloush, 2020). The first two is undertaken on behalf of the owner, while the latter two are presumed to be neutral. The metric of betweenness is therefore relevant is measuring the effects of such a combination of consequences such as payment risks.

(e) Flow Betweenness

Despite the significance of flow betweenness, its applicability is limited by its inability to account for weighted connections and link-level analysis. To overcome these limitations, Freeman et al. (1991) proposed the flow betweenness variant. The metric takes into account weighted connections and offers an alternative method for determining which connection is the most central as opposed to the nodes (Chowdhury et al., 2011). This method permits the measurement of connection capacity. Among the previous applications was the calculation of the rate at which a bridge between unrelated construction accidents causes or prevents the occurrence of accidents (Eteifa & El-Adaway, 2018). Agryzkov et al. (2019) also utilized it to calculate the traffic load on infrastructure networks. Consequently, by focusing on which connection acts as an intermediary bridge, the flow betweenness metric provides a method for evaluating issues such as contractor susceptibility to payment risks.

2.12.9 Partitioning Metrics

Partition metrics are significant because they provide a method for dividing a network into distinct sections (Wasserman & Faust, 1994). Existing methods with comparable functions include cluster analysis, modularity, structural holes, structural equivalence, and clique analysis (Lee et al., 2018). Despite their diversity, their purpose is to enable, among other things, the profiling and analysis of roles and relationships (Solis et al., 2013). In the context of construction contracting, role profiling is essential because it can indicate the contribution of diverse participants' actions or inactions to project outcomes (Li et al., 2011). Some outcomes reflect issues such as payment-related disputes (Mbachu, 2011), risk co-occurrences, and differences between expected and actual outcomes (Fidan et al., 2011). This suggests that the responsibility for such outcomes is attributable to a variety of disparate causes (Zhu & Cheung, 2020), which are in turn associated with disparate roles. Due to their networked nature, one of the greatest challenges is, for instance, identifying cause-and-effect relationships. Nonetheless, research such as Weng et al. (2010) and Yang et al. (2020) indicates that partitioning-based SNA metrics are a viable approach.

The partitioning metrics are classified according to their top-down and bottom-up perspectives (Sloane & O'reilly, 2013). Starting with a single node or connection, the bottom-up method entails partitioning and grouping a network until suitable sets are identified. The top-down approach, on the other hand, examines the entire network and then determines where it can be divided into fragments. In the present study, roles are reflected by practices that result from interactions between contextual determinants. The points where incompatibilities appear due to inadequate alignment are the split points. This theory assumes that splits will occur when ties between dissimilar interests are weaker. This implies that individuals with similar interests will form stronger bonds and, consequently, have a lower degree of dissimilarity. Consequently, such a network will have a lower incidence of contractual disputes, such as payments.

For instance, because design and construction are separated in the design-bid-build context, there is cohesion between the site owner and design-related roles (Bankvall et al., 2010). Since design is performed on behalf of the owner, the structure of contract elements such as drawings, specifications, and bills of quantities reflects their shared interests. On the contrary, site owner/design-related roles and construction-related roles are not unified. This context is indicative of weaker connections between the site owner/design-related roles and construction-related roles. Therefore, the top-down related metrics are more applicable in this context.

There are numerous top-down related partition metrics (Lee et al., 2016). These include structural holes, structural equivalence, block modeling, and the Lambda set. The structural hole metric has been utilized in micro-level and partitioning analyses (Yang & Zou, 2014). The concept of structural holes is therefore discussed separately from other partition metrics.

(a) The Concept of Structural Holes

A structural hole is a measure of gaps in a network structure, which was originally developed by Burt (1995). Specifically, it focusses on assessing the implications of absence of direct connections between separated or clustered units, also known as alters (Badi et al., 2017). Such an assessment is important because it suggests opportunity for the broker, also known as an ego to connect the disconnected actors or roles. However, the brokerage position has a duo outcome. It can enable one of the sides to gain at the expense of the other. An example of a gain is where the project owner reduces his project financing cost by underpaying, paying late or completely failing to pay for work done by contractors. Conversely, the project owner's financial gain reflects a loss to contractors. In this sense, the concept of structural holes can be useful in the assessment of risk propagation.

In network terms, a structural hole represents a position occupied by the brokerage functions. Its basic concept is illustrated by Fig. 2.4, which comprises of four nodes. Out of the four nodes, three, that is, alters are connected directly to the central node, called an ego. The position occupied by the node ego depicts a hole in the sense that without it the alters will not be able to connect directly. In a payment dispute risk network, where the nodes are risk causes and the lines between them risk events as consequences, identification and measuring the node which occupies a structural hole can inform about risk propagation. In this context, propagation is the capacity of a node to control what flows through it by virtue of occupying a structural hole.

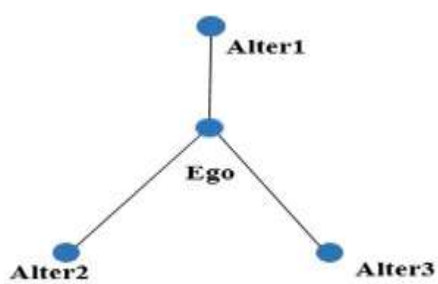


Figure 2.4: An Example of an Ego Network

Source: own formulation

In the area of construction engineering and management, relatively few studies have been able to apply the concept of structural holes. For example, Heng and Loosemore (2013) have applied it to identify the enablers and disenables of communication requirements within a facility management organization. Similarly, Badi et al. (2017) and Pryke et al. (2011) also apply the concept structural hole to examine how construction marketing strategies can confer advantages or disadvantages. As a result, they were able to determine the performance variations of intermediary functions. In this sense, the concept provides a means assessing a two-sided outcome.

Additionally, the idea of a structural holes is relevant because projects involve integration of separated resource owners and therefore the extent of brokerage in turn determines the extent of flows such as payments. Fellows and Liu (2012) espouse a similar idea by using the concept of boundary spanners and objects. According to them, boundary spanners represent designated contract administrators, while the objects represent reference tools such as contract documents, which include drawings, bills of quantities and the contract. Di Marco et al. (2010) also examined the role boundary spanners and objects in integrating separated project teams. In this sense, the concept of boundary spanning is similar to that of the structural hole, and therefore can be used interchangeably.

In other contexts, Rodan (2010) also used the concept of structural holes in establishing the influence of managers as brokers on organizational performance. That is significant because it identified autonomy, opportunity recognition, competition, information arbitrage and innovativeness as the enablers of the concept of structural holes. Autonomy is illustrated by the absence of a connection between similar or dissimilar nodes but which are connected to the same ego, that is, broker. Indeed, as Fig.2.4 illustrates, the ego at the center occupies an autonomous position, which suggests an advantage over the Alters. For example, if Alters 2 and 3 are contractors and Alter 1 is a construction owner/client in need of construction services, it means that the ego (consultant) is in a position to conduct a bidding competition. The aim of organizing for a competition among the bidders is to determine who can contract with Alt1 and at what price. In this sense, Fig. 2.4

provides a means of structuring competition and in turn an opportunity to make a gain or loss.

The position of opportunity recognition is however premised on the principle of information asymmetry. This means that the consultant's position in Fig. 2.4 offers an opportunity to distribute unequal information to the bidders and the project owner. This position portends a more informed consultant than his contacts, which provides an opportunity to disrupt the flow between the contractors and the project owner. This way, the consultant's position is therefore more influential.

In a contracting context, the level of influence a consultant (spanner) has depends on its position in the network. Such a position is important because it can indicate the capacity to control flows (Heng & Loosemore, 2013). Under the D-B-B contracting system, a contract administrator is thus in position to disrupt flows between the project owner and contractors. However, the disruption can result in one sided benefit. Since the administrator is hired by the owner (Ndekugri et al., 2007), he is presumed to first serve the owner's interest. This will however in turn disadvantage the contractor in various ways. For example, it is not uncommon for the consulting unit to conceal the true financial position of the owner in situations where there is funding deficit prior to the signing the contract. The consequences reflect in events such as payment disputes.

The boundary objects such as the contract documents can also provide useful indicators of structural holes. This is because are characterized by contractual incompleteness (Chang & Ive, 2002). From a construction procurement perspective, contractual incompleteness conceptualizes the inability to fully specify all the possible contingencies upon which a construction project will be realized (Walker & Pryke, 2011). Its indicators include relatively higher extent of provisional sums, contingencies and variation clauses (Walker & Pryke, 2009). Such indicators also suggest the level of uncertainty, whose practices are sometimes misaligned with certainty (Malatesta & Smith, 2011). For example, the application of fixed price contracts before construction assumes certainty rather than uncertainty context. In this sense, a contract document is a boundary connector whose consequence can be reflected in events such as disputes over the value of work done (Mbachu, 2011). Therefore, by conceptualizing such events as structural holes, provides a way of measuring their payment dispute propagation capacity.

In measuring structural holes, Burt (1995) proposed a set of metrics such as effective size, efficiency, constraint and hierarchy. The logic of these metrics is premised on the degree of redundancy in terms of the extent to which the connections between alters of an ego are connected (Jenssen & Greve, 2002). If the construction owner, that is, alter 1 in Fig 2.4 is unconnected or lacks direct connections with contractors (Alter 2 and 3), the consultant depicted as an ego at the center will have more control. This is because the position of the ego enables receipt of non-redundant information. This contrasts with redundant information indicated by presence of direct or strong connections between alters (Burt, 1995). Hence, the presence of direct or strong connection between the alters reduces the amount of control an ego can have. In other words, reduced control regarding the flows between alters, is an indicator of redundant connections. Therefore, the more the degree of non-redundant connections, the greater the ego's controlling capacity will be.

(b) Other Partition Metrics

The other common top-down related partitioning metrics include structural equivalence (Loosemore, 1998), blockmodeling (Weng et al., 2010), hierarchical clustering (Solis et al., 2013) and Lambda set (West, 2014). Nodes are considered to be structurally similar if they share similar connections, otherwise they are dissimilar (Weng et al., 2010). The metric is appropriate where there is need to split nodes according to their dissimilarities due to states such as competing economic interests (Lee et al., 2016). The Euclidean distance is one of the common methods for measuring structural equivalence (Li et al., 2011). Some of the relevant applications include identification of competing strategies (Lee et al., 2016) and establishing the central or peripheral roles.

Roles and positions are also partitioned by a combination of structural equivalency and hierarchical clustering (Li et al., 2011). Hierarchical clustering is a mapping technique that indexes interdependencies between clustered nodes or connections

(Solis et al., 2013). The approach was for example used to index the connections between clustered water resource obstacle factors. The approach was also used to map the interconnectedness between construction sustainability factors (Valdes-Vasquez et al., 2013). Similarly, Solis et al. (2013) used it to capture and analyze the tendency to form connections between teams that share similar understanding. These examples suggest that the connections between clusters can indicate the degree of similarity or dissimilarity.

Blockmodeling refers to a set of methods used to discover and present a block model (Wasserman & Faust, 1994). A block model is a matrix structure which assigns nodes to identified clusters and constructing connections between identifies clusters (Borgatti, 2009). This means that the identified clusters are the blocks and their interconnections with other blocks represents a model. This allows the connections between blocks or positions in the structural equivalence to be identified and analyzed (Wasserman & Faust, 1994). The approach was for example used to apportion different risk factors into the roles of involved participants (Yang et al., 2020). The lessons leant during the construction phase were also presented in block models (Aragao & El-Diraby, 2019).

Taken together, this section demonstrates that SNA is a feasible approach in modeling and analyzing payments within their interconnectedness context. Because of its three sets of standardized metrics, it promises a better alternative to other approaches such as the system dynamic modeling.

2.13 Summary of the Knowledge Gap in the Literature

This chapter establishes that the concept of payment risks in terms of lateness, underpayments, and non-payments to construction contractors is embedded in a context of interdependence. This observation is implied by the "iron triangle" framework (Pollack et al., 2018), the occurrence of payment-related disputes (Cheung & Pang, 2014), and cost variation risks (Choudhry et al., 2014) . These topics have in common that they suggest a system perspective in which components are interconnected in some way (Ahn et al., 2017). Despite the fact that their analytic approaches assume a disconnected perspective, the concept of payment is depicted as either an enabler or a consequence of certain system components.

For instance, there is a connection between the cost component of the "iron triangle" and the contractor's payment obligations. Consequently, these obligations often indicate incompatibilities with the owner's desire to construct the project at the lowest possible cost (Chang & Ive, 2002). Indeed, the attainment of the objective of the lowest possible cost sometimes necessitates the use of strategies such as paying late, underpaying, or not paying at all (Wu et al., 2011b). The conceptualization of payment risk suggests a cost-saving channel and, consequently, a positive outcome from the owner's perspective. On the other hand, payment risks suggest a negative impact on the financial status of the contractor. Therefore, adopting a perspective of interconnectedness can provide a suitable means of connecting the positive and negative aspects of payment risk.

However, payment studies such as Abdul-Rahman et al. (2014); Mbachu (2011); Peters et al. (2019), presumed a disconnected perspective, and hence concentrate on identifying independent single causes. For instance, Peters et al. (2019), postulated that nine factors identified in the literature contribute to the payment problem. The factors included the client's limited financial capacity, payment withholding, and certification delay. However, these factors are interconnected in some way and, as a result, their contribution to payment risks is iterative rather than singular. It can be suggested, for instance, that the latter two are results of the client's limited financial capacity. Intuitively, the contractor's payment risk portends cost savings for the client. Therefore, adopting a connected perspective enables the identification of a cause-effect relationship.

A further limitation of the existing empirical literature on payments is that their conceptual and methodological approaches are not fully compatible with the interconnectedness characteristics of the payment concept. Xie et al. (2019), for instance, use systems dynamic modeling (SDM) to examine the effects of payment delays. Their approach was useful because it demonstrated the causality of payment delays using a simulated system model. This output was analyzed by means of structural equation modeling (SEM). However, SEM is predicated on the assumption of independence, which is inappropriate for an interconnected context. This limitation implies that SDM lacks relevant computational metrics. SNA is deemed a suitable alternative because it can model and calculate a variety of aspects of a networked system due to its modeling and calculation capabilities. Lee et al. (2018), reviewed SNA applications in the construction topics such as stakeholder interactions, communication, risks and quality management

The chapter also reveals that some of the theoretical logics underlying construction procurement systems, such as design-bid-build, were borrowed from standard product market systems. For instance, the D-B-B is supported by the market mix components of place, product, price, and promotion (Skitmore & Smyth, 2007). Nevertheless, their assumption is not entirely compatible with the novelty of executing construction projects. For instance, in the market mix, "place" refers to the distribution channels between producers and their input suppliers, on the one hand, and producers and their buyers, on the other. However, in construction processes, 'place' refers to owner-determined procurement routes tied to a fixed site (Arditi et al., 2008). The misapplication of these theoretical principles is reflected in contractual practices. However, there is little discussion in the payment literature regarding how the incompatibility of standard product distribution channels and the fixed nature of a construction site affect payment risks.

In conclusion, the failure to address the highlighted aspects reveals three gaps.

1. The first is an inability to clearly recognize interdependencies between study variables.
2. Second, the payment literature has not considered the influence of interactions between incompatible practices on occurrence of risks.
3. Third, there is a scarcity of application of theoretical assumptions and identification of their links to payment risks. As a result, there is no way of assessing the efficacy of payment risk mitigation measures.

As a result of addressing the identified research gaps, the current study aims to bridge a number of methodological, theoretical, and practical gaps.

2.14 Conceptual Framework

A conceptual framework is a diagrammatic representation of concepts and their relationships to the phenomenon being studied (Ngulube et al., 2015). The concepts in this diagram are typically classified as independent, intervening and dependent variables (Creswell & Creswell, 2017). Consequently, Fig. 2.4 depicts the relationships between contextual factors, incompatible practices, the intervening process and occurrence of contractor payment risks. The two sets on the left represent independent variables, whereas the set on the right, contractor payment risk, represents the dependent variable. The middle variable intervening process between them. With this understanding in mind, Fig. 2.5 shows that there is a reciprocal interdependence between contextual determinants and incompatible, which leads to an interdependence network and in turn, contractor payment risk consequence. Therefore, the occurrence of payment risks is a result of an intervening process between the two sets of independent variables.

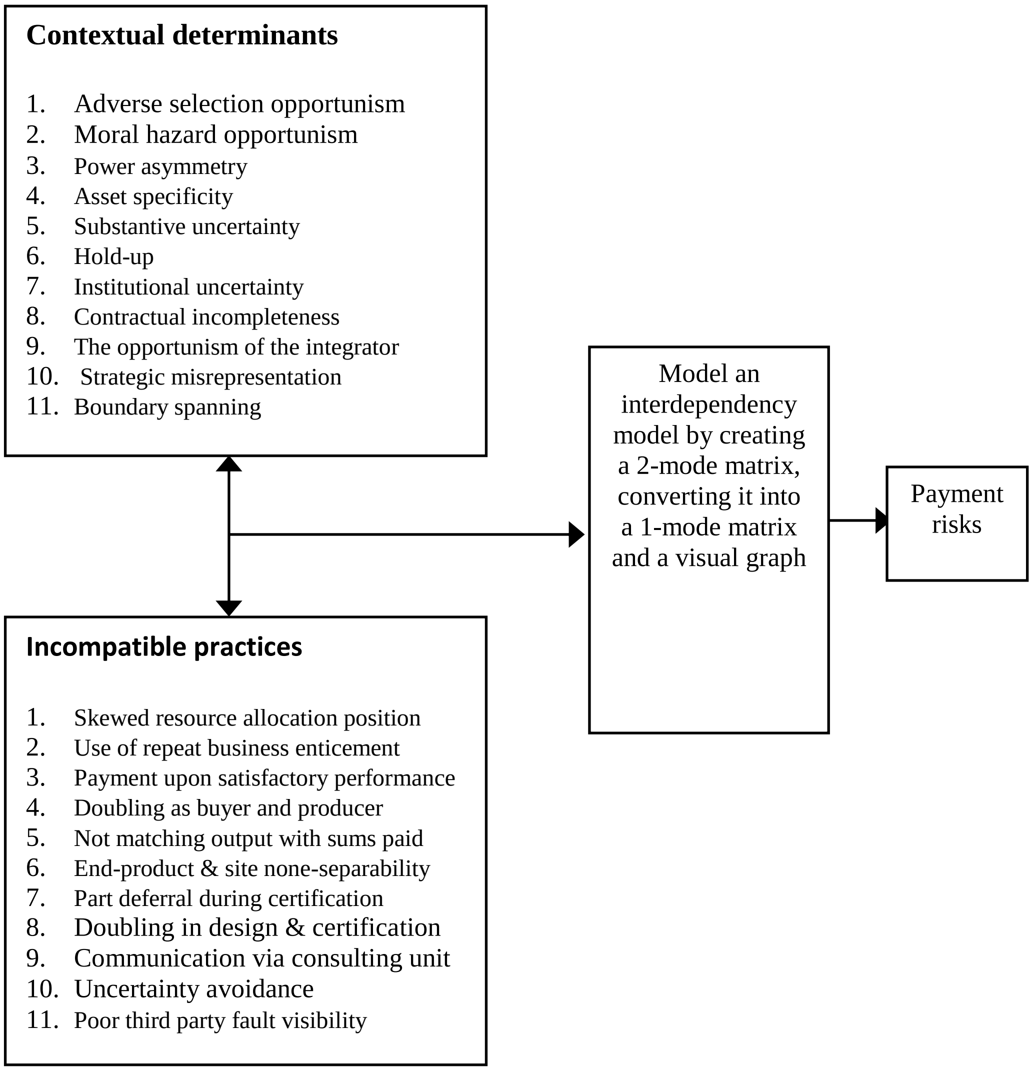


Figure 2.5: A Conceptual Framework for the Study

Source: own construction

2.15 Research Propositions

In order to meet the specific objectives, three sets of propositions were put forward. The details are provided below.

1. That the payment concept is a phenomenon embedded in a number of construction project parameters, including cost, time, and quality, to name a few. Due to this interdependence, contractor payment risk events may result in late underpayment or non-payment. Multiple context-based determinants illustrate how their interconnected nature contributes to payment-related risks. As a result, it supports the proposition that:

   The co-occurrence of payment disputes is influenced by the interdependence of (i) process specificity, hold-up, (iii) site asset specificity, (iv) power asymmetry, (v) bounded rationality, (vi) adverse selection of the owner, (vii) contractual incompleteness, (viii) moral hazard of the owner, moral hazard of the consulting unit, and (x) transaction frequencies.

Consequently, the data from payment dispute cases was used to validate the co-occurrence of the listed contextual determinants.

2. That practices are generated by the interactions between contextual determinants. However, without proper alignment with the interactions between contextual determinants, applying them to the procurement of design-bid-build construction projects is likely to result in incompatibilities. The occurrence of problems such as payment risks is evidence of this. This lends support to the claim that:

   Incompatibilities between practices of (i) skewed resource allocation position, use of repeat business enticements, (iii) payment upon satisfactory performance, (iv) doubling in buying and production functions, (v) not matching output with sums paid, (vi) inseparability of the end-product from its site, (vii) deferred certification, (viii) combining design and certification roles, centralizing communication through the consulting unit, (x) uncertainty avoidance, and (xi) poor visibility of fault by the third party influences payment risks.

The judgment from subject matter experts who were involved in the resolution of the payment disputes was used to rate the practices. This output was then used to determine the extent of incompatibility.

3. The vulnerability of contractors to payment risks is a result of the interconnectedness of risk practices as a result of their contextual determinants. Eleven sub-positions reflect this proposition. This table demonstrates that the sub-propositions resulted from interactions between contextual determinants and incompatible practices. To evaluate them, subject matter experts' opinions were utilized. Consequently, the output was utilized to construct a model of an interdependency network.

2.16 Chapter Conclusion

This chapter has reviewed the literature of the study. First, it discussed the concepts that are relevant to the study setting. In this regard, the concepts of project governance, construction procurement system, structure and functions, vulnerability and the blockchain were discussed. Secondly, the components of the sub-payment system were identified and explained. Fourth, the payment concept was framed within an interconnected perspective. The fifth component involved explaining the need for a new institutional thinking in tackling payment risks. This was followed by presenting the case for an integrated theoretical framework. As a result, the role of the market mix, transaction cost economics and the principal-agency theories were outlined. Additionally, dimensions of interdependencies were identified and discussed from the complexity perspective. Eight, the existing payment model related studies were reviewed and their drawbacks identified. The need to profile the interdependencies between the latent and patent factors was also underscored. The frameworks of contextual determinants and incompatible practices were also unveiled. The chapter also reviewed the social network analysis perspective, presented a summary of the knowledge gaps and a conceptual framework.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the study's methodology. It is divided into a three-phased methodology, social network analysis tools, and criteria for grading study excellence. These are elaborated upon below.

3.2 A Methodology for Developing Interdependency Network Model

This study developed a data-driven model of interdependency networks rather than an experimental simulation. Because of this, the model is based on empirical evidence gleaned from actual data. Similar examples can also be found in the construction engineering and management literature such as Eteifa and El-Adaway (2018); Wambeke et al. (2014); Zhou and Irizarry (2016). One similarity is that the modeling data is derived from case study contexts. As a result, the modeling procedure needs to be conceived in a way that represents a complex situation. This study conceptualizes construction contractor payment risks in an interconnected context, which is one of the characteristics of a complex setting (Davies & Mackenzie, 2014). In accordance with this understanding, a three-phased process was developed (Fig 3.1).

The first step aimed to establishing the influence of contextual determinants on contractor payment risks. This effect was measured at the node level as opposed to the link level. Nodal influence varies based on network properties such as whether or not the network is weighted. A weighted network enables the determination of its magnitude (Barabási, 2013). Nevertheless, the point is that nodal measurements differ from edge measurements. Consequently, the first objective focuses on examining contextual determinants as nodes.

With the preceding context in mind, this section describes how data from private and public payment dispute cases were utilized to determine the nodal influence. The contextual determinants in Table 3.2 were synthesized from the literature and then validated using payment dispute cases. This output was incorporated into the second objective, which addresses incompatible practices. This suggests that there is a connection between contextual factors and practices. This is due to the fact that payment is an integral part of procurement systems such as the design-bid-build option. This suggests that the concept of payment cannot be separated from its contextual elements. As a consequence of this interdependence, practices such as price determination prior to construction tend to reflect contextual differences between the certainty of the standard product market and the uncertainty of the design-bid-build structure (Malatesta & Smith, 2011). In this sense, practices are a product of context, implying the existence of a relationship between them. Therefore, there is a connection between the first and second objective.

The objective phase describes the indexing of incompatible practices. In this instance, contextual factors were used to frame incompatible practices. Assessing the differences between the standard product manufacturing process and construction procurement from a D-B-B perspective yielded incompatible practices. In turn, the framework was used to develop research questions. Subject matter experts' responses to these questions were gathered. The data collection steps were combined with those of phase three. Afterwards, the data was analyzed using distinct social network methods.

The third objective explains how a model of an interdependency network was created. Here, a framework was developed that incorporated a revised list of contextual determinants from phase two. It consisted of revised contextual determinants and incompatible practices and was subsequently utilized to generate propositions. This output was utilized to formulate a schedule for data collection. The collected data was then utilized to create a two-mode network matrix. This matrix was then transformed into a model of interdependency network. In accordance with methods for determining risk (Wambeke et al., 2014), the practices represent risk causes.

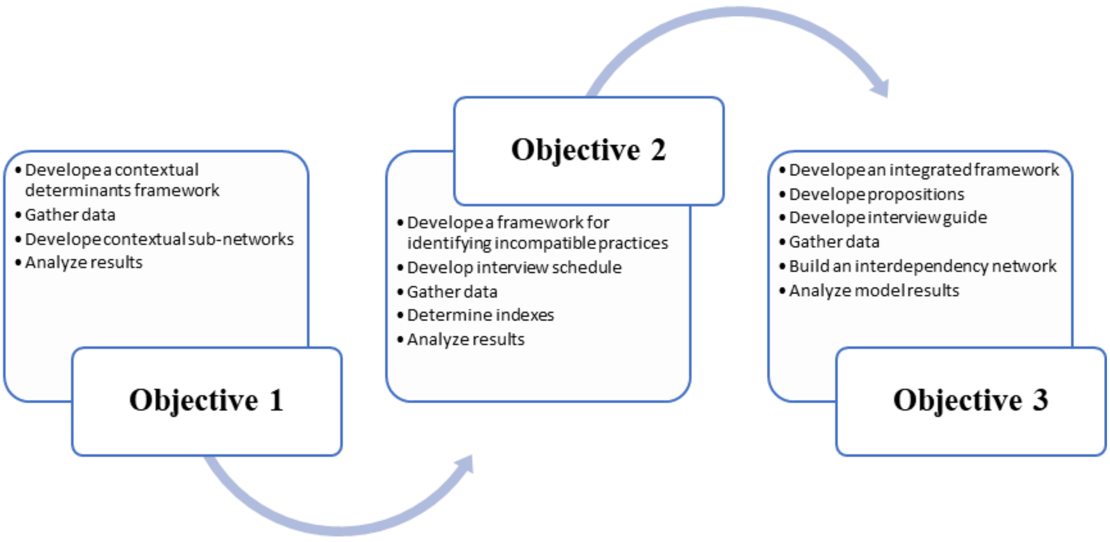


Figure 3.1: Three-step Research Methodology

Source: own construction

3.3 Objective One

A seven-step procedure was developed to determine the contextual factors that influence construction contractor payment defaults in terms of late, underpayments, and non-payments. These are outlined below:

3.3.1 Unit of Analysis

A unit of analysis refers to the subject of interest, which can be a person, an organization, a process, an event, a decision, or a policy (Bryman, 2016). In Chang and Ive (2007a), for instance, the unity of analysis pertains to how and why the presence of certain contextual conditions contributes to disputes. This analysis unit is exemplified with evidence from three dispute cases within a single project. Similarly, Forsythe et al. (2015)'s unit of analysis is the extent to which building information modeling systems can reduce information imbalance between parties, with evidence drawn from project cases. In both cases, the unit of analysis is distinct from the data sources.

There are three interconnected units of analysis in this study. The unit of analysis for the first objective is the network that influences construction contractor payments. As a focus of interest, it implies that payment dispute cases are not cases in and of themselves, but rather sources of evidence illustrating how and why the network of contextual determinants influences payment defaults. Similarly, the unity of analysis for the second objective concerns the effect of interdependencies between incompatible practices on contractor payment risks. For the third objective, the unit of analysis is interdependence.

3.3.2 Data Collection Technique

For the purpose of analyzing the influence of a network of contextual determinants on payment defaults, an online documentary archiving approach was chosen. Its defining characteristic is that it is unobtrusive, meaning that the cases from which data is collected are unaware of the investigation (Saunders et al., 2016). Consequently, the behavior of the cases does impact the data collection process. Therefore, the use of this technique promotes the collection of evidence that is not distorted.

In addition, the observable evidence is described as hidden, nonreactive, indirect, and naturalistic because data collection procedures cannot disrupt the natural setting of the evidence (Janetzko, 2008). As a result of data being stored in online archives, there is a sense of permanence in this method, and the information can be verified (Saunders et al., 2016). Considering these benefits, an online archival documentary technique was selected.

The archival document method is a component of the diagnostic strategy typically used to analyze construction disputes (Cheung & Pang, 2014), which tends to generate more insightful findings than the subject matter approach. This is usually attributed to the fact that its design focuses on revealing interactions between underlying events. By examining the structure of interconnections, its components, such as contextual causes, can be uncovered. As a result, characteristics such as their dormancy state can be described

3.3.3 Source of Data

Data from payment dispute cases was used to examine the influence of a network of contextual determinants on contractor payment defaults. Typically, payment disputes arise from disagreements regarding payment between project owners/clients and their contractors, owners versus consultants versus and main contractor versus subcontractors. Depending on the contract structure, the methods and steps for resolving disputes between a project owner and their principal contractors can vary (Haugen & Singh, 2015). The FIDIC is one of the common standard contracts that provides for claim determination by the engineer when using the D-B-B option (Kondev, 2014). The rejection of the claim constitutes a dispute, the resolution of which involves a series of stages.

The typical stages consist of referral to a dispute review board, conciliation, arbitration, and then litigation (Mante, 2018). In Kenya, the public procurement oversight authority PPOA and the Joint Building Council JBC are also commonly used (Abwunza et al., 2021). The PPOA allows for mediation, arbitration, and litigation, whereas the JBC only allows for arbitration and litigation. This progression of steps and their interdependence is crucial. In the absence of an agreement to bypass any stage, a lower level must be exhausted prior to escalation to the next level. Therefore, the cases that proceed to arbitration and then to the court indicate dissatisfaction with the decision made at a lower level.

Again, with the exception of litigation, the other methods are bound by confidentiality principles (Haugen & Singh, 2015). As a result, access to data is restricted. Consequently, construction payment disputes filed in court offered a suitable alternative. The National Council for Law Reporting publishes such cases in Kenya at http://kenyalaw.org/caselaw/cases.

3.3.4 Sampling Method

Sampling in practice may be random or non-random (Bryman, 2016). In this study, the typical "purposive sampling" method was used. As a non-randomized technique, the choice was influenced by two reasons. First, random methods are appropriate when a sampling frame is available (Saunders et al., 2016). However, there is no sampling frame for payment dispute cases in Kenya. Indeed, the cases posted on the http://kenyalaw.org/caselaw/cases portal are general commercial disputes. It was therefore necessary to select a sample that exemplifies the influence of contextual factors on payment defaults. Second, random samples assume all variables to be independent of one another (Rai & Thapa, 2015). On the contrary, this study considers payment defaults to be the result of interdependencies between contextual determinants and incompatible practices.

(a) Case Selection Procedure

The case selection procedure consisted of three steps. These steps are detailed below.

i. The initial step consisted of determining the search period. In this regard, the search was restricted to the previous decade. The selection of ten years was influenced by the realization that human cognitive abilities to recall and process past events decline with time (Chang & Ive, 2007a). This was important because the second research goal required input from the parties involved in payment dispute cases. With this in mind, the number of payment dispute cases selected was limited between 2010 and 2019.
ii. In the second step, an online search was conducted on the http://kenyalaw.org/caselaw/cases portal. The search period spanned from January 3, 2020, to February 20, 2020. The terms "construction payment disputes" and "construction payment claims" were utilized. This procedure resulted in the retrieval of 97 cases. They involved various types of contractual relationships, and the causes of the payment dispute were also diverse. As a result, a screening procedure was carried out.
iii. The final step was a screening procedure. This procedure was designed to ensure that 1) the payment dispute case involved the owner/client versus the main contractor, 2) the case did not involve an application to stay proceedings, and 3) the case did not seek the disqualification of the arbitrator. This process resulted in the dismissal of twenty-eight cases because they involved the project owner/client versus subcontractors, employees, and

consultants. Additionally, thirteen cases were excluded because the parties requested a stay of proceedings pending the outcome of the arbitration process. Five additional cases were excluded because they sought the disqualification of the arbitrator. The screening results are displayed in Table 3.1. This table contains 29 cases involving the private sector and 22 cases involving clients from the public sector.

Table 3.1: Payment Dispute Cases Selected for Analysis –2010-2019

	Private sector		Public sector	
Year Decisioned	**Number of cases**	**Percentage**	**Number of cases**	**Percentage**
2010	1	3	1	5
2011	1	3	1	5
2012	5	17	2	9
2013	1	3	2	9
2014	2	7	4	18
2015	6	21	4	18
2016	5	17	1	5
2017	2	7	3	14
2018	3	10	3	14
2019	3	10	1	5
Total	29	100	22	100

Source: constructed from research data

(b) Sample Size

Table 3.1 shows that the private sector sample is distinct from the public sector sample. The separation was necessary due to contextual differences between the two sectors. In the private sector, it is relatively easy to distinguish between the rights and responsibilities of the project owner as the client and the consulting unit as his agent. In the public sector, however, the relationship between the client and his consulting agent is difficult to discern (Krane et al., 2012). As a result, there is an unclear separation of ownership and control, with the main challenge being meaningful involvement of the owner (Zwikael & Smyrk, 2015). As a result, detecting challenges such as conflict of interests becomes more difficult. However, the involvement of private sector owners suggests a relatively lower conflict of interest among consulting agencies. As a result of these contextual differences, it was necessary to distinguish between private and public cases.

Table 3.1 demonstrates that the private sector has 29 cases compared to the public sector's 22. Unlike random sampling techniques, the non-random technique used to sample payment dispute cases lacks clear sample size guidelines (Bryman, 2016). However, Saunders et al. (2016) recommend that 12 to 30 cases are adequate when comparing two different contexts. With this recommendation in mind, the sample sizes of 29 and 22 fall within established standards.

3.3.5 Data Processing Procedures

The payment dispute case files listed in Table 3.1 were sequentially processed utilizing qualitative and quantitative techniques. In the qualitative section, the data from the documents were coded and subsequently sorted. Quantitative SNA methods were subsequently applied to the output of these two steps. These methods are discussed briefly.

(a) Data Coding

Coding is the process of affixing phrases-based labels to textual data (Saldaña, 2021). These phrases represent variables, concepts, or themes, and two common approaches are employed (Heng & Loosemore, 2013). The first approach is data-driven, in which data is used to identify and categorize labels. The second is a theoretically driven approach, which identifies and categorizes data based on a predefined theoretical understanding. This approach was adopted. To operationalize this strategy, the coding scheme presented in Table 3.2 was utilized. Based on this scheme, ten labels representing contextual determinants were assigned to the data. A four-step procedure was utilized to complete this coding process.

i. The initial step consisted of employing NVIVO software. Using the import/file function, the selected case files were imported into the NVIVO user interface.
ii. In the second step, the code/node function was used to create empty nodes. The subsequent naming of these nodes was based on the contextual determinants shown in Table 2.1. In other words, NVIVO nodes represent variables, or contextual determinants.

iii. The third step involved identifying and assigning relevant text passages to coded nodes. This required using the case file function to determine which excerpt corresponds to each node variable. Using the coding stipe and highlight functions, this operation was accomplished. This process grouped excerpts into ten distinct node variable categories.

iv. In the final step, a framework matrix for the private and public categories was sought. This required the transformation of the matrix query results. To accomplish this, the framework matrix function and auto summary functions were selected. These operations resulted in data excerpts displayed in Appendices II. and III.

Table 3 2: A Contextual Determinant Coding Scheme

ID	Label (Determinant)	Definition	Indicator (s)
CD1	Process specificity (progress interdependence)	Contractor vulnerability to progress underperformance breach whose magnitude corresponds to unpaid sums (Chang & Ive, 2007a)	Work-first get paid later and disputed payments (Peters et al., 2019)
CD2	Hold-up	Contractor vulnerability to contractual breach due to cash flow difficulties related to disagreements over the value of work done aimed at the concession for less payments (Chang & Ive, 2007a)	Unfair or termination threats (Ramachandra & Rotimi, 2015b)
CD3	Site asset specificity	Effects of the inseparability of site ownership from its end product hence exposure of contractors to payment risks (Chang & Ive, 2007b)	Ineffective payment remedies (Abdul-Malak et al., 2019)
CD4	Power asymmetry	Practices that involve determination of own procurement rules hence leading to greater control of the production process than that of contractors (Zhu & Cheung, 2020)	Acceptance of unfair contractual terms by contractors (Abdul-Malak et al., 2019)
CD5	Bounded rationality	Constrained verifiability capacity of the third party such as the court due to difficulties in obtaining reliable data (Chang & Ive, 2007a)	The ambiguity between roles of agents and their principal or owners (Peters et al., 2019)
CD6	Adverse selection of the owner	Situations where contractors are selected on the hidden basis that they can survive owner financing deficiencies (Xiang et al., 2012)	Opaque financing arrangements (Xiang et al., 2015)
CD7	Contractual incompleteness	Effects of failing to adapt to the occurrence of unexpected events due to lack of shared understanding among the parties (You et al., 2018)	Inability to share information on the failure of the projected sources of funding (Abdul-Rahman et al., 2014)
CD8	Moral hazard of the owner	Owner behavioral actions calculated at obtaining unmerited gain in respect of the work done, and hence exposing contractors to economic losses (Xiang et al., 2015)	Deliberate refusal to pay for variations (Abdul-Rahman et al., 2014)
CD9	Moral hazard of the consulting unit	Effects of combining contract document supply roles with postcontrast payment administration by the consulting unit (Xiang et al., 2012)	Distrust of the consulting unit by both the owner and contractor (Peters et al., 2019)
CD10	Transaction infrequencies	Uncertainty of the market resulting from more and willing construction contractors than the available and able project owners (Winch, 1989)	Need for work and scarcity of workload (Skitmore et al., 2006)

(b) Sorting

The term' sorting' refers to the process of identifying relationships between codes, that is, variables or constructs (Saldaña, 2021). To investigate the influence of a network of contextual determinants on payment defaults, the NVIVO code frequency technique was employed. This technique is essential because it reveals the frequency with which a code is assigned to portions of the data. To accomplish this, a three-step procedure was followed.

i. The first step was data processing. This was accomplished by accessing the NVIVO interface and selecting the explore/matrix coding query function. The resulting layout consists of raw and column panels.
ii. In the second step, the variables encoded by a node function were entered into the raw side. Likewise, the case files were entered into the column panel at the same time.
iii. The third step consisted of executing the query function. The output of its execution was a matrix query. This is the result for the private matrix query. The procedure was repeated for cases in the public sector. The private and public matrix outputs were ultimately saved and exported to Excel for further analysis.

3.3.6 Data Structuring

In network studies, data is either recorded in a two-mode or a single-mode matrix. While both of these matrices can model networks, there is a significant difference between them. In the two-mode, ties or interdependencies between entities in a matrix are indirect and therefore concealed. In contrast, the one-mode matrix is able to identify direct connections. Consequently, if the collected data are in a two-mode format, the processing will involve three primary steps. The first step involves determining the network's boundary. This is usually accomplished by identifying the raw and column entities and recording them in a two-mode matrix. In step two, the two-mode matrix is converted to a one-mode matrix. The third step consists of transforming the one-mode matrix into a visual network. This procedure is discussed.

(a) Constructing a Two-mode Matrix for Contextual Determinants

As an example, Figure 3.2 depicts a two-mode or incidence matrix. This matrix was derived from a matrix quarry procedure in NVIVO software. One of its features is the ability to swap between rows and columns. The arrangement, however, is determined by the analytical unit of interest. In this regard, the focus is on which cases illustrate contextual determinants of payment default via subsequent events (risk causes). Cases of payment dispute represent events, whereas contextual factors represent the roles of actors. In this sense, it represents a two-mode actor by event matrix. In case C5, for instance, the contextual determinant CD1 occurred twice. Similarly, in instances such as C6, the contextual factor CD1 only occurred once. In addition, there was no occurrence of contextual determinant CD1 in cases C1 and C2. The final column on the right displays the frequency of contextual determinants based on their occurrence (Fre). It indicates that contextual determinant CD 3 co-occurred 24 times, which is the highest frequency.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	Fre
CD1	0	0	0	0	2	1	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	0	**10**
CD2	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2	0	0	0	2	0	0	0	1	0	1	0	0	**10**
CD3	1	0	0	1	1	1	0	0	1	1	0	2	0	1	1	2	0	3	0	0	1	1	2	2	0	1	0	1	1	**24**
CD4	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	2	0	1	1	0	2	0	0	0	0	0	0	**10**
CD5	2	0	2	0	1	0	1	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	2	0	1	**15**
CD6	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**4**
CD7	0	2	1	0	0	0	0	0	0	0	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	**10**
CD8	2	0	0	0	0	0	0	0	0	0	2	10	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	3	**19**
CD9	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0	**6**
CD10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**

Key: C1-C29 =Case; CD1-CD10 =Contextual determinant

Figure 3.2: A Two-mode Matrix for Private Sector Payment Dispute Cases

(b) Conversion of Two-mode to One-mode Matrix

Converting a two-mode matrix to a one-mode matrix is a common method for overcoming the inability to detect direct interdependencies (Borgatti, 2009). With direct interdependencies between entities (nodes), for instance, (El-Adaway et al., 2017b) was able to determine the extent of ties. This output was then utilized to determine the capacity to initiate and transmit construction accidents. The magnitude parameter of a one-mode matrix is indexed by metrics including geodesic distance, Euclidian distance, and eigenvector centrality. With these indices, risks can be managed more effectively, making it possible, for instance, to assign liability to the correct source of risk consequence.

The conversion procedure involves multiplication of the two-mode matrix by its transpose (De Stefano et al., 2011). Therefore, if the matrix in Fig. 3.2 is labeled 'A,' it's adjacency 'P' can be calculated as shown in, for instance (Chowdhury et al., 2011). This calculation is predicated on the formula $P=AA^T$. Where A represents the two-mode matrix, also known as an incidence matrix, and A^T represents its transpose. Transposition of matrices involves exchanging the position of rows with columns and vice versa (Borgatti, 2009).

In other words, the adjacency matrix P is the product of the adjacency matrices AA^T (De Stefano et al., 2011). A matrix is adjacent if it is square in the sense that the number of row and column entities (elements) are equal. Therefore, the presence of a line is indicated if the value of the intersection cell is one; otherwise, the value is zero (Wambeke et al., 2012). A binary adjacency matrix is one whose intersection values range between one and zero (Borgatti, 1997). In contrast, an adjacency matrix is deemed valued or weighted when its cell values exceed one (De Stefano et al., 2011). The weighted lines in this study represent the magnitude or capacity to initiate and transmit payment defaults.

In this study, $P=AA^T$ was computed using the UCINET version 6 software, which is based on the methodology outlined in(Borgatti et al., 2002). This process consisted of four steps.

i. The first step was to upload the excel version of the non-square matrix, such as the one shown in Fig.3.1, to a dashboard known as the 'DL editor.' The result was a file in the computer language DL format.
ii. Second, the DL file was uploaded to the conversion dashboard. This conversion dashboard can be accessed by selecting the 'affiliations' (2-mode to 1-mode) option in the data tab.
iii. The third step consisted of selecting the row or column option. Since direct connections between contextual determinants were of primary interest, the raw option was utilized.

iv. In the fourth step, the conversion method was selected. Here, the maximum sums of cross-products method were utilized for two reasons. To begin, it employs the standard matrix multiplications of $P=AA^T$. In addition, it takes into account weighted matrices as opposed to binary ones. Additionally, this procedure was repeated for the public sector matrix.

3.4. Objective Two

A comparative case study approach is utilized to determine the degree of misalignment between standard market product manufacturing practices and design-bid-build construction procurement processes and their influence on contractor payment risks. In accordance with the recommendations of (Ulibarri, 2015), six steps were designed. These include (a) describing the study setting; (b) identifying contrasts; (c) identifying the data source; (d) selection procedures; (e) data collection method; and (f) outlining procedures for data collection.

3.4.1 Comparative Case Study Design

This phase employs a comparative case study design. This design is distinct from others, such as the typical, extreme, and critical designs (Bryman, 2016), in that it emphasizes the logic of comparison and contrast. Consequently, it provides a useful means of connecting policy contexts, such as interactions between competing entities (Bartlett & Vavrus, 2016). Such policies are reflected in the standard forms of contract such as the FIDIC red book for the design-bid-build (D-B-B) option when procuring construction projects (Besaiso et al., 2018). This type of contract involves numerous procedures and practices. However, it is argued that they were borrowed from the standard market manufacturing system, which combines hierarchical and market structures (Chang, 2013). Their theoretical premises imply that they were created for the standard market product. For instance, the roles of producers and buyers are distinct. However, the D-B-B case is characterized by some overlap and role-swapping (Crespin-Mazet & Ghauri, 2007). This comparison is important because it provides a method for identifying contextual differences and connections with consequential outcomes.

Table 3.3 contrasts the characteristics of standard product manufacturing with those of a design-bid-build procurement process (columns 'A' and 'B'). The incompatible practices in column 'D' are the result of a contextual misalignment between the contexts. These incompatibilities are represented by their respective indicators (Column E). However, incompatibilities are a consequence of the interactions between contextual determinants (Column C). These determinants point to conceptual differences between manufacturing and construction procurement settings.

Second, by contrasting the two contexts, the study is able to demonstrate that practices are the result of contextual determinants. This makes it possible to trace, for instance, the interdependencies between the negative and positive sides of risk consequences (Qazi et al., 2020b). A comparison of construction procurement systems and manufacturing-based studies, such as that conducted by (Skitmore & Smyth, 2007), indicates that the D-B-B is the most dissimilar. With these considerations in mind, a comparison of the manufacturing and D-B-B processes is used to illustrate contextual differences and how they contribute to contractor payment risks.

Another reason for selecting a comparative case study design over other designs such as surveys is that it allows for the illustration of a complex context. Because practices do not operate in isolation (Bartlett & Vavrus, 2016), the concept of complexity is commonly used to describe the interconnectedness of a system (Davies & Mackenzie, 2014).The method for determining system-level differences is crucial because it takes into account the characteristics of the system's constituent parts. Therefore, a comparative case study design can be used to show the differences between the manufacturing and construction procurement settings.

Table 3.3: A Framework for Identifying Incompatible Practices

Features			Incompatible practices	Indicators
Manufacturing	**Construction under (D-B-B)**	**Contextual determinants**	**(P)**	
A	B	**C**	**D**	**E**
Continuous & voluminous production	Discontinuous production	CD1	1. Skewed resource allocation position (Wu et al., 2008)	One-off nature of construction (Turner & Müller, 2003)
		CD2	2. Use of repeat business enticement (Wu et al., 2011a)	Need for work (Skitmore et al., 2006)
The buyer is located outside the production firm	The buyer doubles as a co-producer	CD3	3. Payment upon satisfactory performance (Malatesta & Smith, 2011)	Work-first get paid later (Odeyinka & Kaka, 2005)
		CD4	4. Doubling in buying and production (Crespin-Mazet & Ghauri, 2007)	Contractor switching (Winch, 2008)
		CD5	5. Not matching output with sums paid (Chang & Ive, 2007a)	Contractor cash flow difficulties (Abdul-Rahman et al., 2014)
		CD6	6. End product site inseparability(Chang & Ive, 2007b)	Skewed control rights (Abdul-Malak et al., 2019)
The process integrator is under unified ownership	The process integrator is also a supplier	CD7	7. Part deferral during certification	Delay in certification of variations (Mbachu, 2011)
		CD8	8. Doubling in design & certification (Ndekugri et al., 2007)	Design inadequacies (Mbachu, 2011)
		CD9	9. Communication via consulting unit (Li et al., 2011)	Kickbacks (Abdul-Rahman et al., 2014)
The production cost is a sole liability of the producer	The product price is determined ahead of production	CD10	Uncertainty avoidance (Chang & Ive, 2002)	Intentional pre-contract cost understatement
		CD11 (Boundary spanning)	10. Poor third party fault visibility (Chang & Ive, 2007a)	Unequal information distribution (Xiang et al., 2012)

Source: Synthesized from the indicated sources

3.4.2 Identification of Contrasts

Bartlett and Vavrus (2016) suggest combining horizontal, transversal, and vertical techniques when identifying contrasts. The horizontal method compares how similarities and differences between theoretical principles can result in diverse practices. The transversal axis entails the determination of underlying interrelationships. The vertical method examines similarities and differences at different scales, such as geospatial and temporal. In this case, all three are used.

Consequently, a framework for operationalization is presented in Table 3.3. The differences between columns 'A' and 'B' serve as an illustration of the horizontal method. These columns compare and contrast the characteristics of standard product manufacturing with those of construction procurement under the D-B-B structure. The transversal method is exemplified in Column 'C,' which lists the contextual determinants. Thus, their interactions highlight the distinctions between the standard product market and the construction procurement context. Indeed, their contextual differences are reflected in their practices. The vertical is exemplified by the degree of uncertainty as the difference between the required and available information to make a decision at a particular time. As a result, the incompatible practices in column 'D' indicate a mismatch between the two contexts. Therefore, their indicators are displayed in Column E.

Another feature of Table 3.3 is the presence of an additional contextual determinant, CD11. This determinant represents boundary spanning as manifested by a third party's poor visibility of the fault. From the perspective of design-bid-build FIDIC, a third party refers to a dispute resolver between the construction owner and his contractors (Ndekugri et al., 2007). Usually, a certifier such as an engineer, mediator, arbitrator, or the court performs this function. However, the combination of agency and certification roles creates dilemmas, such as whose interests should take precedence. Since boundary objects consist of contract documents, it is difficult for the third party to obtain reliable information under these conditions. Typically, the contract administrator holds these documents on behalf of the owner. In this context, it is unlikely that the administrator will disclose information favorable to the contractor's claim. Given this justification, it is necessary to include the boundary-spanning CD11 determinant (Table 3.3).

3.4.3 Source of Data

The extent of incompatibilities was determined based on the opinions of subject matter experts (SME). This process yielded indexes, which were then used to develop a model of an interdependency network. The SME method is applicable in situations where prior knowledge and familiarity are crucial factors (Rodriguez et al., 1991). An example of specialized knowledge is a deeper understanding of how the differences in interactions between manufacturing standard market products and design-bid-build construction can contribute to payment risks. The register of practicing arbitrators maintained by the Kenya chapter of the chartered institute of arbitrators is one of the appropriate sources. The qualifications of SME were:

- Possession of a degree in the construction domain, specifically architecture, civil engineering, quantity surveying, and construction management;
- Accreditation as a dispute resolver in the construction field; and
- Experience resolving payment-related disputes of at least eight years

This register was accessed between 2 December 2020 and 30 January 2021 via the portal located at https://ciarbkenya.org/dispute-resolvers/. The list of dispute resolvers revealed, among other things, a diversity of professional backgrounds. In the category of construction professionals were civil engineers, architects, quantity surveyors, and project managers. Due to the variety of construction dispute types (Cheung & Pang, 2014), it was necessary to identify individuals with expertise in resolving payment disputes. Due to this, the payment dispute cases listed in Table 3.1 served as the basis for identifying the relevant SME.

3.4.4 Selection of Subject Matter Experts

The first step in selecting suitable subject matter experts in terms of their ability to rate the extent of practice incompatibility involved subjecting the data in Table 3.1 to another level of screening. Four criteria were applied to the data set in Table 3.1 to filter out the experts who took part in the resolution of payment dispute cases. In particular, 1) whether the case was decided within the last 5 years, and 2) whether the experts involved were specifically named in the dispute. 4) Had at least eight years of experience, and 3) whether the named expert was a member of the charted institute of arbitrators.

First, a 5-year time cut-off was chosen so that rating by experts would produce the desired results. Psychologists recognize that the human capacity to remember, retrieve, and process information tends to deteriorate over time(Peterson et al., 2017). With this understanding, case participants whose cases were decided after five years were omitted. Second, some of the cases in Table 3.1 do not explicitly list the parties involved in the dispute resolution. Such cases were dropped because they could not assist in identifying the dispute resolvers. Third, four sets of resolvers are typically involved in a typical resolution of construction dispute cases that have progressed to litigation. The first two sets contain the representatives of the disputing parties, i.e., the construction owner/client and the contractor. The second set may consist of an expert witness, while the final set consists of the arbitrator, mediator, or a judge. All four groups share the common characteristic that they meet the criteria for inclusion in the list of dispute resolvers. This implies that more than one SME may be chosen in a single instance. In conclusion, eight years of experience in the resolution of payment disputes were deemed a suitable cutoff.

In consideration of the preceding criteria, the screening of the cases in Table 3.1 yielded twelve cases. Table 3.4 lists the characteristics of twelve cases.

Table 3.4: Payment Dispute Case Descriptions

Case (C)	Attribute									
	Owner/client			Subject of work			Form of contract			
	Private	Public	Frequency	Building	Civil	Frequency	JBC	PPOA	FIDIC	Frequency
C1	X	0	1	X	0	1	X	0	0	1
C2	X	0	1	X	0	1	X	0	0	1
C3	X	0	1	X	0	1	X	0	0	1
C4	X	0	1	X	0	1	X	0	0	1
C5	X	0	1	X	0	1	X	0	0	1
C6	0	X	1	X	0	1	0	X	0	1
C7	0	X	1	X	0	1	0	X	0	1
C8	0	X	1	0	X	1	0	X	0	1
C9	0	X	1	0	X	1	0	X	0	1
C10	0	X	1	0	X	1	0	0	X	1
C11	0	X	1	0	X	1	0	0	X	1
C12	0	X	1	0	X	1	0	0	X	1
Total	5	7	12	7	5	12	5	4	3	12

Key: Case=C; X= attribute is present; 0= attribute is absent; Building= Building works=; Civil=Civil works=; JBC=Joint building council; PPOA= Public procurement Authority; FIDIC= International federation of consulting engineers

Source: research data

Table 3.4 displays data attributes in three panels. The panel on the left indicates that seven cases belong to the public sector and five to the private sector. Seven cases in the middle block involved building projects, while five cases involved civil engineering projects. The third panel on the far right depicts the distribution of the cases among three contract types. Five cases utilized the Joint Building Council JBC form of contract, three cases utilized the public procurement authority PPOA contract, and three cases utilized the international federation of consulting engineers FIDIC form of contract.

Twenty-four names of dispute resolvers were identified from the twelve cases shown in Table 3.4. One of them served in the capacity of arbitrator for cases 2 and 7. In other words, only 23 potential informants were located. Four of them were eliminated because they lacked contact information. As a result, 19 potential experts were identified for interviews.

3.4.5 Structured Interviewing Method

An online structured interview method was selected for three reasons. First, it enabled the collection of quantifiable responses. This allowed for the creation of indexes that characterize the differences between practices. In phase three, it also allowed responses to propositions linking incompatibility to payment risks to be captured in a matrix format. This is significant because the matrix method offered a suitable way to construct a network of interdependencies. Second, the structured interview method allowed for the clarification of research questions with respondents during the interviewing process. Lastly, the use of an online interview format made it possible to collect data without physical interactions, thereby allowing researchers to circumvent the restrictions imposed by the Covid pandemic.

3.4.6 The Interviewing Procedure

The interviewing procedure followed four stages similar to those proposed by (O'leary, 2004). The stages are 1) planning, 2) interview schedule formulation, 3) piloting and instrument modification, and 4) interviewing.

i. During the planning stage, the 19 experts who had been identified earlier were contacted. Appropriate times and dates for the interviews were discussed and agreed upon. Then, an invitation letter, a sample of which is provided in Appendix I was sent. Three of the 19 contacts declined to participate in the interviews, and four others withdrew their consent shortly after agreeing to participate. Only 12 informants were ultimately interviewed. Yin (2017) asserts that between five and ten respondents can provide reliable information in a case study design such as this one.
ii. The second stage involved developing a preliminary interview schedule. Due to the necessity of collecting two distinct data sets, two draft schedules were created. The first aimed to determine the degree of dissimilarity between the incompatible practices outlined in Table 3.3 and how this degree of dissimilarity influences contractor payment risks. Twelve questions were developed in accordance with the practices outlined in Table 3.3. A 4-point Likert scale was used to evaluate their responses. On this scale, 0 means disagree, 1 means somewhat agree, 2 means agree, and 3 means strongly agree.

iii. In the third phase, pilot interviews were conducted, resulting in alterations to the draft interview schedule. Pilot interviews were conducted with the SME who served as an arbitrator in C1 and a contractor's representative in C7. This duality in terms of participation, diversity suggests a greater degree of representation. During the piloting phase, an online audio/visual conference mode was utilized. The date of this interview was March 29, 2021. The questions listed on the preliminary interview schedule were asked on that day. The preliminary interview schedule was modified in light of the comments and consideration of the responses. Appendix "A.3" shows the final schedule.

iv. In the fourth and final phase, twelve interviews were conducted between April 2 and May 16, 2021. In order to manage the procedure, steps such as sending a reminder at least one day beforehand were taken. On the day of the interview, the interviewer logged in at least thirty minutes early. Before the question-and-answer session, preliminaries such as greetings, discussion of study objectives, and ethical issues were presented. The responses were entered into an Excel spreadsheet. Each session concluded with participants being thanked for their participation. On average, each interview session lasted approximately one hour and thirty minutes.

3.5 Objective Three: An Interdependency Network Model Development Process

Scientific models are seen as simplified descriptions of the real world (Luke, 2015). In addition, the author stresses that network modelers are aware that network models are created for hypothesis testing, structural analysis, identification of their formation, and identification of their dynamic mechanisms. This can be addressed through simulations, empirical methods, or a mixture of the two (Newman, 2003). In the first approach, an experimental model is typically developed and then used to validate data. Examples from the construction industry illustrate this method (Aljassmi et al., 2014; Fang et al., 2012). In the second approach, empirical data are used to establish the model, and construction-related examples are provided (El-Adaway et al., 2017b; Eteifa & El-Adaway, 2018). This study utilized the second approach.

In objective one, the variables in the model are established under objective one and two. The first objective entails the identification of contextual determinants. These are derived from the literature and validated using data from payment dispute cases. The contextual determinants are not entirely compatible with the design-bid-build processes used to realize construction projects because they were created for standard market products. Contextual determinant interactions also result in practices that are only partially compatible with D-B-B processes. To determine the degree of incompatibility between practices, it was necessary to first identify the practices and then evaluate them.

Consequently, the second Objective concentrates on quantifying the degree of incompatibility between practices. In the third phase of the study, the degree of incompatibility is a crucial input for modeling an interdependency network model. The premise is that interdependence is a cause-and-effect relationship. Similar to risk modeling approaches (Fidan et al., 2011; Wambeke et al., 2014), practices assume the role of risk causes, whereas contextual determinants represent their outcomes.

Considering the preceding context, the development of an interdependency network model consists of six steps. These are organized according to the following steps: 1) setting description; 2) formulation of an integrated framework for identifying and operationalizing incompatible practices; 3) selection of cases; 4) selection of subject matter experts; 5) data collection and procedures; and 6) method for constructing two-mode and one-mode matrices.

3.5.1 Model Development Setting

The modeling process is based on a case study design, with an interdependency network model serving as the case of interest. In this way, the case enables the identification of interdependencies and the examination of their connections to contractor payment risks. A further justification is that a case study design is suitable for complex situations. A key characteristic of a complex system is its ability to transform inputs such as practices into nonlinear outputs (Anderson, 1999). The network behavior of a nonlinear system reflects a combination of pooled, serial, and reciprocated interdependencies (Davies & Mackenzie, 2014). In this context, a network represents a complex system. Due to the fact that the developed interdependency network model exemplifies a complex system, Table 3.5 illustrates the relationship between complexity characteristics and the context that exposes construction contractors to payment risks.

The setting shown in Table 3.5 offers a significant insight into the complexity of the modeling assumptions due to their interdependence. Given this, it follows that payment risks cannot be caused by a disconnect between practices and the determinants of their context. Therefore, it is essential to adopt an interconnectedness stance when analyzing and identifying payment risk occurrences.

Table 3.5: The Complexity of an Interdependency Network Model Setting

Complexity feature/assumption	Meaning within an interdependency network modelling context	Indicator
1. The behaviour of parts is dependent on the other parts. Thus, a disconnection causes failure	The non-involvement of the contractor in the contract design stage portends exposure to exploitative practices (Osipova & Eriksson, 2011)	Imbalanced contrasts have a link with payment defaults (Abdul-Malak et al., 2019)
2. Contains a web of interdependencies among its parts. As a result, the parts affect each other	It reflects the context of integrating separately owned resources, which give rise to opposing economic interests (Chang, 2013)	Boundary activities between dissimilar project firms during the integration process (Fellows & Liu, 2012)
3. Complex systems are sensitive to small variations which can lead to severe consequences	Due to the interconnectedness between risk causes, higher risk occurrences and magnitudes are controlled by a smaller portion of the risk causes (Zhou & Irizarry, 2016)	Most disputes/risk can be attributed to roles of owner's agents (Zhu & Cheung, 2020)
4. Systems are influenced by their external events	Vulnerability and capacity to withstand disruptions in terms of resilience represents the negative and positive dimensions of risk consequences (Qazi et al., 2020b)	Some interventions (measures & strategies) fail to achieve their intended goals (Griffiths et al., 2017)
5. The whole is greater than the sum of individual parts	Due to combinations among risk or dispute causes, causation paths can be ambiguous. This behavior can lead to subjective liability apportionment (Schenck & Goss, 2015)	Contestable dispute resolution decisions (Cheung & Pang, 2013)
6. Conversion of linear inputs into nonlinear outputs. Thus, a small change can produce un-proportionate consequences	It reflects the inability to revers ownership of resources incorporated into a construction project site. this is because site ownership excludes suppliers like contractors (Chang & Ive, 2007b)	Contractor switching(Winch, 2008), unfair terminations (Zhu & Cheung, 2020)

Source: synthesized from the indicated sources

3.5.2 Unity of Analysis

Identification of a unity of analysis is a crucial step in the design of a case study (Yin, 2017). In the case study of an interdependent network modeling process, the unit of analysis is the interdependency component. Because interdependence is a critical component of a network that is used to characterize network functions, it is important to understand it. As such, it can provide insight into a number of different aspects. For instance, the interdependency component can be used to assess vulnerability to risks (Guo et al., 2020a) and resilience to disruptions. In this manner, it provides a means of measuring the negative and positive dimensions of a risk consequence. As a result, one side of the interdependent network model is used to determine the construction contractor's exposure to payment risks. On the other hand, it demonstrates the owner's ability to acquire the constructed product at a price lower than the actual. As a result, by connecting the two risk dimensions, the study hopes to broaden understanding of payment risks.

3.5.3 A Framework for Integrating Incompatible Practices with Contextual Determinants

The second step in creating a network interdependency model is determining the model inputs. In order to accomplish this, an integrative framework of incompatible practices and their contextual antecedents is developed (figure 3.3). The raw side of this framework displays the incompatible practices adopted from Table 3.3. The column side, on the other hand, contains a list of modified contextual determinants. Their operational indicators are shown in Table 3.6.

Determinants/Consequence → Practices/Risk cause ↓		Adverse selection opportunism CD 1	Moral hazard opportunism CD 2	Power asymmetry CD 3	Asset specificity CD 4	Substantive uncertainty CD 5	Hold-up CD 6	Institutional uncertainty CD 7	Contractual incompleteness CD 8	Opportunism of the integrator CD 9	Strategic misrepresentation CD10	Boundary spanning CD11
Skewed resource allocation position	P1											
Use of repeat business enticement	P2											
Payment upon satisfactory performance	P3											
Doubling as buyer and producer	P4											
Not matching output with sums paid	P5											
End-product & site none-separability	P6											
Part deferral during certification	P7											
Doubling in design & certification	P8											
Communication via consulting unit	P9											
Uncertainty avoidance	P10											
Poor third party fault visibility	P11											

Key

P=Practice

CD=Contextual determinant

Figure 3.3: Integrative Matrix Framework of Practices and Contextual Determinants

Source: constructed from research data

In contrast to conventional approaches to risk modeling, Figure 3.3 presents incompatible practices as risk causes and contextual determinants as risk outcomes. It is evident from Figure 3.3 that there are no direct interdependencies between causes and their effects. This is due to the fact that the cells suggest correlations between incompatible practices and their outcomes. In addition, the co-occurrences above the diagonal are identical to those below. Due to their similar characteristics, only one side is displayed.

In addition, the column side co-occurrences represent events. Co-occurrence of events is an important factor in determining the frequency of risk (Fang et al., 2012). As a risk occurrence probability, it is determined by the number of risk events in which a cause has been involved (Aljassmi et al., 2014). Risk instances can be measured by documenting actual occurrences or by conceptualizing participation in an event based on the opinions of experts. In this phase, the rating of the payment dispute resolvers who participated in their resolution is utilized.

The second dimension entails measuring the risk's magnitude in terms of interactions between causes and events (Wambeke et al., 2014). Typically, this is achieved by identifying interdependency pathways as links between causes and their effects. In this sense, the interdependency property provides a method for determining the degree to which a system as a network is susceptible to risks.

Table 3.6: A Revised List of Contextual Determinants as a Proxy of Payment Risk Consequences

Contextual determinant	Definition within the construction contracting domain	Patent indicators
1. Adverse selection opportunism	Misrepresentation of owner payment capacity due to un-observability of his true intentions during the contract formation stage	□Non-disclosure of funding arrangements (Xiang et al., 2012) □Nondisclosed intent that contractors will part finance the project (Abdul-Rahman et al., 2014)
2. Moral hazard opportunism	Use of repeat business promise as a disguise for extracting unmerited gain from contractors during the performance stage (Wu et al., 2011a)	□Unreliability of repeat business promises □ Low trust between contracting parties □ Intentional misinterpretation and contract dominance
3. Power asymmetry	The disproportionate process control in favor of owners owing to swapping of with buying functions(Malatesta & Smith, 2011)	□ Disputes over unilateral deductions of value of work done due to alleged defective work (Zhu & Cheung, 2020)
4. Asset specificity	The irreversibility of the inputs incorporated into the end product because its ownership rights exclude non-owners even if they contributed to its construction (Chang & Ive, 2007b)	□Disputes over the value of progress and final account payments (Chang & Ive, 2007a)
5. Substantive uncertainty	The inefficacy of payment remedies due to the misinterpretation of ambiguous and incomplete information (Barman & Charoenngam, 2017)	□ Ineffective payment remedies
6. Hold-up	The ability of the owner or his agents to coerce the contactor into dropping its claims for additional payments (Chang & Ive, 2007a)	□ Unfair termination □ Deliberate failure to honor payment obligations (Abdul-Rahman et al., 2014)
7. Institutional uncertainty	Failure to adapt to the occurrence of unexpected events due to lack of shared understanding among the parties (Barman & Charoenngam, 2017)	□ Shortage of funding due to the unreliability of the projected cash-inflow sources □ Inaccurate owner forecasts
8. Contractual incompleteness	Liability avoidance over the differences between the forecast contract price and the actual outturn price (Turner, 2004)	□ Design errors and failure to value variations (Abdul-Rahman et al., 2014)
9. The opportunism of the integrator	The willingness of the agents to extract unmerited gain owing to their doubling in design/cost planning and contract administration (Winch, 2001)	□ Under valuations (Peters et al., 2019)Rent-seeking (Le et al., 2014)
10. Strategic misrepresentation	It reflects the agent’s conspiracy with the owner disguised by practices that are aimed at understating project cost (Flyvbjerg, 2009)	□ Insufficient funding arrangements (Peters et al., 2019a) □ Counterclaims over alleged defective work
11. Boundary spanning	A network conceptualization, where disconnected entities are connected by boundary objects such as contract documents and spanners such as contract administration roles (Fellows & Liu, 2012)	□ Involvement of many and varied parties in the payment process (Peters et al., 2019) □ Errors in design and poor contract administration (Abdul-Malak et al., 2019)

Source: Synthesized from the indicated sources

3.5.4 Source of Data and Selection Procedure

In constructing a model of an interdependency network, information is gathered from subject matter experts who participated in events resolving payment disputes. Their specialized knowledge is utilized to assess the probability of occurrences and severity of payment risk exposure. The level of expertise is as described previously (Table 3.2). This demonstrated the level of participation in the resolution of cases involving payment disputes.

The procedure for selecting the dispute cases and the dispute resolvers involved is identical to that of phase two. In the previous phase, the SME's opinion was used to determine the extent of practice incompatibilities; in this phase, the SME's opinion is employed to evaluate previously formulated propositions. Therefore, since the SME selection procedure is similar to the steps used in phase two, there is no point in repeating them here.

3.5.5 Data Collection Procedures

The data collection process for modeling an interdependency network consisted of three main steps. These include (a) qualitative framing of interdependencies, (b) interview schedule development, and (c) conducting structured interviews. Each is described in detail below.

(a) Qualitative Framing of Interdependencies

The qualitative framing of interdependencies was required because it resulted in the propositions shown in Table 3.7. To identify interdependencies, a method of narrative synthesis was utilized. In this method, three steps are suggested (Cruzes et al., 2015). These are 1) theoretical framework development, 2) preliminary analysis, and 3) relationship exploration. Each is described in detail.

1. During the theoretical formulating phase, concepts from the marketing mix, transaction cost economics, principal agency, and complexity by interdependency theories were identified and compiled. Then, these were

used to derive and combine the practices in Table 3.3 with the contextual determinants in Table 3.6.

2. During the preliminary synthesis phase, patterns across numerous studies were identified. Column 1 of Table 3.7 serves as an example of how the patterns were later used to describe the relationships between contextual determinants and practices, which in turn influence payment risks.
3. In the final phase of exploring relationships, indicators that suggested the underlying patterns were identified. In column 2 of Table 3.7, a sample of the relationship indicators is displayed.

Table 3.7: Identification of Interdependencies and their Propositions

Interdependency label	Key indicator (s)	Proposition
1. Adverse selection vs owner resource advantaged position	Disequilibrium between tenders and number of bidders (Skitmore et al., 2006)	The contractor's resource disadvantaged position portends exposure to post-contract payment risks
2. Moral hazard vs the repeat business strategy	Contractor's need for work (Skitmore et al., 2006) and the strategy to procure at a minimum cost (Chang & Ive, 2002b)	Unreliability of repeat business promises exposes contractors to payment risks
3. Power asymmetry vs payment upon satisfactory performance	Imbalanced end-product control structure (Zhu & Cheung, 2020)	The less control over the final product exposes the contractor to payment defaults
4. Asset specificity vs doubling in buying and co-production	Unfair contractor termination and replacement (Winch, 2008)	The doubling of production and buying portends unbalanced process control and in turn exposure to payment risks
5. Substantive uncertainty vs not matching sums paid with the actual outturn	Intentionally misapplied contractual terms (Barman & Charoenngam, 2017)	A skewed interpretation of contractual terms can lead to liability misallocation and, consequently, payment risk
6. Hold-up vs delimiting site possession from its legal	Weak rights of payment default remedies (El-adaway et al., 2017a)	The practice of separating site possession from legal ownership exposes contractors to payment risks
7. Institutional uncertainty vs deferred certification	Unanticipated variations and inaccurate cash flow forecasts (Abdul-Rahman et al., 2014)	Lack of understanding over inaccurate cash flow forecasts can expose contractors to payment risks
8. Contractual completeness vs doubling in design and certification	Under-certifications (Peters et al., 2019)	A certifier's defense against liability for inaccurate cost projections, can expose contractor payment risks.
9. The opportunism of the integrator vs impediment of payment flows	Collusion and kickbacks (Le et al., 2014)	The engineering agent's rent-seeking behavior can expose contractors to payment risks
10. Strategic misrepresentation vs uncertainty avoidance	Initiating projects without adequate funding (Peters et al., 2019)	The owner and consulting agent's informational advantages can expose contractors to payment risks
11. Boundary spanning vs poor visibility of fault	Skewed evidence in the resolution of disputes (Ive & Chang, 2007)	Intermediaries can reduce the quality of the third party's decision, which in turn increasing the contractor's exposure to payment risks

Source: synthesized from the indicated sources

(b) Interviewing Schedule

Table 3.7 items were utilized during the stage of interview schedule formulation. According to Appendix IV,' the interview schedule consists of twelve propositions, their respective questions, and a four-point Likert scale. Using this scale, 0 means disagree, 1 means slightly agree, 2 means agree, and 3 means strongly agree. This interview schedule was used to collect data for modeling, identifying, and analyzing the interdependencies shown in Table 3.7.

(c) Interviewing Procedure

The opinions of subject matter experts were gathered through the use of a structured interviewing technique. The rationale for selecting this method is identical to that presented in phase two. Therefore, it is unnecessary to repeat them here. Similarly, the procedures for selecting interviewees and conducting interviews are identical to those outlined in phase two.

3.6 Social Network Analysis Quantification Methods

This study employed several SNA techniques. Some are utilized throughout all three phases, while others are unique to each research objective. Across all three objectives, for instance, the two-mode and one-mode matrix is used. Similarly, Table 2.4 provided a summary of the metrics and concepts at the macro level. In addition, this subsection explains how different aspects of the research were measured and analyzed.

3.6.1 Measuring Influence of Nodes on Payment Dispute Risks Using Centralities

In determining a node's level of influence in a network, the SNA perspective suggests using the concept of centrality. There are numerous metrics associated with centrality. However, only weighted degree, eigenvector, and Bonacich power were used to measure the influence of contextual determinants on co-occurrences of payment dispute risk. The results of these complementary methods are used to triangulate each other. They were computed using UCINET software version 6.72.

This is accomplished by inputting the results of the one-mode matrix into the Network function. Following this step is the selection of the Centrality function. This step provides a list of various centrality measures from which to select the required metric. A one-mode matrix is inputted onto a dashboard upon which the selection is displayed.

Nevertheless, it is crucial to provide a concise explanation of the weighted degree, eigenvector, and Bonacich power metrics. As a result, their outline is presented below.

1. **Weighted Degree Centrality.** In an undirected network, degree centrality measures a node's influence in relation to the number of its immediate connections. The direction of influence is assumed to be equal if it is undirected. In the context of risk assessment, the level of influence indicates how much risk a contextual determinant can generate among its immediate neighbours. In this way, it provides a method for ranking contextual factors based on their likelihood of causing payment disputes. Since degree centrality does not account for unweighted data, the weighted degree centrality metric developed by Opsahl et al. (2010) was utilized instead.
2. **Eigenvector Centrality**. This metric measures how well connected a node is to other central nodes. In doing so, it takes into account all of a node's possible connections and their associated weights. In this manner, eigenvector centrality reveals a contextual determinant's level of influence in enabling other determinants and being enabled in return. Eigenvector centrality assigns scores to nodes based on the premise that connections to nodes with higher degrees indicate greater influence than connections to nodes with lower degrees. In this regard, it yields superior results to degree centrality.
3. The **Bonacich Power** centrality is a modification of the degree centrality method that measures the degree of power of a node based on the connectivity of its neighbours. This applies to a network in which the nodes have varying degrees, indicating a status of power disparities. If, for instance, a node is connected to nodes with lower degrees, it will exert a greater influence over them. In contrast, if a node is connected to nodes with a higher

degree, its influence will be diminished. In addition, a normalization beta factor is typically applied to eigenvector and Bonacich power centralities.

3.6.2 Measuring Payment Dispute Risk Propagation Using Structural Holes

In the network approach to risk modeling, the connectedness of risk causes or determinants can enable or disable risk outcomes (Fang et al., 2012). In contexts where connections are indirect or ambiguous, however, studies such as Eteifa and El-Adaway (2018)demonstrate that an event-based approach can identify co-occurrences between risk causes. In accordance with this context, evidence of late, incomplete, or non-payments can be obtained by identifying cases of payment dispute co-occurrence. Various metrics can be used to measure the propagation of payment dispute risks in such co-occurrences. The concept of structural holes is one of the most prevalent methods for calculating risk propagation capacities(Song et al., 2019). Effective size, efficiency, constraint, hierarchy, and hole signature are typical metrics associated with the concept of structural hole(Saglietto et al., 2020). Although brief descriptions of these metrics are provided, only the first three are utilized in the current study.

1. The **effective size** metric measures the frequency with which each node is disconnected from other nodes. This metric indicates the number of non-redundant connections, and the greater it is, the larger the effective size of a node that fills a structural hole. This metric computes the total number of non-redundant connections to each focal node, also known as an ego (Borgatti, 1997). The effective size score ranges from 1 to the node with the greatest number of observed direct connections that is not an Ego. The ego is the central node that connects the unconnected or indirect nodes, also known as alters(Saglietto et al., 2020). Weak connections represent gaps because they have the potential to impede the spread of ideas or risk (Burt, 2001). In conclusion, the greater the effective size value, the greater the risk propagation capacity.
2. The **efficiency** metric measures the non-redundant portion of the network. This metric is computed similarly to effective size, but its score is normalized by the

number of alters the ego possesses (Borgatti, 1997). A higher score indicates that a greater proportion of alterations have indirect connections (non-redundant), resulting in decreased diffusion efficiency. A low score, on the other hand, indicates that a small number of alters have non-redundant connections, resulting in a greater diffusion efficiency. Thus, the metric reveals the maximum number of non-redundant connections and optimizes the number of structural holes per connection.

3. The metric of **constraint** measures the degree of dependence on a particular ego by determining the absence of holes among alters (node). In this manner, it indicates the absence of alternative options (Heng & Loosemore, 2013). This metric has the same influence as the site and process asset specificity Table 3.7 and hold-up indicator Table 3.6. As a result, the constrained node is rendered irreversible and therefore susceptible. So, a lower score means less constraint and, as a result, less vulnerability to exploitations. In contrast, a higher score denotes greater constraint and, consequently, greater risk exposure vulnerability.
4. **Hierarchy** quantifies the degree to which the constraint metric is concentrated on a single alter (node). Consequently, a higher score indicates that constraint is concentrated in a single node, whereas a lower score indicates that constraint is uniform across all alter nodes (Scaliante Wiese et al., 2014).
5. The metric of hole signature is a technique for determining the relationship between the degree of the node and the extent of the constraint.

3.6.3 Constructing Interdependencies Based on Flow Betweenness

After constructing a 1-mode adjacency matrix, the second and third research objectives suggests a focus on connections. As a result, a flow betweenness metric is used to establish links between incompatible practices and the enablers of those practices. The metric, developed by Freeman et al. (1991), takes both weighted and unweighted data into account in proportion to the paths of the entire network, rather than the shortest path (geodesic). The geodesic distance technique presupposes the presence of a few intermediaries, which results in faster transmissions (Aljassmi et al., 2014). However, to determine the relatively higher degree of dissimilar connections between the boundaries associated with the D-B-B in comparison to other structures(Skitmore & Smyth, 2007), all possible network connections must be considered. For example, Li et al. (2011) use the flow betweenness metric to assess the influence of intermediary roles on contractual relationships, and Eteifa and El-Adaway (2018) use it to determine the rate at which a connection between unrelated construction accidents causes enables or disenables accident occurrences. With these examples, it appears that adopting a networked perspective on unrelated roles can help reveal the associated conflicting interests and strategies.

3.6.4 Measuring Dissimilar Connections and Clustering

One method for partitioning an interconnected data structure is to use a structural equivalence metric. Consequently, it is possible to measure similarities or dissimilarities. As an illustration, connections within clusters, such as the consulting unit, frequently exhibit similar interests, and thus their degree of similarity can be quantified. Clusters with competing interests, on the other hand, exhibit weaker points and thus indicate separation interfaces, as there are more economic differences between clusters than within Table 3.3. Thus, the extent of the differences reflects payment-related challenges and is thus quantifiable using techniques such as the structural equivalence matrix (Loosemore, 1998). While other techniques, such as hierarchical clustering (Solis et al., 2013), can accomplish the same thing, the Euclidean distance method enables the profiling of roles based on their dissimilarities.

3.6.5 Measuring Distances between Connections

To index dissimilar connections and their patterns, one method considered relevant for this study is the Euclidean distance. In comparison to other methods, it is optimized for non-linear and weighted relationships. Due to these capabilities, its score can be greater than one, in contrast to similarity measures, which have a range of scores between 0 and 1. For example, when the lowest score is zero, the connections are more similar in terms of their utility-maximizing interests. On the other hand, the closer the score is to zero, the less dissimilar the connections are. Lee et al. (2016), in particular, employ the Euclidean distance method to deduce the strategies that distinguish the performance of firms bidding on construction projects for the same client. The application of the Euclidean distance method to this conceptualization reveals how the degree of dissimilarity enables payment problems.

3.6.6 Using Eigenvector and Eigenvalues to Describe Critical Initiators and Transmitters

One of the ways of measuring entities that initiate and transmits risks is to use the method of Eigenvector and Eigenvalues. The Eigenvector centrality is regarded appropriate since it links various eigenvalue constants with their corresponding eigenvectors and so allows for the identification of the most significant connections based on the contribution of the entire network. Eigenvalues, as used in El-Adaway et al. (2017b), reflect the extent of the pattern of connections based on the method of weighted geodesic distances determined from the location of each node, an incompatible practice in this respect. Thus, the measure solves the drawbacks of degree and closeness centralities (Chowdhury et al., 2011). The weighted geodesic technique finds the shortest connecting path between practices (Pishdad-Bozorgi et al., 2017).

3.6.7 Determining Vulnerability Controls

In objective, it is necessary to establish vulnerable interdependencies due to the controlling roles of boundary objects and the integrator's behavior. This implies that the inability to maintain a balance between the resources incorporated into the project and their payments demonstrates vulnerability to payment risks. As a result, the maximum-flow betweenness metric was chosen. This metric computes the intensity of flows between nodes. In contrast to traditional betweenness, it is sensitive to weighted connections and focuses on flows between nodes (Eteifa & El-Adaway, 2018). In the D-B-B, objects such as contractual documents and integration agents represent a minimum value because they indicate interdependence between dissimilar organizations. A maximum value, on the other hand, indicates interdependence within an organization.

3.6.8 Locating Payment Flow Disruptors

Finally, to profile vulnerability, the lambda set method is also used. This method considers vulnerability to risks at its peak where interdependence is weakest and at its minimum where it is strongest (West, 2014). The maximum-weakest assumption is frequently used to locate cut-points and is also related to the concept of interdependence between heterogeneous ownerships. On the other hand, the weakest assumption implies the existence of interdependence between homogeneous units. West (2014) used the maximum-weakest principle to identify areas of flow disruption. This approach also allows for the profiling of vulnerability to payment risks.

3.6.9 Establishment of Interdependencies

Establishing interdependencies is usually done by finding network entities through positional, event, and relational approaches (De Stefano et al., 2011). Chowdhury et al. (2011) demonstrate, the positional approach bases the list of network entities on organizational roles. The event-based approach identifies entities that are interdependent based on their co-occurrence in events. As Pishdad-Bozorgi et al. (2017) demonstrate, one of the examples is the interdependence of practices resulting from an engineering-procurement-construction (EPC) system. The relational approach, on the other hand, entails interactions between human actors, such as communication between project teams. Because Kenya lacks an official list of payment dispute resolvers, their assessment of the D-B-B practices' effect on payment risks is event-based.

3.7 Criterial for Judging Research Quality

In research, validity and reliability are commonly used as measures of quality(Saunders et al., 2016). Validity is the extent to which a construct or variable accurately represents an investigated phenomenon, whereas reliability is the degree of duplication (Bryman, 2016). With this knowledge in mind, the associated parameters for the two quality measures are discussed. The objective of the quality measures is to guarantee the truthfulness, confirmability, transferability, and dependability of the findings.

3.7.1 Research Validity

In a case study design, adherence to study construction and investigation validity is a crucial aspect of research (Yin, 2017). Since this study is based on a case study design, data and theoretical triangulation were used to ensure the study's validity (Quintão et al., 2020). In the first objective of the study, two sets of payment dispute cases were extracted from an online archival record. The first set consisted of 29 cases involving owners/clients from the private sector. The second set included 22 cases from owners/clients in the public sector. The cases aimed to determine the co-occurrence and magnitude of contextual determinants of late payments, underpayments, and non-payments. The study confirmed the co-occurrence of contextual factors across multiple payment dispute cases based on network analysis. In this way, triangulation of data was illustrated.

Similar to the first objective, the second and third objectives exhibited data triangulation. For example, the second objective assessed the incompatibility of contracting practices that emerged from the first phase's contextual determinants and their relationship to payment risks. Twelve subject matter experts were asked to evaluate the practices through a structured interview process. Some practices were determined to be more incompatible than others based on the responses received. In this sense, the utilization of 12 evidence sources demonstrated data triangulation.

The test of theoretical triangulation was also met by the study. This is due to the fact that its contextual determinants and contractual practices were derived from literature based on market mix (MM), transaction cost economics (TCE), principal-agency (PAT), and complexity by interdependency theories. As a result, some variables in the study were complemented while others were contrasted. For instance, the technologically distinct interfaces involved in the transformation of independently owned resources into a construction project suggest a complement to the interdependencies in the theory of complexity by interdependency. Similarly, numerous contrasts were depicted. For instance, it was discovered that the practices associated with the place element in the MM were not fully compatible with those of the site and process specificity in TCE. Therefore, the study passed the theoretical triangulation test because it drew on multiple sources of evidence.

It is important to consider both the internal and external components of an investigation's validity (Bryman, 2016). Internal validity in a case study design is concerned with demonstrating whether interdependencies between variables contribute to the investigated problem (Quintão et al., 2020). In this study, the private and public subnetworks demonstrated that the frequency and magnitude of payment disputes are dependent on the interactions between contextual determinants. In addition, this interaction produces incompatible practices that are associated with payment risks. It was also demonstrated that the practices acted as risk factors. The risk causes were used to construct a model of interdependency network. The model results identified, among other things, ten interdependency channels to payment risks. In this regard, the study met the criteria for internal validity.

External investigation validity is concerned with the degree of environmental (Yin, 2017). Statistical generalization is commonly used in designs such as surveys (Bryman, 2016). Nonetheless, in case study designs such as this one, analytical generalization is frequently used (Quintão et al., 2020). This was determined by comparing the study's findings to a priori theoretical principles. The scale-free network topology presented in Chapter two is one example of such a principle. In fact, it was determined that the findings of chapters four and five were consistent with this principle. In this regard, it was determined that 20% of the risk practices initiated and transmitted approximately 80% of the payment risks. This finding was confirmed by the power law equation, which is also consistent with the Pareto principle or the idea that the rich get richer. In this regard, the research met the criteria for theoretical generalization.

3.7.2 Research Reliability

Reliability is measured by the ability to replicate the study (Bryman, 2016). Most of the time, internal and external reliability measures are used in research designs like surveys (Quintão et al., 2020). In contrast, case data bases and protocols are utilized in case study designs such as this one. Accordingly, in the first phase of the study, the selected payment dispute cases were coded and excerpts were provided in appendices 'E' and 'F'. In the second and third phases, the demographic profiles of the selected subject matter experts who rated incompatible practices and propositions used to construct the interdependency network model are depicted in Table 4.13. Protocols, whose purpose is to outline case-specific rules and procedures, are another method for addressing threats to reproducibility. In accordance with this, chapter three describes the rules and procedures utilized in this study.

Another way to address reliability concerns is to provide a clear operationalization framework for the research variables (Creswell & Creswell, 2017). Such a framework is essential because it provides a basis for replicating the study. In Table 3.2, a coding scheme for the contextual determinants applied in phase of the study is provided as an example. Each labeled determinant is theoretically defined and its operational indicators are identified within the framework. Therefore, the study can be replicated if such frameworks are provided.

3.8 Ethical Considerations

In research, the concept of ethics refers to the adequacy with which standardized behavioral principles have been adhered to and, consequently, their impact on those from whom data has been obtained (Saunders et al., 2016). These principles span the research design, data access, collection, analysis, and reporting processes (Bryman, 2016). These include researcher safety, data access, participant privacy, and informed consent. Various precautions were taken by this study to prevent their collective violation.

The topic of construction contractor payments in the Kenyan construction industry is characterized by personal sensitivity and confidentiality. Payment details pertain to the owner/client, the contractors, and, by extension, their respective agents. Therefore, it is difficult for parties outside the network to obtain payment-related information. In this study, the data set was compiled from online public repository cases of payment disputes. As such, no authorization was required to access these records; however, precautions were taken to protect the privacy of the parties named in the cases. This entailed assigning code labels to the cases and excluding the text containing the names of the parties from the data excerpts. Overall, the National Commission for Science, Technology, and Innovation granted a research permit, which is appendix VIII.

In selecting the subject matter experts for the second and third objectives, the study accounted for potential ethical violations. First, the invitation to participate stated that the data collected would be used exclusively for research purposes. The primary focus of the study elucidated the reason for conducting the research. In addition, informed consent was obtained from subject matter experts. As a result, the responses were assigned Appendix VI through Appendix VII. This means that the findings and results cannot be linked to those who took part in the study.

3.9 Chapter Conclusion

To this end, this chapter has presented the methodology of the study. It is arranged under the philosophical positioning, research strategy, methodologies for each of the three research phases, the social network analysis quantification concepts and metrics. The final part discussed the criterial for judging the research quality that comprised of the measures of validity and reliability. It also explains the ethical principles and how measures to their violations were addressed. The next, chapter presents data analysis and discussion.

CHAPTER FOUR

RESULTS, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents results, analysis and discussions of three objectives.

4.2 Objective One

This objective presents results, analysis and discusses pertaining influence of contextual determinants on payment disputes as a proxy for payment risks from an interconnected perspective. By conceptualizing contextual determinants as nodes, the position of the nodes is characterized and analyzed. To do this, evidence of contextual variables was extracted from the payment dispute cases whose decisions were rendered between 2010-2019. The results entails demographic profile, matrix, graphical, nodal and structural hole.

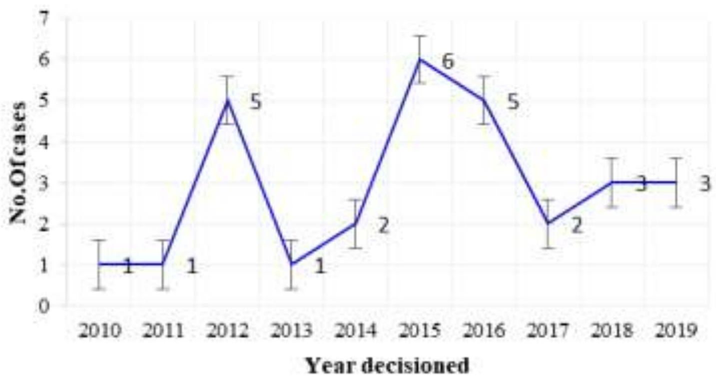
4.2.1 Demographic Aanalysis

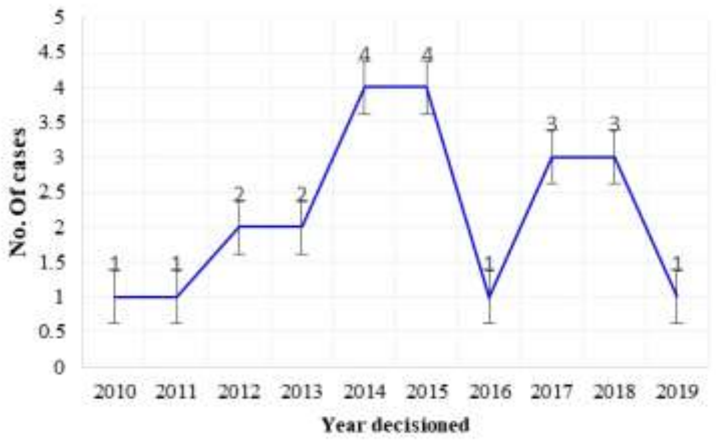
The data on demographics is analyzed and discussed under a ten-year distribution trend, the subject of work and form of contract conditions. These are discussed within their respective subsections below.

(a) A Ten-year Trend Distribution

Fig. 4.1 (a & b), presents trend distribution of the sampled payment dispute cases according to the decisioned year. The first part shows that the private sector had 29 cases, which were decisioned between 2010 and 2019. A notable observation is that the year 2015 had the highest number of cases, while 2010, 2011 and 2013 had the least, that is, one case each. Since the sampled cases are as a result of case referals from lower dispute resolution forums such as arbitration, the distribution of the peaks and lows do not indicate increase and reduced dispute instances. Accordingly, the study of these litigations is merely evidence as to the co-occurance of contextual causes. In turn, their analysis provides a way of identifying the associted practices, which in phase two are assessed for compatability.

Fig. 4 (b) shows that the public sector had 22 cases over a ten-year period. Similar to the private sector, the highest number of cases occurred in the year 2014 and 2015. Moreover, 2010, 2011, 2016 and 2019 had the lowest number of cases. Due to the contextual differences between private and public contracting, the two clusters are analysed and discussed separately.

<table>
<tr><th>Year decisioned versus No. of cases</th><th>Sector (n)</th></tr>
<tr><td>
</td><td>Fig. 4.1 (a)

Private (n)= 29</td></tr>
<tr><td>
</td><td>Fig. 4.1 (b)

Public (n)= 22</td></tr>
</table>

Figure 4.1: (a & b) Number of Selected Payment Dispute Cases from 2010-2019

Source: constructed from filed data

(b) Type of Work

Fig. 4.2 presents background of the cases in terms of their work typology. First, the center circle shows that 57% of the cases involved the private sector, while public sector involved 43% of the cases. The private sector cases involve a direct contract between the construction owner/client versus the main contractor. There is also a direct contract between the owner and a consulting unit. Depending of the type of contract conditions, the leadership of the agency may be held by an architect, an engineer and a project manager. This agency relationship portends existence of an indirect relationship between the main contractor and the consulting unit. This asymmetry tends to promote a position in which the consulting unit can broker information to the disadvantage of project owners and their contractors. Because the consultant is hired and paid by the project owner, the role is sometimes used to exploit contractors. The lack of a direct connection, despite acting on behalf of the project owner and participation as a supplier of design and cost plans tends to expose contractors to risks such as payment disputes. However, tracing how the owner's cost economization strategies via the consulting agent is connected to the payment related disputes is for example less apparent. Thus, the private/public sector dichotomy is relevant because each setting has some distinctive features that in turn may portend varied payment dispute causation patterns.

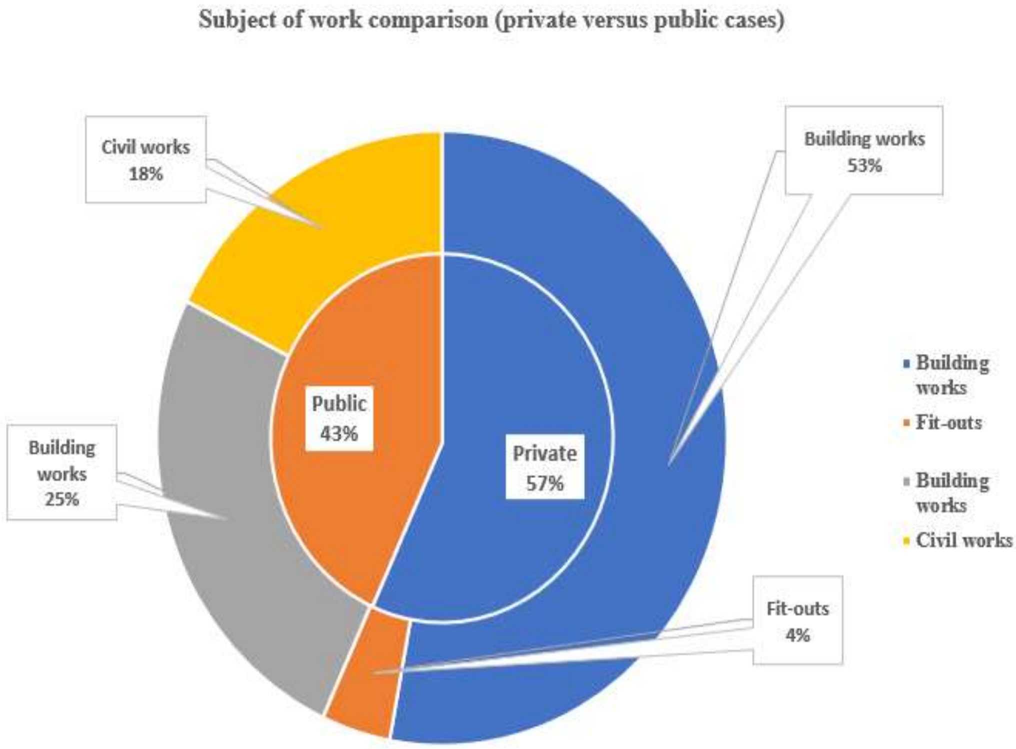


Figure 4.2: Subject of Work in Payment Dispute Cases from 2010-2019

Source: constructed from filed data

Secondly, the outer circle compares the type of work as per the cases from the private and the public sector respectively. In the private sector, 53% of the cases involved building type of works, while fit-outs represented 4% of the cases. On the other hand, the public sector payment disputes involved 25% of building works and 18% of the civil engineering works. A notable difference is that the private sector is not involved in the civil works. Similarly, an observable commonality is that building works account for a majority of payment disputes. While a private client can undertake civil works such as roads and railways, their popularity with the public sector is indicative of the public sector's social-economic mandate. Therefore, the differences in the occurrence of payment disputes should be understood for that context.

Another reasons as to why the building works are more prone to payment disputes is suggested by their overreliance on the fixed price contract mechanism than the case is with the civil works. A key principle of the fixed price mechanism is a tendency to swap certainty with uncertainty (Malatesta & Smith, 2011). This swapping is reflected in practices such as determination of contract prices ahead of construction. However, because a completed construction product does not exist at the time of signing the contract, certainty practices are not fully compatible with the context of realizing construction projects. The result includes contestations manifested in outcomes such as payment disputes, which reflect a negative side of the risk to contractors. Therefore, the distribution of payment dispute occurrences indicates the contextual differences between the type of project work and ownership. This finding is in line with studies that focus on uncertainty such as Gao et al. (2018), and thus, reinforces the significance of the link between project complexity and occurrence of transactional risks.

(c) Form of Contract Comparison

Fig. 4.3 presents a comparison on the form of contract conditions upon which the cases were founded. The inner circle depicts the payment dispute occurrences according to the private and public sector respectively. The private side of the outer circle shows that a majority of the cases, that is, 47% were based on the Joint Building Council JBC 1999 edition. Additionally, 6% utilized base poke contract conditions, while 4% were based on the International Federation of Consulting Engineers FIDIC red book 1999. On the public side of the outer circle, a majority, that is, 23% utilized the Public Procurement Oversight Authority 2005 edition. Additionally, 18% of the cases utilized the FIDIC Red book, while only 2% utilized base poke conditions. Accordingly, at least two findings can be stated.

The first observation is that the FIDIC form is more popular with the public sector than the private sector. According to Fig. 4.2, that popularity stems from its wide usage in civil works than other types of work. This is because the civil works forms part of the public sector's core mandate than the case is with the private sector. Accordingly, fewer payment disputes are associated with the FIDIC conditions of contract than other forms. This finding suggests a correlation with the associated payment mechanisms. While the FIDIC red book entails more than one payment mechanism, the cost-plus tends to dominate the civil works (Malatesta & Smith, 2011). Unlike, the fixed price mechanism, the cost-plus is based on uncertainty rather than certainty principle. In other words, the cost-plus payment mechanism is premised on the assumption that the contract price cannot be determined with complete accuracy before the product is constructed. As a result, it provides for ways of adapting to the futuristic deviations, which in turn means relatively fewer payment disputes. Indeed, this finding is corroborated by studies such as Love et al. (2015), which find that cost variations are more severe in civil projects than their building counterparts.

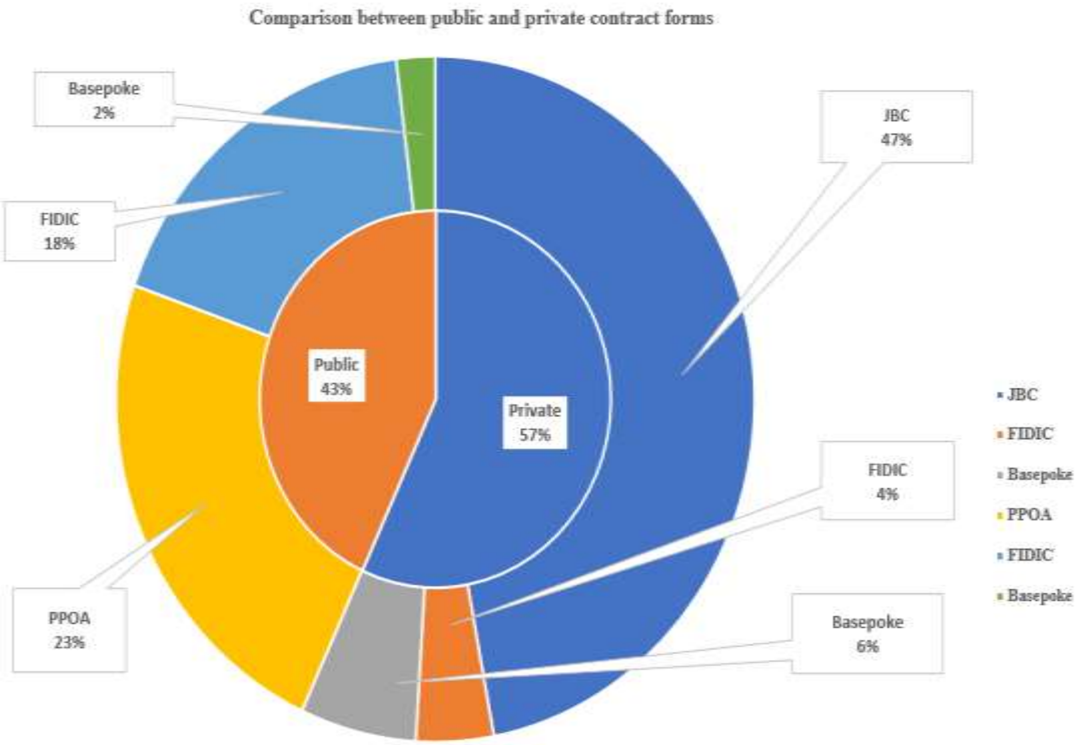


Figure 4.3: Public versus Private Contract form Comparison

Source: constructed from filed data

Another observation is that more payment disputes are associated with the JBC conditions than it is the case with the PPOA. A key feature of the PPOA is that the bidder's litigation history is a critical part of the contract award criteria. In turn, this practice also influences the construction market. In line with prior observations such as Skitmore et al. (2006), there are more bidders than the number of projects on tender at any one given point in time. This inequality suggests that certainty of the future workload is a possible hindrance on the part of the contractors in seeking redress in arbitration and litigation. Therefore, a lower occurrence of payment disputes in the public sector does not provide a comprehensive account.

4.2.2 Result on Matrix Analysis

In this subsection, the data from the two sets of payment dispute case is used to establish the contextual determinants outlined in Table 3. 2. This result is first presented in a two-mode matrix format.

(a) Two-mode Matrix for the Private Sector

Table 4.1 presents a two-mode a private sector data set, which is also an incidence matrix. As highlighted by the gray shade, the rows represent 29 payment dispute cases, while the column represents 10 contextual determinants. Their conceptual definitions and indicators were presented in Table 3.2. As such, Table 4.2 fleshes out the measured determinants. Overall, Table 4.1 indicates the number of times that each contextual determinant co-occurred in the 29 cases. According to the last column, which is shown in bold, site asset specificity had the highest occurrence, that is 24 times. Its occurrence suggests the contractor's inability to reverse resources (work) which have become part of the site. The inseparability of the site from its end-product, portends that contractual site possession by the contractor is not equivalent to legal ownership. The effect of this inequality is evidenced by various excerpts (Appendix E & F). This is in line with studies that cite inseparability of the constructed product from its site as a critical feature in setting the construction context apart in comparison with sectors such as manufacturing (Winch, 2003). The factor contributes to imbalanced interdependencies (Lin et al., 2017), which in turn provide exposure to transactional risks.

Table 4.1: Two-mode Private Sector Data Set

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
CD1	0	0	0	0	2	1	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	0
CD2	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2	0	0	0	2	0	0	0	1	0	1	0	0
CD3	1	0	0	1	1	1	0	0	1	1	0	2	0	1	1	2	0	3	0	0	1	1	2	2	0	1	0	1	1
CD4	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	2	0	1	1	0	2	0	0	0	0	0	0
CD5	2	0	2	0	1	0	1	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	2	0	1
CD6	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CD7	0	2	1	0	0	0	0	0	0	0	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0
CD8	2	0	0	0	0	0	0	0	0	0	2	10	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	3
CD9	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0
CD10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: constructed from filed data

The most frequent occurrence is followed by the moral hazard of the owner and bounded rationality whose occurrences are 19 and 15 respectively. Again, each of the determinants, that is, CD 1, CD2, CD4 and CD7, which represent process specificity, hold-up, power asymmetry and contractual incompleteness co-occurred 10 times. Lastly, CD 9, CD6 and CD 10 co-occurred 6, 4 and 1 times respectively.

Table 4.2: Contextual Determinants Measured

Node ID	Contextual Determinant
CD1	Process specificity (progress interdependence)
CD2	Hold-up
CD3	Site asset specificity
CD4	Power asymmetry
CD5	Bounded rationality
CD6	Adverse selection of the owner
CD7	Contractual incompleteness
CD8	Moral hazard of the owner
CD9	Moral hazard of the consulting unit
CD10	Transaction infrequencies

Source: Constructed from field data

The evidential excerpts for the occurrence of 10 determinants is presented in Appendix E. An important observation is that because of the lack of direct connections between the row and column variables, a nodal influence on the co-occurrence of payment defaults cannot be computed.

(b) Two-mode Matrix for the Public Sector

Table 4.3 presents a public sector two-mode matrix. As highlighted by the gray shading, the row presents 10 contextual determinants, while the column shows 22 cases. The contextual determinants are similar to those presented in Table 4.2. The last column, which is in bold presents frequency of occurrence. Just like the private sector cases, CD3, which represents site asset specificity had the most occurrences.

This result indicates that the in situ character of construction has an effect on contractor payment risks. It demonstrates the irreversibility of the contractor's resources once they have been integrated into the site, which is legally the property of the project owner. Under the D-B-B procurement system, such effects imply that the owner has greater process control, allowing him to configure the cost of realization to his advantage. This compares with Crespin-Mazet and Ghauri (2007), who demonstrate how the practice of doubling in buying and production functions by the project owner can influence occurrence of payment risks. The finding also emphasizes how the owner or his agents can use the irreversibility characteristic to extract economic benefits at the expense of his contractors. A significant implication of this finding is that it explains why the D-B-B is sometimes preferred over other procurement systems despite its ties to a number of consequences. This is consistent with the findings of Osipova and Eriksson (2011) , who found a correlation between the selection of the D-B-B procurement system and construction disputes and inequitable risk transfer.

Unlike, the private sector, contractual incompleteness (CD7) had the second most occurrence. The principle of contractual incompleteness is a significant feature of the D-B-B system, where data was sourced from. In that setting, for instance design roles are separated from construction. Thus, since CD7 suggests an inability to adopt to unexpected changes due to lack of a shared understanding regarding the default cause. This finding is reflected by indicators such as disagreements over liability apportionment of for example cost variances. It, thus, points to some unique features of the public sector contracting such as ambiguities over separation of ownership and control. The principle of separation of ownership and control means that legal project owner is ideally different from the controlling agent, in this regard a consulting unit. However, in the Kenyan public sector construction contracting, the roles of the owner and the controlling agent tend to be fused. This therefore explains why the contractual incompleteness related variations are more prevalent than case is with the private sector. This finding compares with Cheung and Pang (2013), who found that contractual incompleteness is a significant source of construction disputes.

Table 4.3 shows that process specificity (CD1), adverse selection of the owner (CD6) and moral hazard of the consulting unit (CD9) are the third, fourth and fifth most frequent causes of payment defaults respectively. Moreover, both hold-up (CD2) and power asymmetry (CD4) had equal occurrences. It is also shown that the moral hazard of the owner (CD8) had the least occurrence while there was no evidence of transaction frequency related payment disputes.

Compared to the private sector case, the absence of aspects of transaction frequency reflects some incompatibilities with some requirements of public contracting. Indeed, evidence from chapter two suggests that the context of transaction frequency explains that the effects of the pre-contract indicate an imbalance between more potential contractors than the number of projects on tender. The effect is reflected in characteristics such as seasonality of construction workload, whose mitigation measures include a repeat business in sense of futuristic promises. However, this strategy tends not to be in line with some public contracting requirements such as the fairness.

A key limitation of the two-mode for the private and public matrixes is the lack of direct connections between variables. As a result, nodal analysis from the perspective of interconnectedness is not possible. Moreover, it is also not possible to determine the relative influences of the contextual determinants on payment defaults. This limitation is however resolved by converting the two-mode matrix to a one-mode matrix.

Table 4.3: Two-mode Public Sector Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22
CD1	0	0	1	0	0	0	0	0	0	0	2	2	0	0	1	0	0	0	1	3	0	0
CD2	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
CD3	0	0	0	1	0	0	1	1	1	1	1	0	3	0	1	0	1	1	0	3	1	1
CD4	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
CD5	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
CD6	0	0	0	2	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0
CD7	0	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	3	1	1
CD8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
CD9	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0
CD10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: constructed from filed data

(c) One-mode Matrix of Contextual Determinants for the Private Sector

Table 4.4 (a) presents a one-mode matrix inclusive of diagonal entries for the private sector case. This matrix is computed by multiplying matrix 4.1 with its transpose. An interesting observation about the diagonal values is that they are similar to the two-mode matrix frequencies (Table 4.1). This similarity provides a mathematical proof that the matrix has adjacency properties. This in turn indicates that the transformation from two-mode to one-mode is equivalent to the original structural properties (Sánchez-García, 2020). In this sense, the computation is valid.

In the adjacency property, the value of one indicates presence of a link, while a zero indicates that a link is absent. Thus, the diagonal values indicate presence of self-loops. However, since a contextual determinant does not interact against itself, (Table 4.4(b) presents a one-mode or adjacency matrix without diagonal values. Because of its symmetric properties, the values above the diagonal mirrors those below the diagonal. This property also means that the matrix is undirected such that the outgoing and incoming directions are equal. In other words, the sequencing direction is not relevant. For example, in Table 4.4 (b), the co-occurrence interaction between CD1 to CD2 and vice versa is equal, as indicated by a value of 2.

Table 4.4: (a) A One-mode Private Sector Matrix with Diagonals; (b) Without Diagonals

(a)

	CD1	**CD2**	**CD3**	**CD4**	**CD5**	**CD6**	**CD7**	**CD8**	**CD9**	**CD10**
CD1	10	2	5	5	5	2	1	2	3	0
CD2	2	10	3	3	2	0	4	1	3	0
CD3	5	3	24	8	7	2	0	5	1	1
CD4	5	3	8	10	4	1	1	2	0	0
CD5	5	2	7	4	15	3	3	4	3	0
CD6	2	0	2	1	3	4	1	1	0	0
CD7	1	4	0	1	3	1	10	2	4	0
CD8	2	1	5	2	4	1	2	19	0	0
CD9	3	3	1	0	3	0	4	0	6	0
CD10	0	0	1	0	0	0	0	0	0	1

(b)

	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10
CD1	0	2	5	5	5	2	1	2	3	0
CD2	2	0	3	3	2	0	4	1	3	0
CD3	5	3	0	8	7	2	0	5	1	1
CD4	5	3	8	0	4	1	1	2	0	0
CD5	5	2	7	4	0	3	3	4	3	0
CD6	2	0	2	1	3	0	1	1	0	0
CD7	1	4	0	1	3	1	0	2	4	0
CD8	2	1	5	2	4	1	2	0	0	0
CD9	3	3	1	0	3	0	4	0	0	0
CD10	0	0	1	0	0	0	0	0	0	0

Source: Constructed from field data

Another observation is that the lines represent co-occurrence between the contextual determinants. In this regard, the contextual determinants are the nodes and linens between them represent payment dispute co-occurrences. The idea of co-occurrence captures the number of times the various dimensions, that is, contextual determinants of payment disputes occurred together. Moreover, these concurrences are weighted rather than binary. The weighting parameter indicates that beyond the presence of co-occurrences, a weighting is equivalent to the degree of impact. As an illustration, the co-occurrence between CD4 and CD3 suggests that it contributed to the highest severity of payment risks, as indicated by a value of 8.

(d) One-mode Matrix of Contextual Determinants for the Public Sector

Table 4.5 (a & b), presents a one-mode and hence an adjacency matrix. Its computation methodology is the same as that of the private case illustrated by Table 4.4 (a & b). The diagonal values are similar to the frequencies illustrated by Table 4.3. This means that matrix 4.5 (b) is symmetric and undirected. Since it is symmetric, the values above the diagonal mirror those below it. As a result, a value of one indicates presence of pairwise interactions between contextual determinants, while a value of zero indicates absence of a co-occurrence.

For example, there is a co-occurrence between CD1 and CD4, which means that process specificity and power asymmetry co-occurred in one payment dispute risk.

This is in line with Crespin-Mazet and Ghauri (2007), who found that the practice of doubling in buying and production by project owners has the potential of tilting control to their favor. The first function entails paying for design and construction. Contractor. The second entails production because of supplying and retaining legal possession on which the project is built. As a result of unequal process control, contractors are exposed to payment risks. However, a co-occurrence does not exist between CD1 and CD2. This means that process specificity and hold-up did not co-occur. This implies that CD1 and CD4 contributed to the overall payment risk causation by a magnitude of 1, while CD1 and CD had a zero magnitude.

Another observation is that beyond showing presence or absence of interactions, matrix 4.5 (a & b) is weighted. The greatest magnitude measured by 8 co-occurrences between CD7 and CD3. This is represented by an interaction between contractual incompleteness and site asset specificity. 8 co-occurrences are equal to that between power asymmetry (CD4) and site asset specificity (CD3) for the private sector. This is despite 29 cases for the private sector compared to 22 for the public sector. Since their common denominator is CD3, the observation pinpoints to its criticality. This is in line with Skitmore and Smyth (2007), who underscored the critical influence of the "site" on the choice of procurement practices, and their connections with how the "price" is paid. In that study, the site represents both the geospatial location and owner determined procurement practices.

Table 4.5: (a) (a) A One-mode Public Sector Matrix with Diagonals; (b) Without Diagonals

		CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10
	CD1	10	0	5	1	2	2	5	1	2	0
(a)	CD2	0	2	1	1	0	0	0	0	0	0
	CD3	5	1	17	2	1	5	8	1	1	0
	CD4	1	1	2	2	1	0	0	0	1	0
	CD5	2	0	1	1	4	0	0	0	1	0
	CD6	2	0	5	0	0	7	3	1	0	0
	CD7	5	0	8	0	0	3	12	1	1	0
	CD8	1	0	1	0	0	1	1	1	0	0
	CD9	2	0	1	1	1	0	1	0	4	0
	CD10	0	0	0	0	0	0	0	0	0	0

(b)

	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10
CD1	0	0	5	1	2	2	5	1	2	0
CD2	0	0	1	1	0	0	0	0	0	0
CD3	5	1	0	2	1	5	8	1	1	0
CD4	1	1	2	0	1	0	0	0	1	0
CD5	2	0	1	1	0	0	0	0	1	0
CD6	2	0	5	0	0	0	3	1	0	0
CD7	5	0	8	0	0	3	0	1	1	0
CD8	1	0	1	0	0	1	1	0	0	0
CD9	2	0	1	1	1	0	1	0	0	0
CD10	0	0	0	0	0	0	0	0	0	0

Source: Constructed from field data

4.2.3 Graphical Analysis of Payment Dispute Co-occurrences

Fig. 4.4 (a & b) presents a graphical view of a sub-network of payment dispute co-occurrences. It comprises of contextual determinants as nodes, which are numbered as CD1 to CD10, and co-occurrences between them indicated by lines. This sub-network is created by inputting the matrix in Table 4.5 (a & b) into the Netdraw application. The Netdraw application comes as a companion of the UCINET software. To create it, the spring embedding technique was used as it is based on the shortest geodesic distance between the nodes. As a result of this approach, a graphical drawing is produced in a way that the nodes with the shortest distances are placed close together. This way, the generated graph as illustrated by Fig. 4.5 (a & b) is relatively easy to read.

By inspecting the graph, several observations can be made. For example, all nodes in the first graph are connected. However, in the second graph node CD10 is disconnected from the rest of the graph. Another observation is that some nodes have more connections than others. For instance, in the first graph, node CD3 and CD5 have the highest number of connections (nodal degree), while CD10 has the lowest number of connections. In the second graph, node CD3 and CD7 have the highest number of connections. However, node CD10 has zero connections. In this sense CD10 is therefore an isolate (Li et al., 2016), which implies that the payment dispute risks associated with it are relatively easy to control. Indeed, the repeat business aspects of the transaction frequencies is against the public sector procurement principles. Therefore, the associated payment risks can be controlled with relative effort.

Moreover, in the first graph only CD3 has connections to each of the contextual determinant. Similarly, in the second graph, other than lacking a connection with CD10, CD3 is connected to the rest of the nodes in the graph. This visual inspection offers a way of assessing metrics such as the density of the overall network (Li et al., 2016). The density metric can range from 0 to 1, where, a lower density means a lower risk transmission capacity and the converse is also true. Accordingly, it can be stated that the private sector projects are more vulnerable to contractor payment risks than the public sector projects. This can be explained by the fuzziness between the interests of the owner and the agents who manage public projects. The result includes a conflict between the agent's personal interests and those of the public, which is also reflected in consequences such as disagreements over the value of work done. This finding is supported by Turner and Müller (2004), who found that combination of representation and project control roles by the agent exposes the owner to opportunistic risks. However, because the controlling agent is hired and paid by the principal (Project owner), this study finds that the contractor is also exposed to opportunistically instigated payment risks.

(a)

(b)

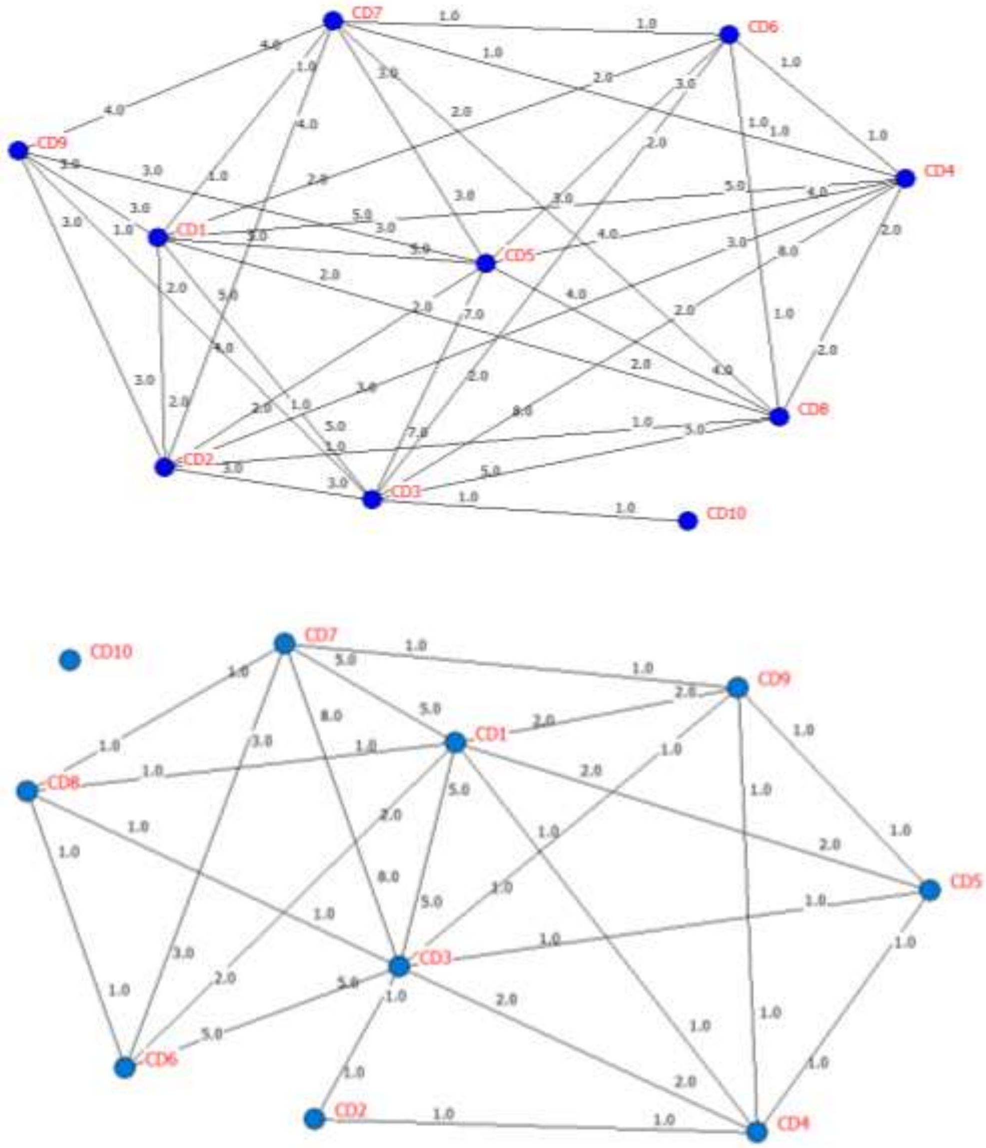


Figure 4.4: (a) Private, and (b) Public Payment Dispute Subnetworks

Source: filed data

A key commonality between the two graphs in Fig. 4.4 (a & b) is that they are undirected. This property is illustrated by the fact that each pair of nodes has two equal values, placed next to each line. In other words, the incoming level of influence is equal to the outgoing influence. Therefore, the sequence of payment default co-occurrences is irrelevant. This symmetry is equivalent to the measure of nodal degree, which in the context of risks can indicate number of opportunities or vulnerability. In this regard, ascertaining the relative capacities of contextual determinants to influence risks requires another level of analysis. Therefore, the next section uses structural measures to characterize contextual determinants and their co-occurrences in payment disputes.

4.2.4 Macro-level Analysis of Payment Dispute Co-occurrences

In the analysis of risk initiations and propagation properties, quantitative measurements are more concise and precise than visual inspections (De Nooy et al., 2018). With this understanding in mind, payment dispute co-occurrence is conceptualized as a risk. Accordingly, Table 4.6 presents measurements for the graphical subnetworks illustrated in Fig. 4.4 (a & b). First is the network size in terms of the number of nodes or ties. Thus, there are 10 nodes in the private and public subnetworks. Similarly, the private subnetwork has 64 ties, while the public subnetwork has 44 ties. This indicates that the private subnetwork is larger than the public subnetwork. This observation is also triangulated by the differences in their respective unweighted average degrees per node, which stands at 6.4 and 4.4 respectively. This observation demonstrates that every contextual determinant is on average connected to 6 or 7 others and 4 or 5 respectively. If the network sizes were equal, then it can be stated that the co-occurrence of payment disputes is more likely in the private sector than public projects.

Another observation is that the index for the private subnetwork density is 0.711 against 0.489 for the public sector. This observation suggests that payment dispute risks transmission is faster in the private than the public sector. A score greater than 0.5 means that the contextual determinants are better connected and can therefore transmit risks. A related measure is the index of connectedness. This measure shows that the private subnetwork is fully connected as indicated by a maximum score of 1, which depicts 100% connection level. On the contrary, the public subnetwork is less connected as indicated by a value of 0.8, which depicts 80% level of connection. This measure is also reinforced by the index of fragmentation. According to it, the private subnetwork has a score of ‘0’, while public has a score of 0.2 or 20%.

Fragmentation in the public subnetwork arises because the determinant transaction of frequency is isolated from the main network. This observation suggests that the likelihood of repeat business is higher in the private sector than the public sector. This finding is supported by Fazekas et al. (2016), who assert that recurrent contract award practices is an indicator of lack of equity and corruption risks.

Table 4.6: Connectivity Measurements for the Whole Network

Index	**Private**	**Public**
Number of nodes	10	10
Number of ties	64	44
Unweighted Avg Degree	6.4	4.4
Deg Centralization	0.222	0.5
Unweighted density	0.711	0.489
Connectedness	1	0.8
Fragmentation	0	0.2
Avg Distance	1.311	1.389
Diameter	3	2

Source: Constructed from field data

The average distance or path length is a measure which describes the average number of steps between connected pairs of nodes (Zhou & Irizarry, 2016). Because such pairs are thus reachable, a shorter distance between them is an indicator of faster propagation. On the other hand, a longer distance suggests less propagation capacity. Since the private sector has an average distance of 1.311 compared to 1.389 for the public sector, it means that a payment dispute risk can be propagated by at least 1 or 2 connections. Because of the shorter transmission between risk causes, it can therefore be stated that payment dispute risks are difficulty to control in both the private and public cases. This is in line with Fang et al. (2012), who found a correlation between shorter average distance between risk causes and triggering of other risk consequences. This network property makes it difficult to control risk transmission.

Lastly, the diameter index indicates that transmission of payment dispute risks in the private sector requires at most 3 connections, while in the public sector 2 steps are required. Because diameter is the longest distance of all shortest paths between nodes, the shorter it is the better the transmission efficiency, and the converse is also true (Zhou & Irizarry, 2016). It can therefore be stated that payment risks in public projects are more difficult to control than the case is with the private projects. As suggested in Peters et al. (2019), this finding can be attributed to the factor of greater bureaucratic control. This portends that the public sector payment process involves more parties than the case is with the private sector. Although bureaucratic mechanisms are designed to provide checks and balances, Hosseini et al. (2020) found that they can contribute to opportunistic risks, which includes under stating the value of work done. This finding also pinpoints to the influence of intermediary roles. For example, in the case of the public sector there is a less clarity concerning aspects such as the distinction between ownership and control.

4.2.5 Nodal Analysis

Table 4.7 compares the influence of nodes based on centrality measures for the private and public subnetworks (cases). As illustrated by the scores in the brackets, the contextual determinants have been ranked based on the measures of weighted degree, Eigenvector and Bonacich. This result set identifies similarities and dissimilarities across the private and public cases. According to Table 4.7, site asset specificity, bounded rationality, contractual incompleteness and process specificity are the four topmost determinants. A further thematic analysis and discussion is offered.

Table 4.7: Comparative Centrality Analysis of Contextual Determinants

Node	Contextual determinant	Weighted degree		Eigenvector		Bonacich power	
		Private	Public	Private	Public	Private	Public
CD1	Process specificity	1.095(3)	1.616(2)	0.302(5)	0.386(3)	0.95(5)	1.42(3)
CD2	Hold-up	0.788(6)	0.185(9)	0.193(6)	0.029(9)	0.61(6)	0.14(9)
CD3	Site asset specificity	2.215(1)	2.335(1)	0.647(1)	0.695(1)	2.04(1)	1.81(1)
CD4	Power asymmetry	0.912(4)	0.894(4)	0.339(3)	0.074(6)	1.07(3)	0.38(6)
CD5	Bounded rationality	1.452(2)	0.432(7)	0.423(2)	0.067(8)	1.33(2)	0.35(7)
CD6	Adverse selection of the owner	0.358 (9)	0.654(5)	0.113(9)	0.275(4)	0.35(9)	1.11(4)
CD7	Contractual incompleteness	0.804(5)	1.156(3)	0.135(7)	0.519(2)	0.42(7)	1.66(2)
CD8	Moral hazard of the owner	0.648(7)	0.217(8)	0.337(4)	0.069(7)	1.06(4)	0.38(6)
CD9	Moral hazard of the consultant	0.591(8)	0.511(6)	0.119(8)	0.087(5)	0.37(8)	0.45(5)
CD10	Transaction infrequencies	0.028(10)	0(10)	0.017(10)	0(10)	0.05(10)	0(10)

Source: Field data

4.2.5.1 Site Asset Specificity

The first observation from Table 4.7 is that the three measures generate a uniform rank for the determinants of site asset specificity (CD3) and transaction frequency (CD10). In this case, (CD3), emerges as the topmost determinant, while CD10 is ranked as bottom last. This means that site asset specificity has the most influence on payment dispute risks, while transaction frequency has the least influence. In other words, site asset specificity, which according to Table 3.2 indicates the effects of the inseparability of the legal site ownership from the constructed product, is the most critical determinant across the cases. Accordingly, a further analysis is provided.

Table 4.8 presents site asset specificity related excerpts. Specifically, it thus presents a sample of three excerpts for each of the private and public sectors cases to illustrate the point. An observable commonality from the six cases relates to the inability of the contractor to reverse its inputs in the form of work done once fused with the site. This inseparability suggests a link with the differences between the practice of delimiting legal site ownership versus the contractual possession held by the contractor. This is because contractual possession does not translate to legal site ownership. Among other things, this delimitation tends to weaken payment default remedies since in the absence of timely and full payments the contractor cannot redeploy its inputs. It can therefore be stated that the exclusion of the contractor from the legal site ownership rights assignment portends a point of payment risk exposure.

Table 4.8: Examples of Excerpts on the Influence of Site Asset Specificity on Payment Disputes

Sector	Case Reference	Excerpt
Private	C11	He added that although a Revised Final Certificate No. 6 dated 26 May 2010 (at page 16 of the Plaintiff's Bundle of Documents marked Plaintiff's Exhibit No. 1) was prepared and forwarded to the Defendant for payment, the Defendant persisted in its refusal to honour the same, in spite of several reminders
	C13	That the Plaintiff's claim arises out of unpaid Certificates Numbers 15 and 16 which were duly certified by the Project Architect and approved by the Quantity Surveyor […] The Defendant further averred that, while the Quantity Surveyor had expressly admitted in writing that the Final Account had substantial errors, it had declined to recall or suspend the Final Certificate which is the foundation of this suit.
	C16	Replying Affidavit, copies of correspondence in relation to the fact that the Defendant, in his words, had ignored the said Certificate and/or correspondence going way back to June 2009. The said Certificate had never been settled, despite the clear provisions of the Contract
Public	C4	He added that the appellant remained put on the site until it handed over possession on 11th May, 2017. By his own assessment, which he set out in a schedule produced in court, the total outstanding amount of extra works at the time he was giving evidence was Kshs.38,187,693 and he prayed for the same.
	C7	He further admitted the defendant was given final certificate and statement of final account. The amount shown as due and payable to the plaintiff was shown as 20,688,259.98. He concluded by stating that the defendant is ready and willing to pay the plaintiff only Kshs.9, 000,000/-.
	C13	The Respondent deposed in the Replying Affidavit inter alia at paragraphs 19, 44-45, that, the disagreement relating the values in the final Certificate still lingers

Source: Field data

4.2.5.2 Bounded Rationality in Private Sector Cases

Table 4.7 shows that according to the three measures, bounded rationality is the second topmost determinant for the private cases. On the other hand, other than process specificity that is ranked second by the measure of weighted degree, contractual incompleteness is identified by both Eigenvector and Bonacich power as the second topmost determinant within the public cases. However, to a large extent both the Eigenvector and Bonacich power have a similar set of ranking. This is because these measures are based on a similar normalization UCINET beta factor of 0.995. This normalization factor represents the largest eigenvalue. Thus, the result from any of two measures is considered more consistent than that of the degree centrality. As a result, this subsection discusses bounded rationality in respect of private sector cases, while the determinant of contractual incompletes is considered under the public cases.

Table 4.9: Examples of Excerpts on the Influence of Bounded Rationality

Sector	Case Reference	Excerpt
Private	C8	The Defendant's letter dated 19th March 2014 to the Plaintiff Exhibit marked "FBR 2" that was annexed to the Defendant's Further Affidavit shows that the Defendant terminated the contract as the Plaintiff was said to have abandoned the works and failed to meet the necessary contractual requirements in accordance with Clause 12 and 13 of the Agreement.
	C11	It is plain from the aforestated clause that it was therefore the responsibility of the Architect, and not the Plaintiff, to seek and obtain prior approval for the variations from the Defendant. There is absolutely no evidence to show that the variations were implemented against the advice or instructions of the Architect […] The Defendant has not given any explanation at all why it has not paid the difference that is not in contention
	C24	The Respondent further argues that as at the purported termination of the contract, the value of work had been understated by approximately 265,201,046/= which put the Respondent in extreme financial stress and that the Applicant has not paid fully as alleged.

Source: Constructed from field data

The determinant of bounded rationality according to for example Sarhan et al. (2017b), is premised on the limited capacity to retrieve and process information and that historical data may not be fully reliable. The result includes a constrained capacity of the dispute resolvers not involved in the actual project realization process such as the arbitrators and courts to make an accurate determination. Decision makers are therefore faced with a verifiability problem. This is illustrated by for example two contentious positions presented by excerpt C8 (Table 4.9). On one hand, the plaintiff (contractor) sought an award over unpaid sums in respect of work done before contract termination. On the other hand, the client counterclaimed on grounds of work abandonment. However, the breach of abandonment is connected with the owner's project financing obligations as reflected by actions such as timely and full payment. In this regard, it is therefore possible that the contractor's breach was induced by the omissions of the owner. However, establishment of this link in the face of conflicting accounts from both sides poses verifiability challenges. Therefore, the cause-effect analysis approach used in the analysis of payment dispute cases is constrained by the inability to unambiguous identify connections between the cause and effect.

4.2.5.3 Contractual Incompleteness in Public Sector Cases

The measures of Eigenvector and Bonicich power show that contractual incompleteness is the second topmost determinant when it comes to public cases (Table 4.7). According to the weighted degree, it is however the third topmost determinant. Since Eigenvector and Bonicich power provide a more consistent measure, this subsection illustrates the public sector cases. This implies that the public sector has a higher affinity in applying the practice the lowest possible project realization cost than the private client. This is illustrated by the excerpts presented by Table 4.10. As a result, they for example suggest a link between contestation over liability for variations and information imbalances.

Table 4.10: Examples of Excerpts on the Influence of Contractual Incompleteness

Sector	Case Reference	Excerpt
Public	C2	The appellant paid the sum of Kshs.194,087,963.51 commensurate with the 100% contractual works completed. However, the respondent, in its plaint dated 13th March, 2012 claimed a further sum of Kshs.7,882,793/= from the appellant, made up as follows;-[…] by holding that there was an outstanding sum of Kshs.7,882,793/= when there existed documents to prove that the full contractual sum had been paid by the appellant
	C4	[…] Kshs.21million as opposed to 38 million. Expounding further, he submitted that the contract sum of Kshs.11,762,395 had to be revised upwards taking into account the adjustment made to the construction works due to the damage caused by perennial floods.The Defendant has not given any explanation at all why it has not paid the difference that is not in contention
	C15	[…] From the variation notes, there are site visits on 15.4.2014 that speak to the recommendations made by the clerk of works and district works officer of Matungulu. It is noteworthy that if the plaintiff did part of the work and failed to complete the same due to obvious delay in payment, he was not to blame.

Source: Constructed from field data

Indeed, the three case excerpts in Table 4.10 suggest that the point of contention is in respect of liability for cost variations. For example, C2 involved a design-bid-build contract, where among other things cost is endogenous with design which is however produced by the consultant on behalf of the owner. This portends that the design roles and the attendant cost changes should be borne by the owner. The appellant (project owner)'s position is however contradictory since it suggests that the contract price should equal to the actual outturn as reflected by the constructed output product. Therefore, it can be stated that lack of understanding regarding the source of unexpected changes contributes to misallocation of cost variation risks, and in turn exposure to payment risks.

4.2.5.4 Process Specificity

The measures of weighted degree, Eigenvector and Bonacich power show a mixed set of results as regards the third topmost determinant (Table 4.7). For instance, the measure of weighted degree ranks process specificity as the third topmost determinant for the private cases. On the contrary, it ranks contractual incompleteness as the third topmost determinant for the public cases. Additionally, the measure of Eigenvector recognizes power asymmetry as the third topmost determinant for the private sector. However, it identifies process specificity as the third topmost determinant within the public cases. Similarly, the measure of Bonacich power recognizes process specificity as the third topmost determinant for the public cases. However, within the private cases, Bonacich power identifies the moral hazard of the owner as the third topmost determinant. Because the result of Eigenvector and Bonacich power is more consistent than that of the weighted degree, this subsection discusses the influence of process specificity.

Accordingly, the excerpt cases presented by table 4.11 illustrate the influence of process specificity. This determinant explains how performance obligations of the contractor are affected by the omissions of the contractor (Table 3.2). This is illustrated by for example, C1 from the private sector. In this case, one payment certificate was underpaid, while payment was delayed in the other. As attested by C7 under the private sector, underpaying and paying late has a negative implication on the obligations of the contractor in terms of consequences such as delayed completion. Additionally, case 3 under the public sector also shows that project abandonment is another consequence. Therefore, it can be stated that such consequences have a potential to expose contractors to cash flow related risks.

Table 4.11: Examples of Excerpts on the Influence of Process Specificity on Payment Disputes

Sector	Case Reference	Excerpt
Private	C1	The Main Contractor continued to execute works and once again made another application for interim payment number 03 for Kshs. 3,503,712.64 on 12th April 2017. The certificate was yet again grossly delayed being issued on 7th July 2017 for 2,069,697.60. However the contractor immediately presented it to the Employer. It was not however paid within the 14 days provided in the contract.
	C7	The parties thereby agreed to value the works carried out by the Defendant per the disputed Interim Certificate at Kshs. 31,653,120.87; and that the Defendant was to hand over the Project Site and all keys to the Plaintiff upon the signing of that Agreement. At Clause 3 thereof, an agreed schedule was set out as to how the Plaintiff was to pay the aforesaid sum over a period of 90 days from the date of handover of the Project.
	C19	The 1st defendant has been presented with various certificates which have remained unsettled for periods in excess of fourteen days
Public	C3	Under the first contract, works were completed and payments substantially made. A balance of Kshs. 483,891.20 however remained unpaid. Under the second contract, funding for the project encountered problems and the contract was "abandoned". An amount of Kshs. 663,298.50 that had been certified as at 2nd October 2002 was not paid.
	C12	Certificate No.1 for Kshs. 1,810,349.45 issued on 14/11/2008 and paid on 15/2/2010. There was a delay in payment of 458 days […] Certificate No. 5 for Kshs. 5,390,990.95 dated 22/11/2008 and paid on 15/2/2010. There was a delay of 450 days
	C15	There is a statement for payment on account that is dated 25.6.2014 and the valuation of work done by the plaintiff was Kshs 4,624,000/-. This answers the question that the valuation was due for payment. The plaintiff admitted having received payment for the same although after a period of two years.

Source: Field data

4.2.6 Structural Hole Analysis of Dispute Risk Propagation

Table 4.12 presents the measures of structural holes in respect of the private and public subnetworks. The concept of structural hole illustrates nodes that connect disconnected or weak connections with other nodes in the network (Saglietto et al., 2020). The premise is that by spanning across disconnected or weakly connected nodes, flows between them can enabled or disenabled. In the context of payment dispute risk subnetworks, the idea of enabling indicates the extent of risk propagation or transmission (Song et al., 2020). Such a transmission implies capacity to control the allocation of the positive or negative side of a risk outcome. The common measurement metrics include effective size, efficiency and constraint. Therefore, the result for each of the measures is analyzed and discussed.

First, effective size is used to measure the capacity of a node to reach other nodes beyond its immediate connection. This implies that a value of 1 indicates the smallest size, and the higher it is, the greater the capacity of a node to reach other nodes. By implication it also means more risk propagation capacity. In Table 4.12, site asset specificity CD3 has the largest structural size for both the private and public cases. It can therefore be stated that the practices associated with CD3 propagates most payment dispute risks. Such practices include the separation between legal site ownership and contractor's contractual site possession.

Second, the metric of efficiency is used to determine the number of direct connections that a focal node, also known as ego has. Thus, the more the direct connections, the greater the propagation capacity is likely to be. The measure of efficiency ranges from a value of 0 to 1. Thus, the closer a value is to 1, the greater the risk propagation capacity. Table 4.12 shows that there is a variance between the level of propagation efficiencies in private cases compared to the public cases. In the private cases, contractual incompleteness (CD7) has the highest score, which indicates the point at which greatest risk propagation capacity occurs. On the side of public cases, the fastest propagation is caused hold-up related features (CD2).

Table 4.12: Structural Hole Measures and their Payment Dispute Propagation

	Private subnetwork			Public subnetwork		
ID	Effective size	Efficiency	Constraint	Effective size	Efficiency	Constraint
CD1	4.421	0.553	0.49	4.169	0.596	0.59
CD2	3.894	0.556	0.476	1.375	0.688	0.738
CD3	5.072	0.634	0.443	5.306	0.663	0.507
CD4	3.381	0.483	0.531	3.2	0.64	0.541
CD5	4.691	0.586	0.444	2.255	0.564	0.618
CD6	2.827	0.471	0.562	1.368	0.342	0.828
CD7	4.482	0.64	0.443	2.208	0.442	0.687
CD8	3.281	0.469	0.54	1.837	0.459	0.83
CD9	2.779	0.556	0.489	2.838	0.567	0.647
CD10	1	1	1	0	0	0

Source: Field data

The determinant of contractual incompleteness reflects roles associated with boundary objects and spanners (Fellows & Liu, 2012). The objects represent tools such as drawings and bills of quantities, while spanners represent contract administrative roles. However, due to some limitations they present critical sources of payment dispute risk propagation. For example, the boundary objects are characterized with contractual gaps (Walker & Pryke, 2011). Similarly, Hamledari and Fischer (2021) linked the spanner's contract administrative roles with the problem of unequal information distribution. Therefore, according to the measure of efficiency, fastest payment risk propagation in the private sector is through intermediary roles.

On the contrary, the fastest payment risk propagation point in the public sector is hold-up (Table 4.12). This determinant represents contractor vulnerability to contractual breach due to induced cash flow difficulties through actions such as disagreements over the value of variations accompanied by termination threats (Table 3.2). Hold-up actions represent economic weapons used by an advantaged actor during the exchange process. This finding demonstrates that the practice of work first get-paid later is a critical mechanism that the owner can use to for example renegotiate the contractor's variation claims to his advantage. On the other hand, owners can also be exposed to opportunistic exploitations by contractors particularly in situations of weak contractual safeguarding mechanisms. However, this risk is usually mitigated by use of an owner appointed contract administrator. This is in line with the finding by Peters et al. (2019) that bureaucratic control is a major contributor to contractor payment risks.

Third, the metric of constraint measures the extent to which an alter node is constrained by a focal node. This way, the metric indicates lack of alternative routes. The lowest score indicates, least constraint, which suggests a higher risk transmission capacity through alternative connections. In the private sector, site asset specificity (CD3) and contractual incompleteness (CD7) have equal least scores, thus indicating that they are the least constrained nodes. In other words, the practices associated with inequality in end product control and contractual gaps are the points through a majority of the payment dispute risks are propagated. Because the owner's main objective is to realize the constructed project at the least possible price (Chang & Ive, 2002), the finding demonstrates the need for contractors to consider efficacious safeguarding mechanisms. However, in the public sector, most payment risks are propagated through practices stemming from unequal end product control rights.

The preceding result suggests that there is a close connection between the practices associated with site asset specificity and contractual incompleteness. The site is for example one of the critical elements of the market mix framework, which on one hand it refers to construction procurement routes (Skitmore & Smyth, 2007). The payment dispute data is drawn from the design-bid-build option; whose characteristics show that it is designed to enable the owner best achieve his goals. Such goals include incurring the lowest possible cost (Chang & Ive, 2002b). Thus, less end product contractor control is one of the ways of achieving the goal of lowest cost. This is reflected in practices such as the separation between the legal site ownership and the contractual possession held by the contractor. In this sense, such a separation represents an intersection between the two practices. Therefore, the separation between end product control and site possession provides a way through which most payment dispute risks are propagated.

In sum, the results of comparative centrality analysis and structural hole suggest that there is a need to consider additional aspects when modeling payment risks. First, the assessment of the ten contextual determinants for example does not fully account for the role played by the boundary objects and spanners in payment risk propagation. There is therefore need to consider its contextual contribution. Secondly, it has emerged that practices are a result of interactions between the contextual determinants. There is therefore a need to identify and assess the extent to which such practices are compatible with the design-bid-build project procurement system. Given these recommendations, the next phase of this study focusses on assessing the compatibility of the practices associated with the examined contextual determinants.

4.3 Objective Two

This phase sought to establish the extent of incompatibilities as a result of contextual misalignments between the design-bid-build system of procuring construction projects and the standard product market settings. The practices reflect roles as for example illustrated by the FIDIC old red book (Besaiso et al., 2018). The purpose of the comparison is to index and profile the extent of incompatibilities and in turn establish their connection with payment risks.

4.3.1 The Demographic profile of subject matter experts

Table 4.13 presents a summary of the interviewees' backgrounds. In particular, it shown that they served as arbitrators in ten cases, while representing the contractor in one and the owners in the other. Their involvement in resolution of payment disputes ranged from 6 to 61, with the majority having more than ten years. Additionally, their corresponding experience ranged from 8 to 35 years, averaging at 20 years. It can be suggested that the greater number of cases and years of experience indicates in-depth context knowledge. Because of this, their views indicate the interview's reliability and quality.

Table 4.13: Background of Interviewees

Interviewee	Case Ref.No.	Role in the case	Profession	Years of experience	Number of cases
SME 1	C1	Arbitrator	QS	10	33
SME 2	C2	Arbitrator	QS	35	24
SME 3	C3	Arbitrator	C.Eng.	8	11
SME 4	C4	Contractor Rep.	QS	30	61
SME 5	C5	Arbitrator	QS	21	18
SME 6	C6	Arbitrator	C.Eng.	29	41
SME 7	C7	Arbitrator	QS	20	55
SME 8	C8	Arbitrator	QS	31	20
SME 9	C9	Owner. Rep.	QS	26	24
SME 10	C10	Arbitrator	QS	8	6
SME 11	C11	Arbitrator	QS	9	14
SME 12	C12	Arbitrator	C.Eng.	18	43

Key: SME=Subject matter expert; C=Case; Rep= Representative; QS=Quantity surveyor; C. Eng. =Civil Engineer

Source: Field data

4.3.2 Practice by Event Two-mode Matrix

Table 4.14 presents a two-mode or incident matrix. The rows of this matrix represent practices, while the columns represent experts. It a two-mode because the row variables are distinct from the column variables. The judgment by experts represents an event. As a result, this data structure lacks direct connections and therefore it is not able to determine the indexes of direct connections.

In Table 4.14, there are 11 rows representing practices, denoted as P1-P11. On the other hand, it contains 12 columns representing experts, denoted as Ex1-Ex12. The column immediately adjacent to Ex12 presents the frequencies (Frq) obtained by summing the column scores. These scores indicate the number of times the practices co-occurred together as a result of being scored by the experts. The scores are shown by the matrix cells. Because the data structure presents two data points, the cell scores do not indicate presence or absence of connections. Therefore, to assess the extent of practices compatibility, it is necessary to convert the two-mode matrix into a one-mode matrix.

Table 4.14: A 2-Mode Practice-expert Event Matrix

	Ex1	Ex2	Ex3	Ex4	Ex5	Ex6	Ex7	Ex8	Ex9	Ex10	Ex11	Ex12	Frq
P1	1	2	3	0	1	2	1	1	0	2	2	3	18
P2	2	1	2	1	3	2	0	1	1	3	2	3	21
P3	3	3	3	3	1	3	2	2	2	3	3	2	30
P4	3	3	3	1	2	3	0	3	2	1	3	2	26
P5	3	3	3	3	3	2	2	3	3	3	3	3	34
P6	2	3	3	1	3	3	1	3	2	2	3	2	28
P7	0	1	3	3	1	1	3	2	2	3	3	2	24
P8	0	1	3	1	1	2	3	3	1	2	2	2	21
P9	1	1	3	1	0	1	0	1	2	2	2	1	15
P10	1	3	2	1	1	3	3	2	2	3	3	2	26
P11	3	3	1	2	2	1	3	2	1	3	3	1	25

Key: P1-P11=Practices; Ex1-Ex12 =Expert

Source: Field data

4.3.3 Practice-by-practice One-mode Matrix

In assessing the extent of practice compatibility or otherwise, a one-mode matrix was computed. This matrix indicates the number of times the experts interacted through practices. Such a matrix is commonly referred to as an adjacency matrix, where interactions indicate co-occurrence of practices at the experts' event. Table 4.15 presents the practice-by-practice matrix. Its computation followed the UCINET steps (Borgatti et al., 2002). This was accomplished by using the Data tab's Affiliations (2-mode to 1-mode) function. Following that, the matrix in two-mode was uploaded. Between the row and column tabs, the row was chosen. The sum of cross-products was chosen as the conversion method from the eleven available. This resulted in a matrix with a single mode.

Table 4.15: 1-Mode Practice-practice Multivalued Adjacency Matrix

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
P1	18	15	17	15	18	17	14	15	12	16	13
P2	15	21	18	17	21	19	15	15	13	17	16
P3	17	18	30	24	29	25	23	19	15	25	23
P4	15	17	24	26	25	25	17	17	14	21	19
P5	18	21	29	25	34	27	23	20	15	24	24
P6	17	19	25	25	27	28	19	19	15	23	20
P7	14	15	23	17	23	19	24	19	14	21	19
P8	15	15	19	17	20	19	19	21	13	19	16
P9	12	13	15	14	15	15	14	13	15	14	12
P10	16	17	25	21	24	23	21	19	14	26	21
P11	13	16	23	19	24	20	19	16	12	21	25

Key: P1-P11=Practices

Source: Field data

4.3.4 The Result of the Connections between Practices

Table 4.16 presents the result of connections between incompatible practices based on the maximum flow betweenness method. Because the matrix is symmetric, the scores above the diagonal are the same as those below it. As a result, there is no point of presenting a full matrix. Although the diagonal scores aren't particularly relevant, they nonetheless do indicate how much influence each practice's connections have. This case, in particular, the diagonal cells have equal scores of 11, which indicate that the roles are similar. Another observation is that the off-diagonal scores indicate that the influence of connections across clusters varies, and hence roles are therefore dissimilar. However, to determine their extent, further analysis is required.

Table 4.16: Maximum Flow Betweenness Matrix

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
P1	11										
P2	152	11									
P3	152	166	11								
P4	152	166	194	11							
P5	152	166	218	194	11						
P6	152	166	209	194	209	11					
P7	152	166	184	184	184	184	11				
P8	152	166	172	172	172	172	172	11			
P9	137	137	137	137	137	137	137	137	11		
P10	152	166	201	194	201	201	184	172	137	11	
P11	152	166	183	183	183	183	183	172	137	183	11

Key: P1-P11=Practices

Source: Field data

4.3.5 The Result of the Extent of Dissimilarity between Practices

To compute dissimilarity indices, the result of Table 4.16 is transformed into a structural equivalence matrix. This output is illustrated by Table 4.17. Its computation is predicated on the premise that the closer the Euclidean distance to zero is, the greater the conflict of interest between the practices and hence the roles. As a result of the symmetry of that matrix, only the result below or above the matrix is required. This demonstrates that, as indicated by their respective indexes, the varying dissimilarities between practices have varying connections. Above all, only six (6) indexes, highlighted in bold, are associated with the payment issue. The most significant link among the six is (P3, P5), which has a score of zero. This index demonstrates that paying for satisfactory performance and failing to match progressive payments to the amount of work completed have a similar but opposite effect on the contactor cluster. As a result, P3 implies a proactive strategy, whereas P5 implies a reactionary one.

To illustrate the impact of strategy differences, consider that under the D-B-B structure, the related roles are performed on behalf of the construction owner by the consulting cluster (Besaiso et al., 2018). This combination, however, has the effect of shifting the owner's control over the realization process to his or her advantage. Interestingly, the shifting of control compares with the bargaining power in Chang and Ive (2007a). As a result of the interaction between P3 and P5, it appears that the owner's strategy is more effective than the contractor's reactionary strategy. Furthermore, such efficacy assumes utility-maximizing owner capacity, as evidenced by late, under-, and non-payment strategies. As a result, this finding implies that the payment problem is not a coincidental occurrence but rather highlights the importance of strategic actions.

Table 4.17: Structural Equivalence Matrix of Euclidian Distances

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**
P1	-										
P2	39.6	-									
P3	119.8	84.92	-								
P4	98.17	61.52	29.15	-							
P5	119.8	84.92	**0**	29.15	-						
P6	115.08	79.72	9	22.34	**9**	-					
P7	81.71	44.1	46.58	20	46.58	40.48	-				
P8	54.74	**15.87**	71.24	46.91	71.24	65.79	29	-			
P9	**45**	83.38	160.33	140.04	160.33	155.98	124.31	98.19	-		
P10	107.46	71.47	18.79	**12.12**	18.79	11.31	31.1	57.2	148.84	-	-
P11	79.76	42.07	48.45	22.02	48.45	42.4	**2.24**	26.94	122.42	33.08	-

Key: P1-P11=Practices

Source: Field data

To further explain the second finding, Table 4.17 indicates that the second most significant connection, as indicated by a score of 2.24, is (P7, P11). It exemplifies the interaction between the practice of deferring certification of certain aspects of work performed and the less effective third-party dispute resolution mechanism. For example, certification is frequently delayed due to a discrepancy between the actual output and the contract price (Abdul-Rahman et al., 2014). However, this practice limits the contractor's ability to complete the project on time. Indeed, for an owner whose primary objective is to acquire the constructed facility at the lowest possible price (Chang & Ive, 2002), the cost of completion compared to the amount owed dictates whether to terminate and switch to another contractor. Arbitration or court mechanisms frequently prove ineffective for the contractor (Ive & Chang, 2007), as the information necessary to prove its case is held by the consulting cluster. As a result, the duty of the owner-information custodian (Sha, 2011), is to safeguard the construction owner's interests first. Under these circumstances, information likely to benefit the claimant (contractor) is rarely disclosed (Xiang et al., 2012). Again, the practice of combining supply of contract documents and certification enables certification functions to be manipulated in a way that compensates for the owner's financing inadequacy. However, these tactics are difficult to detect through arbitration or court mechanisms.

To illustrate the third finding, Table 4.17 demonstrates the significance of connection (P5, P6), which has an index score of 9. This connection illustrates the interaction between the failure to match progressive payments to the amount of work completed and the end product's inseparability from its site. Indeed, this entails the owner's reactive strategy being combined with the irreversibility of the construction site. In the latter case, it is the role of the buyer/owner to establish own procurement rules. This role in turn allows the contractual site possession element to be separated from its legal ownership. As a result, the role separation in turn enables the practice of doubling in buying and production. This is commonly demonstrated by the role of paying for work performed by a contractor while supplying own site but which combines to becomes part of the output. With this advantage, the buyer or owner can determine their utility. As a result of this chain of events, payment remedies such as those outlined in Wu et al. (2011b) become less effective.

4.3.6 The Result of the Disintegration and Integration Profile

Table 4.18 and Fig. 4.5 were derived using partitioning methods and then used to profile the observed connections. They demonstrate a profile in which eleven disintegrated practices integrate to varying degrees on ten levels. Notably, connection (P3, P5), 0.000 initiates the pattern of integration, connection (P1, P9), 0.000 is the last connection to integrate, and index (112.297) is the point at which all

11 practices fully integrate. At least two significant observations can be made in light of these results.

Table 4.18: Hierarchical Clustering of Structural Equivalence Matrix

Level	1	9	3	5	6	4	10	2	8	7	11
0.000	.	.	X	XX	.	.	.	.	.	.	.
2.236	.	.	X	XX	.	.	.	.	.	X	XX
9.000	.	.	X	XX	XX	.	.	.	.	X	XX
12.124	.	.	X	XX	XX	X	XX	.	.	X	XX
15.875	.	.	X	XX	XX	X	XX	X	XX	X	XX
17.891	.	.	X	XX	XX	XX	XX	X	XX	X	XX
32.669	.	.	X	XX	XX	XX	XX	X	XX	XX	XX
44.290	.	.	X	XX	XX	XX	XX	XX	XX	XX	XX
45.000	X	XX	X	XX	XX	XX	XX	XX	XX	XX	XX
112.297	X	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Source: Field data

To begin with, it is demonstrated that the initiating index, 0.000, and the last to integrate, 45.000, are adjacent. They are, however, dissimilar to the extent of a 45.000-dimension distance. This distance reflects the locational proximity, indicated by the representative nature of the consulting cluster's certification functions on behalf of the construction owner. Indeed, the same consultant performs the functions denoted by index 45.000 (P1, P9), where P1 entails resource allocation functions such as tender document preparation and contractor selection on behalf of the owner. Simultaneously, P9 entails information coordination between the owner and the contractor. Though P1 and P3 and P5 belong to two distinct sub-clusters, they are carried out by the consulting cluster on behalf of the construction owner and thus correspond to the site and financing roles. However, as Skitmore and Smyth (2007) note, the site reflects the owner-determined procurement structure, which includes design, specifications, and cost estimates. For this reason, the indexed roles are close to one another and also overlap. As a result, it can be stated that the consulting and construction owner clusters are more informed than the contractor cluster. This suggests that they can conspire to for example initiate the construction process without sufficient funding (Peters et al., 2019). The result includes transferring owner financing obligations to the contractor through strategies such as late, under, and non-payments.

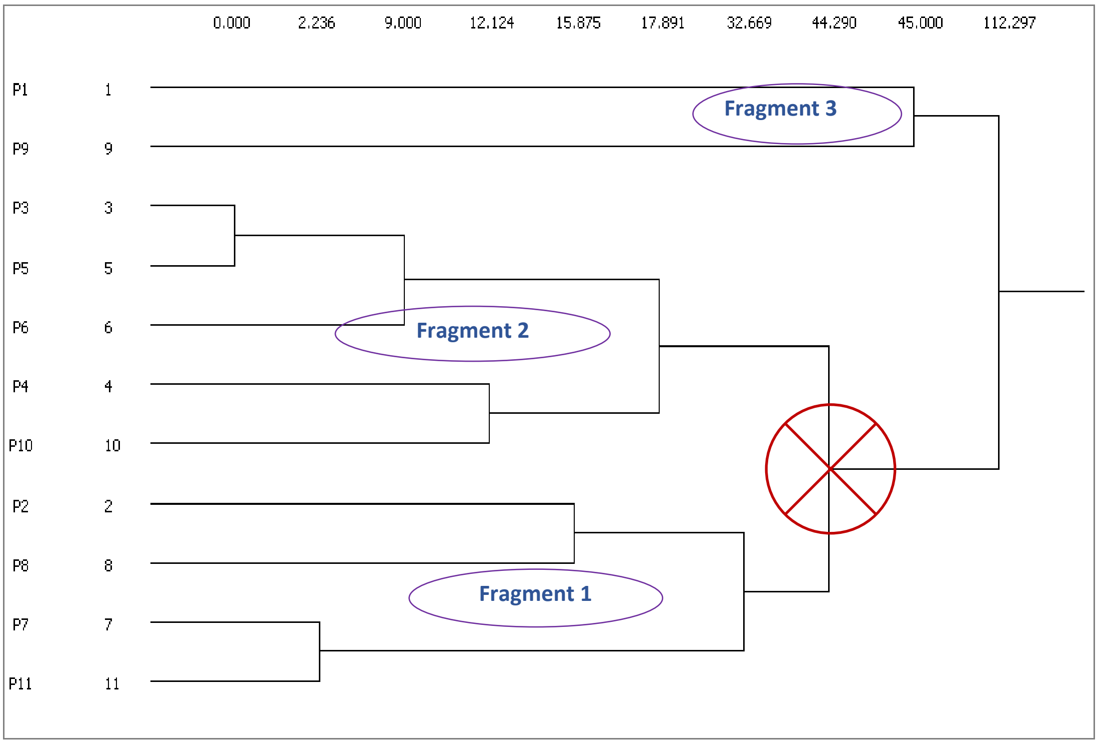


Figure 4.5: Clustering Dendrogram According to the Euclidean Method.

Key: P1-P11=Practices

Source: Field data

Second, index 44.290 and its y-axis intercept (Fig. 4.5) represent a position that is also represented by a T-junction and a gate valve. That point underpins the consulting cluster's intermediary functions in the D-B-B structure. A disconnection, on the other hand, disintegrates three fragments. Indeed, each fragment exhibits a distinct pattern, as indicated by its slope, implying the presence of three conflicting interests. As a result, they depict the interactions between the buyer/owner of the construction, the designer, the contract administrator, and the contractor. They must, however, be integrated to realize a constructed facility. Accordingly, practices 2, P4, and 6 are related to the site but have an immobile character. As a result, this feature distinguishes the end product's ownership rights from the construction contractor's temporary site possession.

Additionally, the consulting unit's roles in terms of design, associated plans, and tendering processes are distributed across the three fragments. This is illustrated by the locations of P1, P2, and P8, and P10. Simultaneously, the consulting cluster is accountable for the roles associated with P3, P5, P7, P9, and P11. While these roles are associated with the payment certification process, Fig. 4.4, illustrates that they are also distributed across the three fragments. As a result of this overlap, identification of clear role separation and the attendant interests is made difficult. This fusion tends to impair timeliness, completeness, and certainty of payment to contractors. In summary, this result demonstrates that extent to which practices overlap enables conflicted interests and, consequently, payment problems.

4.3.7 The Block Model Results

Table 4.18 and Fig. 4.5 has demonstrated that the overlap of dissimilar interests and roles facilitates payment problems. However, this result does not reveal the underlying causes of variation within and across practices. Being aware of these variations is important because it can serve as a springboard for re-alignment of the misaligned roles. Additional analysis is however required to bridge this gap.

The block modelling approach based on CONCOR or Tabu optimization is the most frequently used approach (Yang et al., 2020). Both algorithms are based on a rule that correlates the elements of an equivalence matrix according to a predefined number of clusters. This implies that these techniques are premised on a bottom-down approach. However, this contrasts with the top-down hierarchical clustering and similar methods used to create Fig. 4.5. In this approach, a data driven network is partitioned after it has been created. Consequently, given the three fragments obtained in Figure 4.5 as the desired number of blocks, the Tabu method was used. The procedure groups matrix entities with fewer dissimilarities together and those with more dissimilarities apart. In comparison to the CONCOR method (Yang et al., 2020), the Tabu technique was chosen because the input data from Table 4.17 is weighted or valued.

	1 P1	2 P2	8 P8	4 P4	5 P5	6 P6	7 P7	3 P3	11 P11	10 P10	9 P9
1 P1		39.598	54.736	98.168	119.796	115.083	81.713	119.796	79.762	107.462	45.000
2 P2	39.598		15.875	61.522	84.918	79.725	44.102	84.918	42.071	71.470	83.385
8 P8	54.736	15.875		46.915	71.239	65.788	29.000	71.239	26.944	57.201	98.189
4 P4	98.168	61.522	46.915		29.155	22.338	20.000	29.155	22.023	12.124	140.043
5 P5	119.796	84.918	71.239	29.155		9.000	46.583		48.446	18.788	160.331
6 P6	115.083	79.725	65.788	22.338	9.000		40.485	9.000	42.403	11.314	155.978
7 P7	81.713	44.102	29.000	20.000	46.583	40.485		46.583	2.236	31.097	124.306
3 P3	119.796	84.918	71.239	29.155		9.000	46.583		48.446	18.788	160.331
11 P11	79.762	42.071	26.944	22.023	48.446	42.403	2.236	48.446		33.076	122.421
10 P10	107.462	71.470	57.201	12.124	18.788	11.314	31.097	18.788	33.076		148.839
9 P9	45.000	83.385	98.189	140.043	160.331	155.978	124.306	160.331	122.421	148.839	

Figure 4.6: Optimized 3-block Solution for Structurally Dissimilar Practices.

Key: P1-P11=Practices

Source: Field data

Compared to Fig. 4.5, Fig 4.6 presents a realignment in the form of a block model solution. The first thing to notice in Fig. 4.6 is that fragment 1 contains P2, P7, P8, and P11. However, Table 4.19's block 1 contains P1, P2, and P3. Second, P11 has been moved from fragment 1 to block 2 from fragment 1. Thirdly, P1 has been moved from fragment 3 to block 1 from fragment 3. As a result of this re-assignment, the goodness of fit correlation coefficient is 0.77 out of a maximum of 1. That coefficient is derived from a comparison between the model depicted in Figure 4.6 and one in which all elements with a score greater than 1 are Ones and those with a score less than 1 are Zeros. A level of agreement of at least ¾ is typically considered to be a good fit. This output is presented by Table 4.19, while their densities are shown in Table 4.20.

Table 4.19: Block Assignments

Block	Practices
1	P1,P2,P8
2	P3,P4,P5,P6,P7,P10,P11
3	P9
Correlation coefficient = 0.771	

Key: P1-P11=Practices

Source: Field data

The density matrix of Table 4.20 indicates the sources of variation within and across blocks. For instance, although block 3 contains only P9, it receives more than it sends to the other blocks. Indeed, this is in line with the D-B-B structure, which emphasizes the consulting unit as the intermediary between the construction owner and the contractor cluster. This result explains the closeness between pre-contract design, cost, and specification data roles on one hand and performance roles on the other. However, such a misalignment runs counter to the presumed partiality associated with the certification roles because their purpose is to mediate the flow of resources between the owner and the contractor. According to Abdul-Malak et al. (2019), combining certification and agency roles contributes to a majority of payment problems. Therefore, it is necessary to pay closer attention to how the interactions between divergent roles contributes to payment risks.

Table 4.20: Density Indexes of the Block Models

Block	1	2	3
1	36.74	74.23	75.52
2	74.23	25.76	144.61
3	75.52	144.61	

Source: Field data

4.4 Objective Three

This sub section presents the results and discussion of the developed interdependency network model. Its macro-level, micro-level and portioning aspects are also analyzed. The subject matter expert session used to rate the practices was also used to rate the propositions for model development. Their demographic profile is therefore similar to that of objective two.

4.4.1 The Two-mode Payment Risk Matrix

Table 4.21 presents the result of a two-mode payment risk matrix. The raw side represents practices obtained from the second phase. The exposure to payment risks is caused by the incompatibility of practices, while their consequences are the reflected by the payment risk events. These events were evidenced by the contextual determinants. The risk practices were rated by the twelve subject matter experts indicated by the column dimension. The rating was formulated into schedule of twelve propositions and corresponding questions (Appendix A.3). This resulted in the two-mode matrix (Table 4.21).

Table 4.21: A Two-mode Payment Risk Matrix

	Ex1	Ex2	Ex3	Ex4	Ex5	Ex6	Ex7	Ex8	Ex9	Ex10	Ex11	Ex12	Frq
P1	1	2	3	0	1	2	1	1	0	2	2	3	18
P2	2	1	2	1	3	2	0	1	1	3	2	3	21
P3	3	3	3	3	1	3	2	2	2	3	3	2	30
P4	3	3	3	1	2	3	0	3	2	1	3	2	26
P5	3	3	3	3	3	2	2	3	3	3	3	3	34
P6	2	3	3	1	3	3	1	3	2	2	3	2	28
P7	0	1	3	3	1	1	3	2	2	3	3	2	24
P8	0	1	3	1	1	2	3	3	1	2	2	2	21
P9	1	1	3	1	0	1	0	1	2	2	2	1	15
P10	1	3	2	1	1	3	3	2	2	3	3	2	26
P11	3	3	1	2	2	1	3	2	1	3	3	1	25

Key: P1-P11=Risk Practices; Ex1-Ex12 =Expert

Source: constructed from research data

The last column of Table 4.21 presents frequency scores, which indicate the number of times the SME considered the payment risk event to have occurred. For instance, it is shown that the most frequent risk cause is associated with P3, which is indicated by a frequency score of 30. This was in response to the proposition that in the absence of advance payments, the requirement of payment upon completing a pre-specified portion of work presumes that the contractor is selling a completed product inclusive of the design and the site. On the other hand, the least frequent cause is associated with P9, which is indicated by a score of 15. This was in response to the proposition that the structure where communications between the owner and contractor are through the consulting unit tends to create an opportunity for manipulation the flows between the contractor and the owner. The disagreements over the value of work done was used as the indicative construct. Therefore, the last column illustrates whether the payment risk event occurred and the number of times it occurred.

In risk a model network, both frequency of occurrence and severity dimensions are required (Fang et al., 2012). However, Table 4.21 lacks a way of determining the extent of severity. The severity dimension is important because it can indicate the extent to which the contractor is exposed to payment risks. In a networked system, the concept of interdependencies between nodes is usually used measure exposure to risks (Qazi et al., 2020b). To therefore, determine interdependencies between risk practices, the two-mode matrix of Table 4.21 was converted into a one-mode practice-by-practice matrix.

4.4.2 The One-mode Interdependency Network Matrix

Table 4.22 presents a one-mode interdependency network matrix model. The first observation is that the diagonal values are perfectly similar to the risk frequency scores of the two-mode risk matrix. This property proofs that the computation from two-mode to one-mode is valid. The second observation is that the matrix is in line with the properties of an adjacency matrix. This means that the cells indicate interdependencies between risk practices or otherwise. A value of 1 indicates that an interdependency is present, while a value of 0 indicates that an interdependency is absent (Fang et al., 2012). The third observation is that the interdependency scores have values that are greater than 1. This means that the risk matrix is weighted. These weights indicate the severity of the payment risks as a result of the frequency of the risk events and the interactions between the risk practices.

The severest payment risk impact is caused by the interaction between risk practices (P3, P5). This has a value of 29. These points represent the practice of payment upon satisfactory performance and failure to match sums paid with the amount or work done. The corresponding risk events are linked to site asset specificity and substantive uncertainty (Table 3.7). The former event is reflected by the irreversibility of the inputs incorporated into the end product because its ownership rights exclude non-owners even if they contributed to its construction. On the other hand, the event of substantive uncertainty is reflected by the inefficacy of payment remedies due to the misinterpretation of ambiguous and incomplete information.

The least severest payment risk impact is caused by the interaction between practices (P9,P11). This has a value of 12. These points are represented by the practice of project communication via the consulting agent and poor third-party fault visibility. The former practice is triggered by the opportunism of the integrator, while the latter practice is also triggered by the boundary spanning. The opportunism of the integrator is reflected by the willingness of the agents to extract unmerited gain owing to their role of doubling in design/cost planning and contract administration. This behavior is indicated by factors such as under valuations and rent seeking activities. On the other hand, boundary spanning is context where disconnected entities are connected by boundary objects such as contract documents and spanners such as contract administration roles. However, because of system level effects, a score of 12 does not imply that least attention should be paid to P9 and P11.

Table 4.22: One-mode Risk Interdependency Matrix

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**
P1	18	15	17	15	18	17	14	15	12	16	13
P2	15	21	18	17	21	19	15	15	13	17	16
P3	17	18	30	24	29	25	23	19	15	25	23
P4	15	17	24	26	25	25	17	17	14	21	19
P5	18	21	29	25	34	27	23	20	15	24	24
P6	17	19	25	25	27	28	19	19	15	23	20
P7	14	15	23	17	23	19	24	19	14	21	19
P8	15	15	19	17	20	19	19	21	13	19	16
P9	12	13	15	14	15	15	14	13	15	14	12
P10	16	17	25	21	24	23	21	19	14	26	21
P11	13	16	23	19	24	20	19	16	12	21	25

Key: P1-P11=Risk Practices; Ex1-Ex12 =Expert

Source: constructed from research data

4.4.3 A Graphical View of the Interdependency Network Model

Another way of representing the interdependency risk matrix of Table 4.22 is to convert it into a visual network. The created network interdependency model is represented by Fig. 4.7. This model was created using the UCINET 6.72 and its NetDraw companion applications. The process utilized the spring embedding method, which facilitated the identification of nodes with the shortest average path length (Borgatti et al., 2002). UCINET was chosen over other SNA software applications because it comes with a package of relevant analysis metrics.

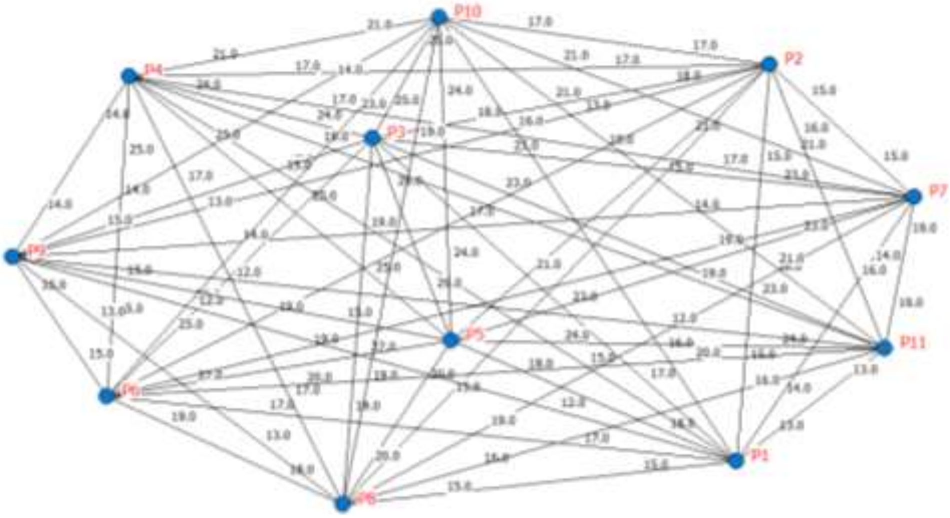


Figure 4.7: Interdependency Network Risk Model Based on Spring Embedder Algorithm

Key: P1-P11=Risk Practices

Source: Constructed from research data

According to Fig. 4.7, there are 110 interdependencies between the 11 risk practices. Each interdependency has two identical lines of equal weights, implying that the incoming magnitude is equal to the outgoing magnitude. In addition, such a characteristic demonstrates that the network is undirected and therefore symmetric. As a result of the symmetric property, there are 55 interdependencies as opposed to 110. This property is also demonstrated by Table 4.22, in the sense that the scores above the diagonal are similar to those below. The matrix denoted Appendix D contains the results of 110 unweighted interdependencies.

Based on the visual inspection of Fig. 4.6, at least two findings can be stated.

a) The severest interdependence (P3, P5) has a score of 29. It represents that the link between the sums paid not matching the actual work done and the requirement of payment based on satisfactory performance, has the greatest contractor payment risk exposure. This suggests that it has the greatest payment risk initiation and transmission capacities.
b) The least severe interdependence risk as indicated by a score of 12, is (P1, P9). It represents that the link between the consulting unit's centralization of project communication and the consulting unit's advantageous resource allocation position, has the least payment risk exposure capacity. Nevertheless, because it is part of an interconnected system, it is essential to assess severity from whole network level.

4.4.4 Descriptive Statistics of the Payment Risk Interdependence Network

Table 4.23 presents statistics at the macro-level of the network model. This result shows that model has 110 interdependencies, whose severity score ranges from 12 to 29. The sum of these interdependencies is 2042, with a mean of 18.564 percent. This is calculated by dividing the sum by the number of observed interdependencies, that is, (2042/110). Another observation is that the deviation from the mean is 17.19%, and the standard deviation is 4.137%. These two scores suggest that interdependencies between risk practices are less dispersed. This observation is also attested by the visual inspection of Figure 4.6.

Table 4.23: Whole Network Descriptive Statistics

ID	Statistic	Value
1	Observations	110
2	Missing	0
3	Minimum	12
4	Maximum	29
5	Sum	2042
6	Average	18.564
7	SSQ	39790
8	Standard Deviation	4.137
9	Variance	17.119

Source: constructed from research data

4.4.5 Macro-level Measurements

Table 4.24 presents measures of the interdependency network model. It shows the average degree of each risk practice is 10. This means that each risk practice is connected to an average of ten other risk practices. Hence, there are 10 alternative risk initiators and transmitters. Another observation is that only a distance of 1 and a diameter of 1 are required to channel the risks within the 110 interdependencies. The relatively fewer steps could be attributed to the effect of intermediary related practices between the owner and contractor. Such intermediaries have enabled the network model to be fully connected. This observation is attested by a connectedness score of 1. As a result, the average geodesic distance equals to one and the weighted density score also equals the global clustering coefficient score. In line withZhou and Irizarry (2016), a higher clustering coefficient, that is, a score loser to1 shows that most of the risk practices have similar characteristics.

Taken together, the macro-level scores indicate that the interdependency network model exhibits a small-world effect. Indeed, Table 4.24 shows that the interdependency network model has a small-world index of 1.291. This index is derived by dividing the geodesic distance score with the global clustering coefficient score. A value greater than one satisfies the small-world criteria (Borgatti et al., 2020), and it implies that only one step or hop is required to connect risk practices that are not neighbors. In line with Zhou and Irizarry (2016), this indicates that risk practices have similar characteristics, which as a result have a capacity to cause faster risk propagation. This finding suggests that the interaction between the risk practices is difficult to control and their choice is intended rather than random.

Table 4.24: Network Interdependency Measures

Item	Description	Value
1	Number of nodes-practices	11
2	Number of edges-connections	110
3	Avg Degree	10
4	Unweighted Density	1
5	Weighted Density	18.564
6	Weighted overall clustering	18.564
7	Connectedness	1
8	Average geodesic Distance	1
9	Diameter	1
10	Small Worldness	1.291

Source: constructed from research data

The small-world property also shows that risk propagation is faster because of the presence of intermediary practices. Indeed, intermediary functions indicate control, which in the case of design-bid-build FIDIC red book is delegated to the engineer (Ndekugri et al., 2007). However, because in that setting the controller combines agency and neutral roles, it implies that the process and the end product can be directed in such a way as the expose the contractor to payment risks.

4.4.6 Eigenvalue and Eigenvector Results

Table 4.25 presents the Eigenvalue and Eigenvector result. This result demonstrates that 80.2% of the interdependencies between risk practices match the overall network pattern. This is the most critical observable pattern. The criticality threshold is met if the score is greater than 70% (Borgatti et al., 2020). Consequently, the score of 80.2% indicates the significance of the overall pattern in enabling payment risks. The ratio of 17.76 demonstrates that the critical pattern is more significant than the second observable pattern. Since the method for determining the most significant pattern of is based on the first eigenvalue, it means that the subsequent eigenvalues are less important (El-adaway et al., 2017b).

Table 4.25 also shows the relative risk contribution capacity of the risk practices (Rank column). In line withChowdhury et al. (2011), the practice with the highest eigenvector score is at the center of the most critical pattern of connections. This implies that such risk practice plays a critical role. On the other hand, a lower score indicates the risk practice is peripheral to the overall pattern of connection. Accordingly, practices P5 and P3 have a critical role while risk practices P9 and P1 have a peripheral role. This suggests that risk practices P3 and P5 have the capacity to initiate and transmit most of the payment risks.

Table 4.25: Eigenvalue and Eigenvector Centralities

Practice	Eigenvalue				Eigenvector	Rank
	Value	Per cent	Cum%	Ratio		
P1	214.93	80.20	80.20	17.76	0.24	9
P2	12.10	4.52	84.71	1.06	0.26	8
P3	11.43	4.27	88.98	1.56	0.35	2
P4	7.31	2.73	91.71	1.35	0.31	5
P5	5.42	2.02	93.73	1.11	0.37	1
P6	4.87	1.82	95.55	1.12	0.34	3
P7	4.34	1.62	97.17	1.32	0.30	6a
P8	3.30	1.23	98.40	1.71	0.27	7
P9	1.93	0.72	99.12	1.47	0.21	10
P10	1.31	0.49	99.61	1.24	0.32	4
P11	1.05	0.39	100.00		0.30	6b
	268.00	100.00				

Key: P1-P11=Risk Practices

Source: constructed from research data

Table 4.26 presents statistics for the eigenvector measurements. In these statistics, the eigenvector scores and for the interdependencies between risk practices show a slight variation. This variation ranges from 0.212 to 0.372. A look at the standard deviation reveals that the variation from the mean is much lower, at 0.047 versus 0.298. This result suggests that there is little variation in the extent to which risk practices generate and transmit payment risks. When compared to a pure star network with a random topology (Lin, 2015), the degree of network concentration is 16.86 percent. This means that a greater number of risk practices are decentralized, since only 16.86 risk practices are driving the overall pattern of interdependencies.

With result of Table 4.25 and 4.26 in mind, the following findings can be stated:

(a) The critical observable connection patterns account for 80.2 percent of all patterns. This means that about 20% of the risk practices determine the critical pattern, as about 80% plays a peripheral role. This demonstrates that most payment risks are initiated and transmitted via interdependence (P3, P5).

(b) Intuitively, the foregoing finding suggests that payment for the contractor resources incorporated into the project is contingent upon 20% of the risk practices. Due to their unpredictability, however, payment risk exposure tends to adhere to the power law or rich get richer principle (Fig. 4.8). In fact, this observation is comparable to Lin's (2015). The power law is a property of a scale-free network model.

Table 4.26: Statistics for the Eigenvalue and Eigenvector Centralities

Statistics	Eigenvector
Minimum	0.212
Maximum	0.372
Mean	0.298
Standard Deviation	0.047
Sum	3.277
Variance	0.002
SSQ	1
MCSSQ	0.024
Euclidean Norm	1
Observations	11
Missing	0
Network Centralization Index = 16.86%	

Source: constructed from research data

Fig 4.8 presents the power law principle, which depicts a relationship between eigenvector scores and the cumulative frequency of pairs of interdependencies. This observation compares well to the small world finding, which had an index score of 1.291. It emphasizes that approximately 80% of payment risks are initiated and transmitted by the risk practices associated with the owners, but performed by their intermediaries. In the context of the D-B-B, this means that the combination of the contract document supply with the certification role by the consulting agent is the driver of most payment risks. Put differently, the ability of the project owner to transfer financing obligations to the contractor is determined by capacity to combine and direct agency and certification roles. Therefore, a combination of agency and certification roles controls most of the payment risk events. This finding demonstrates the central source of the owner's procurement system robustness reflected through capacity to deliver cost economizing benefits. On the other hand, it also demonstrates the central source of vulnerability to contractor's late, underpayments and non-payment risks.

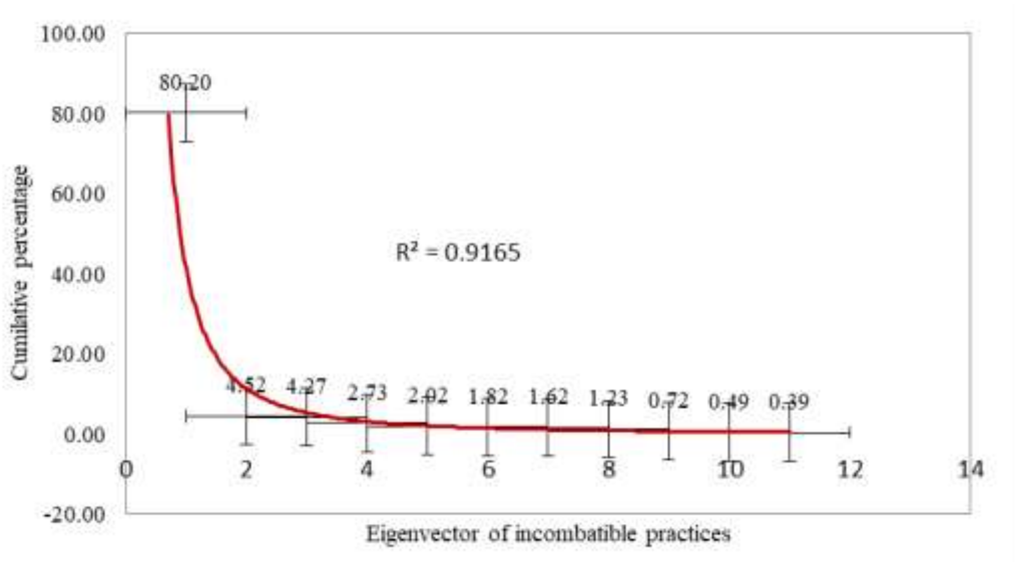


Figure 4.8: The Eigenvector Ddistribution Fitting with the Power-law Equation

Source: constructed from research data

4.4.7 Payment Risk Vulnerability Matrix

Table 4.27 displays relative risk initiation and transmission capacities for ten interdependencies, which also identifies the paths to vulnerability. Their relative magnitude scores are displayed above and below the diagonal. The result shows that interdependency 218—payment upon certificated performance and failure to match work with sums paid—initiates and transmits most risks. Its vulnerability pattern comprises P3, P4, P7, P8, P2 and P1 risk practices. Its transmission capacity is initiated by P3, which suggests the extent of its incompatibility with irreversibility characteristic of the work done. This implies that without advance payments, integration process control favors the legal site owner. Therefore, this inequality explains one of the rationales for the dominance of the D-B-B option.

Table 4.27: Maximum Flow Matrix

Incompatible practices		**P9**	**P1**	**P2**	**P8**	**P7**	**P4**	**P3**	**P5**	**P6**	**P10**	**P11**
P9	Communication via consulting unit	-	**137**	137	137	137	137	137	137	137	137	137
P1	Skewed resource allocation position	**137**	-	**152**	152	152	152	152	152	152	152	152
P2	Use of repeat business enticement	137	**152**	-	**166**	166	166	166	166	166	166	166
P8	Doubling in design & certification	137	152	**166**	-	**172**	172	172	172	172	172	172
P7	Part deferral during certification	137	152	166	**172**	-	**184**	184	184	184	184	183
P4	Doubling as buyer and producer	137	152	166	172	**184**	-	**194**	194	194	194	183
P3	Payment upon satisfactory performance	137	152	166	172	184	**194**	-	**218**	209	201	183
P5	Not matching output with sums paid	137	152	166	172	184	194	**218**	-	**209**	201	183
P6	End-product & site none-separability	137	152	166	172	184	194	209	**209**	-	**201**	183
P10	Uncertainty avoidance	137	152	166	172	184	194	201	201	**201**	-	**183**
P11	Poor third party fault visibility	137	152	166	172	183	183	183	183	183	**183**	-

Key: P1-P11=Risk Practices

Source: constructed from research data

4.4.8 The Payment Risk Vulnerability Profile

Figure 4.9 displays a vulnerability profile. It shows the degree of weakness inherent in the system of incompatible practices to cope with payment risk events. This is demonstrated by ten interdependency channels which are located by the horizontal and vertical scales. It is shown that the 10 interdependencies are clustered into 3 patterns. These three patterns suggest three thematic findings, which are discussed in more detail below.

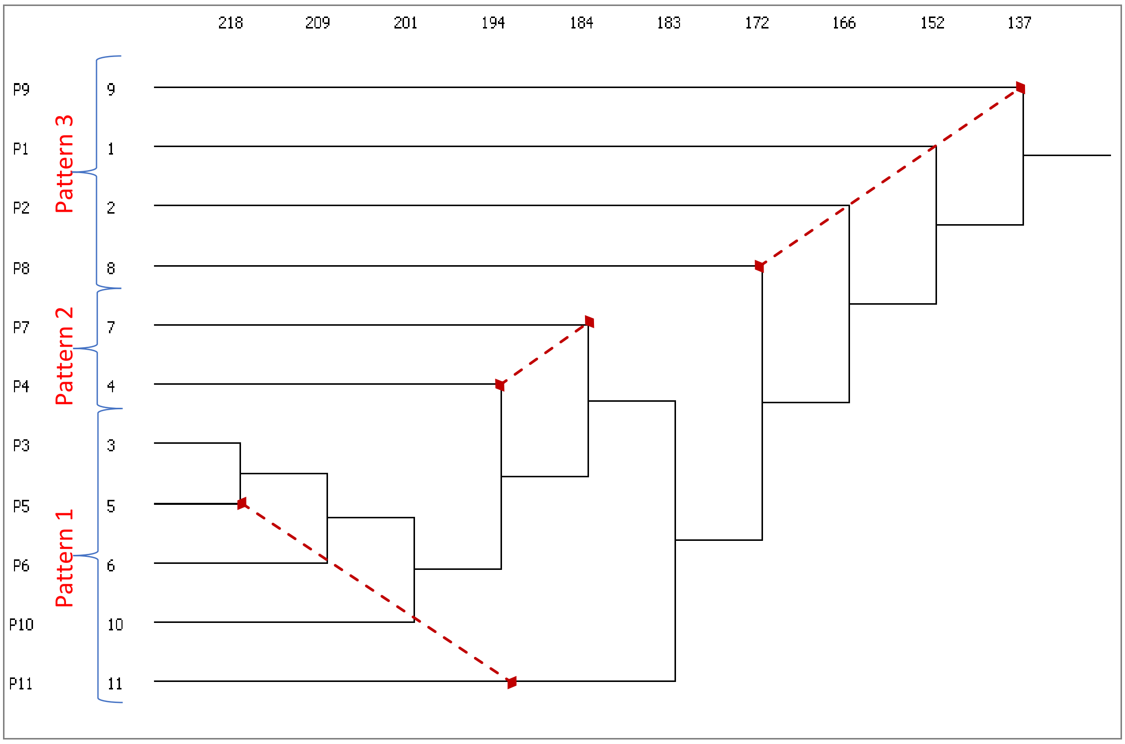


Figure 4.9: Clustered Interdependencies According to the Lambda Method

Key: P1-P11=Risk Practices

Source: constructed from research data

(a) The practice of doubling in buying and production is an economizing strategy

The first finding is illustrated by the interdependence indexed by a score of 218, which indicates the greatest exposure to payment risk. This channel initiates the first pattern, made up of indexes 209, 201, and 183. This pattern is characterized with the steepest slope. This implies that the practice of doubling in buying and production functions is the source of the greatest vulnerability to payment risks. In contrast, prompt and complete payment is arguably an effective reimbursement mechanism. In fact, once the product has been fused with the immovable production site of the buyer, it cannot be undone. As a result, the interdependency represented by index 218 tends to provide an opportunity for the owner to profit unjustly by failing to pay his contractors. This could explain why the procuring side prefers the D-B-B system over other systems.

Table 4.28: Pattern and Connection Specification

Index	Interdependency	Interdependency description	Pattern identifier
218	(P3,P5)	1. Use of skewed post-contract integration structure	Buyer doubling as producer advantages **(1st pattern)**
209	(P5,P6)	2. Insufficient alignment of rights of claim with site inseparability characteristics	
201	(P6,P10)	3. Insufficiently aligned liability for variations	
183	(P10,P11)	4. Impaired third-party fault verifiability capacity	
194	(P4,P3)	5. Unreliability of the presumed impartiality of the contract administrator	Certifier cum owner representative duality **(2nd pattern)**
184	(P7,P4)	6. Concealment of owner financing capacity	
172	(P8,P7)	7. Allocation of design-related variation risks to contractors despite functional independency	Tensions between future promises and performance (**3rd pattern)**
166	(P2,P8)	8. Unreliability of repeat business promises	
152	(P1,P2)	9. Differences between proactive versus reactive market orientations	
137	(P9,P1)	10. Tensions between price certainty and uncertainty	

Key: P1-P11=Risk Practices

Source: constructed from research data

Table 4.28 presents a summary of the vulnerable interdependencies. Each interdependency and its corresponding pattern are described. This result, demonstrates that the overall vulnerability is the result of a network level effect as opposed to the action of a single interdependency. By adopting a networked perspective, it is implied that the effectiveness of any given strategy is contingent on a network of practices. Thus, the viability of a network of practices determines the effectiveness of the owner's strategy. In contrast, the effectiveness of payment default remedies depends on how interconnected practices are. In other words, an advantage for one side is a disadvantage for the other.

(b) The practice of combining certification and agency centralizes brokerage position

The second most critical path to vulnerability is indexed by a score of 209. It comprises of a pattern illustrated by indexes 194 and 184. These indexes indicate that the practice of combining agency and certification roles has a significant influence on how the contractors are compensated. This is because by participating in design and bid preparation on the owner's behalf, the engineering agent becomes better informed about information such as the owner's financing capacity. In contrast, the contractor's non-involvement illustrates a disconnection, which implies less knowledge regarding the owner's financial capacity. Due to the requirement to advance the owner's interests first (Winch, 2001), payment certification can be manipulated for the benefit of the owner. However, this strategy's success is contingent on the level of trust between the owner and his certifier. This could explain why, in contracts like the FIDIC red book, the engineer has more influence than the owner and contractor (Besaiso et al., 2018). Awareness of this finding, reinforces the rationale for decentralizing intermediary functions as for instance proposed by Hamledari and Fischer (2021).

(c) Variations between promises and performance are traceable

Finally, index 172 demonstrates the connection between the occurrence of payment risks and variations. This vulnerability is propagated by risk practices P1, P2, P8, and P9. Its most important insight is that the practice of establishing the end-product price (contract price) prior to construction is a major source of variation from what was promised at the contract formation stage. One of the challenges with such variations includes contestations regarding liability allocation ambiguities. The ambiguities arise because design is separated from construction (P8), but the same designer is also empowered to certify payments. However, design errors and specifications are contributors to cost variances(Eybpoosh et al., 2011). This means that the combination of design and certification roles has an effect of undermining the assumed neutrality associated with the certification role, which includes allocating liability for cost of variations.

The compromised neutrality is complicated further by the fact that the D-B-B setting design is supplied on behalf of the owner (El-adaway et al., 2017a). This duality tends to conflict the assumed neutrality of the certification role and the first point of dispute resolution between the owner and the contractor (Ndekugri et al., 2007). Under this context, the existing practices lack an objective way to identify the cause-and-effect interdependencies. As a result, liability tends to be shifted to the most vulnerable party, and payment default is one of the liability mechanisms. However, the approach illustrated by this study can objectively be used in linking a cause to its consequence. In this sense, this study suggests a less ambiguous method of profiling the cause-and-effect connection.

4.5 Chapter Conclusion

This chapter has presented three sets of interconnected results. The first set to find out the influence of contextual determinants on co-occurrence of payment disputes. Evidence was drawn from payment dispute cases. These determinants were designed for the standard product market setting and therefore not fully compatible with construction contracting practices. Because their interaction also reflects an interaction between contractual practices, some aspects are not fully compatible with parts of construction procurement systems such as the design-bid-build option. As a result, the second set of results presented the degree of dissimilarities between practices under the D-B-B in comparison with the standard market setting. The extent of incompatibility also indicates the extent to which a practice can cause payment risk events. Consequently, the third set of results, modelled an interdependency network. This model captures, risk practices and their risk events through contextual determinants. The model has been used to analyze various aspects of payment risks.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the conclusions about the research aim and objectives, summary of the findings and research implications. It also outlines the study limitations and recommends areas for further studies and draws conclusions. These are discussed in detail below.

5.2 Summarized Conclusions

5.2.1 Assessing the Influence of Contextual Determinants on Co-occurrences of Payment Disputes

Section 4.1 discussed this goal in detail. Ten contextual factors were drawn from the literature to address it, and they were tested on two sets of payment dispute situations. 29 cases from the private sector made up the first group, while 22 cases from the public sector made up the second. The demographics, matrix, graphical, macro-level, nodal, and structural hole studies were performed on this separation. Following each section are conclusions.

(a) Conclusions on Demographic Analysis

Based on the results for the type of work (section 4.1(a)) and the type of contract (section 4.1(c)), two conclusions can be made. First, the study finds that building work is more likely than other types of work to lead to payment disputes. In fact, out of the 57% of payment disputes in the private sector, 53% are about building work. In the public sector, where there are 53% of payment disputes, 25% of them are about building work. Civil works in the public sector were the second most affected, with 18%. On the other hand, there were no disputes about public works in the private sector. So, we can say that building projects are more likely to have payment disputes than civil projects. This result can be explained by the fact that the two sectors have different ways of setting prices. In fact, it was found that the fixed price mechanism was used most often for building work, while the cost-plus mechanism was used more for civil work. Since the construction product doesn't exist when the contract is signed, it was shown that the fixed price mechanism is based on assumptions of certainty instead of uncertainty. So, disagreements over who is responsible for the differences between certain and uncertain assumptions show that there are a lot of payment disputes in the building industry.

Second, the majority of private sector payment conflict cases, or 47%, involved the Joint Building Council's standard form of contract. In contrast, the majority of public sector payment dispute cases, or 23%, involved the Public Procurement Oversight Authority's standard form of contract. Due to disparities in contracting between the two sectors, the conclusion that JBC agreement effects more disputes than PPOA agreement is inconclusive. For instance, the PPOA's contract award criteria require the successful bidder to disclose prior litigation. Due to the requirement for a continuous workload, some bidders choose not to pursue payment complaints. Consequently, the PPOA conditions tend to discourage payment issues from proceeding to forums such as arbitration more so than the JBC criteria. Consequently, the JBC contract conditions are more in line with construction market disparities than those of the PPOA contract.

(b) Conclusions on Matrix Analysis

In Section 4.1.2, the results and analysis of the two-mode and one-mode matrices for the private and public sector dispute cases were shown. Two things can be said based on this set of analyses. First, the practices that go along with the principle of site asset specificity affect the majority of payment dispute cases and have the greatest impact. Site asset specificity was shown by the fact that the construction procurement process had an irreversible effect on the work done by the contractor and by the fact that the contractor was only paid after a satisfactory performance. As a result, it can be stated that in the absence of timely and complete payment, the contractor's contribution in terms of completed work cannot be separated from its site.

Second, the owner's moral hazard is the second most common cause and effect of payment conflicts in the private sector. In this scenario, the owner's cost-cutting tactics result in unjustified gains from the contractor. The impact of these techniques was demonstrated by acts such as failure to pay for variations. Consequently, it can be argued that owners' cost-cutting techniques are more prevalent in the private sector compared to the public sector.

Contrary to the private sector, the public sector's second most common source and influence of payment disputes is the determinant of contractual incompleteness. This finding was supported by the fact that the procurement party and the contractor did not have a common understanding. The failure to communicate information regarding the inability to obtain funding from the anticipated sources was blamed for it. The design consultant, who also serves as the owner's representative, is one of the defining characteristics of the public sector. These ambiguities make it difficult to distinguish between the agency and the actual project owner. A further effect is the absence of distinct role differentiation. Therefore, it may be inferred that the public sector is more likely than the private sector to experience links between cost changes and payment disputes.

(c) Conclusions on the Graphical Analysis

The analysis of section 4.1.3 showed a graphic comparison of the determinants that make a difference in the private and public sectors. Based on this analysis, we can say that contextual factors are more connected in the private sector than they are in the public sector. In the private sub-network, all of the determinants were linked, but in the public sub-network, the determinant of transaction frequency was separated from the rest of the sub-network. This means that doing business more than once was less common in the public sector than it is in the private sector. Based on this fact, we can say that payment disputes are more likely to happen in the private sector than in the public sector.

(d) Conclusions on Macro-level Analysis

At least two observations can be repeated in light of the macro-level analysis (Section 4.1.4). Based on the fragmentation metric, the private sector is more likely to receive repeat business than the governmental sector. This technique has the effect of fostering trust, resulting in fewer instances of dispute. Contrary to the preceding conclusion, it can be concluded that there are less payment disputes in the private sector than in the public sector.

Second, since the diameter of the private subnetwork was 3, while that of the public sector was 2, the private subnetwork was deemed superior. The transfer of payment disputes is faster in the public sector compared to the private sector, as indicated by a smaller dimeter This diameter statistic implies that it is more difficult to control payment disputes in the public sector than in the private sector.

(e) Conclusions on Nodal-level Influence

In section 4.1.5, the influence of context-based factors on payment disputes was assessed. The determinants were thought of as nodes, and their degree, eigenvector, and Bonacich power centralities were used to measure them. This was complemented by thematic analysis. First, the centrality ranking showed that site asset specificity had the most impact on both private and public sector payment dispute cases. This determinant shows the effects of not being able to separate the end product from its site, which makes payment risks more likely (Table 3.2). This is evidenced by the mismatch of certain contractual practices and payment default remedies. For instance, the common practice of being compensated after completing an assignment is at odds with this inseparability feature. One thing that becomes clear is that there is a reason to look at how well some of the current practices align together in terms of compatibility.

Second, there were mixed results when it came to the second most important determinant. From the point of view of the private sector, bounded rationality was the second most important determinant. From the point of view of the public sector, incomplete contracts were the second most important factor. These determinants point to a problem with verifiability that payment dispute resolvers usually have to deal with. This is shown by how hard it is to make a clear link between what caused a payment default and what happened as a result. So, it can be asserted that a lack of direct links with the project execution processes contributes to erroneous payment default cause-effect analysis. Overall, this discovery highlights the need of investigating the role of intermediaries in payment disputes.

(f) Conclusions on the Structural Hole Analysis

The concept of "structural holes" was used to measure the different ways in which payment dispute risk could spread (section 4.1.6). The idea is based on the fact that there are no direct links between nodes or that there are only weak links between them. Metrics for size, efficiency, and constraints were used. At least two things can be said based on this result.

First, in both the private and public subnetworks, the largest size was found in the site asset specificity determinant. This means that practices like separating the legal ownership of a site from the contractual possession of the site are likely to propagate most of the payment disputes. Therefore, to reduce the spread of payment disputes, it is essential to match these practices with the proper payment default mitigation procedures.

Second, based on the measure of efficiency, the fastest payment dispute risk propagation node in the private sector is different from the one in the public sector. In the private sector, the practices related to contractual incompleteness, which are shown by gaps in contractual documents and unreliable contract administration roles, are the ones that spread the fastest. But the fastest way for payment risks to spread in the public sector is when contractors are vulnerable to hold-up demands. In short, the structural hole measures show that most payment disputes are spread by roles that act as intermediaries.

5.2.2 Assessing the Extent of Practices Incompatibility and Connection with Payment Risks

Section 4.2 presents an assessment of the degree of incompatibility between practices and the resulting association with payment risks. Its findings and analysis support at least five conclusions. The structural equivalence analysis was used to create an index of eleven practices. Six of them were determined to be the least compatible, and as a result, their links with other practices were identified (Table 4.17). Zero was found to have the greatest degree of incompatibility. This index represents the relationship between the practice of paying for satisfactory performance alone and the inability to align progressive compensation with the amount of work completed. The latter implies a reactive strategy, whereas the former demonstrates a proactive attitude. The D-B-B structure reveals a tendency by the owner’s side to employ a combination of the two strategies. In contrast, the contractor has the option of responding to the owner's combined strategy. Consequently, a contractor's reactive strategy is associated with control imbalances in the procurement process, which shows that certain payment risks are deliberate rather than incidental.

The second most incompatible interaction has a compatibility index of 2.24. It shows the link between the practice of delaying certification of some parts of finished work and the less effective way of settling disputes through a third party. Because of this mismatch, it is hard to see how the owner's plans to save money and the transfer of financing deficiencies to the contractor are linked.

Third, an interaction with an index of 9 is the third most incompatible. This index illustrates the interaction between the inseparability of the final product from its site and the failure to match progressive payments to the quantity of work performed. This difference makes it possible, among other things, to distinguish between contractual site possession and legal ownership. The results include unequal control rights over the final output. In order to resolve the unequal control of the final product, payment default remedies must be rationalized.

Fourth, hierarchical clustering analysis revealed a strong proximity and overlap between the index that initiated the integration or disintegration and the last index to integrate or disintegrate (Table 4.18 and Fig 4.4). The overlap is represented in the mix of financing, design, supervision, and certification roles. Due to this overlap, unambiguous role separation is not readily apparent. Therefore, the overlap caused by D-B-B practices allows competing interests, which increases the payment risk.

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apparent. Therefore, the overlap caused by D-B-B practices allows competing interests, which increases the payment risk.

Lastly, a blockmodeling analysis revealed overlapping responsibilities and connections to payment-related defaults (Fig. 4.5). This overlap gives the owner greater control over the construction contracting process and the final product. The inequity is made possible by the utilization of an intermediary mechanism, as reflected by the consultation unit. In accordance with the FIDIC red book (Besaiso et al., 2018), the consulting unit is responsible for design, supervision, and certification, as well as acting as the initial point of conflict settlement between the owner and contractor units. Due to the fact that the consulting unit is employed by the project owner, it was determined that the role combination is incompatible with the position's assumed impartiality. In particular, it manifests itself in unbalanced certification and dispute resolution. However, as shown in Table 4.19, the overlaps can be realigned by separating them into three distinct groups. Therefore, there is a connection between overlaps and payment dispute occurrence risks.

The analysis of phase two as a whole showed that the design-bid-build procurement approach is not perfectly reflected in the accompanying practices. This is due to the fact that they reflect contextual factors that were created for typical market product processes. Their incompatibility profile revealed a correlation with contractor exposure to payment-related issues. Therefore, the degree of mismatch between practices is also an indicator of their risk-causing capacities.

5.2.3 Development of an Interdependency Network Model

In section 4.3, the goal of developing a model of an interdependency network was discussed. In that section, the matrix and graphical interdependency network model formats were described. The model results were shown and analyzed using the matrix, graphical, macro-level, eigenvector, scale-free, and vulnerability methods.

The conclusions are discussed below.

(a) Conclusion on the interdependency network matrix and graphical model

First, a two-mode or incidence matrix was used to show the empirical data. This matrix showed, among other things, the frequency result for the number of times the risk practices happened. It was discovered that payment following satisfactory performance is the most common cause of contractor payment risks. The practice was borrowed from the conventional product market, where producers and buyers are clearly separated. However, it was determined that this context was distinct from the practices associated with the design-bid-build system for acquiring construction projects. Therefore, it can be concluded that the degree of incompatibility between practices correlates with the frequency of contractor payment risk occurrences.

The two-mode matrix was transformed into a model of a one-mode matrix network. This model provided a method for determining the interdependencies between payment risk practices and the severity of those practices. Fig. 4.6 illustrated the interdependencies and their magnitude ratings graphically. It was discovered that the most severe payment risk impact is a result of the interdependencies between the practice of payment upon acceptable performance and failure to match quantities paid with the amount or work performed. This is also related to the specificity of the site's assets and the determinants of substantive uncertainty. Consequently, the network model offers a method for describing and analyzing cause-and-effect scenarios.

(b) Conclusion on the macro-level network model analysis

In section 4.3.5, the results and analysis of the interdependency network model at the macro level are shown. It shows some of the effects of the model on payment risks at the system level. A fundamental finding of this research is that risk practices and their interdependencies share comparable characteristics. Similarities between the weighted density and overall clustering coefficient scores back up this finding. This is shown by the fact that the average scores for geodesic distance, diameter, and connectedness are all the same. These similarities suggest that the interdependency network model has small-world properties. With these characteristics, interdependencies between risk practices mean that payment risk spreads more quickly. Also, the speed of spreading is faster because of the roles of intermediaries. This was shown by the design-bid-build practices, which were a mix of agency and neutral roles. So, it's important to pay attention to the topology of the practices that cause payment risk to spread more quickly.

(c) Conclusion on eigenvector and scale-free analysis

In Section 4.3.6, the eigenvector and scale-free analysis were provided. This analysis reveals that approximately 80% of risk practices and their interdependencies have a secondary role in influencing the occurrence of payment risks. In contrast, around 20% of risk practices and their interdependencies control the majority of payment risks. The 20% relates to the interdependencies between the practice of certification after satisfactory performance and the failure to match the amount paid to the amount of work performed. Therefore, 80% of payment risks can be mitigated if 20% of the practices and their interdependencies are given careful consideration.

It was also discovered that the distribution of risk practices and their interdependencies exhibited a scale-free network structure. This was shown by a power low equation, which was used to fit the relationship between the risky behaviors and their total frequency. The result showed that 20% of the risk practices cause and spread 80% of the payment risks. This suggests that the majority of payment risks are planned rather than accidental as indicated by the choice of contractual practices So, on the one hand, it can be said that the design-bid-build system has an 80% chance of obtaining the constructed facility for less than the actual cost by paying late, not paying enough, or not paying at all. This conclusion is also an indication of the robustness of the system. On the other side, it is also possible to conclude that 20% of the risk practices influence the contractor's vulnerability to payment risks.

(d) Conclusion on vulnerability analysis

In Sections 4.3.7 and 4.3.8, ten interdependencies related to contractor payment vulnerabilities were identified and profiled. Their relative capacities for risk initiation and transmission were determined. The most significant vulnerability path to payment risks is represented by practices of payment after satisfactory performance and failure to match the work performed with the amounts paid. This vulnerability implies that the design-bid-build system is susceptible to payment risks in the absence of advance payments. This analysis led to three conclusions.

To begin, it was determined that the procurement side can save money by taking advantage of the common practice of producers also acting as buyers. This is reflected in the practices of retaining legal site ownership while delegating the authority to determine when and how the contractor is paid. Engineers exercise delegated control in contracts such as FIDIC's red book(Fawzy et al., 2019). Therefore, if the procuring party desires to complete the project at a lower cost than the actual, the D-B-B will be preferred.

Second, the second most critical path to vulnerability suggests that the practice of combining agency and certification roles tends to centralize the consulting unit's brokerage position. Due to the assumption of opportunism, the consulting unit is not prevented from extracting unjustified gains to the detriment of both the owner/client and contractor units. Consequently, some standard forms of contract will favor the influence resulting from the combination of agency and certification roles. Nonetheless, the analytical approach depicted in this study offers a method for decentralizing brokerage powers.

The third most critical route to vulnerability is the incompatibility between the methods used to determine the contract price prior to construction. The method is incompatible with the D-B-B procurement system because the constructed product does not exist at the time of contract formation. Consequently, the D-B-B realization processes are marked by dynamic uncertainty. Its magnitude is greatest during pre-contract phases, then decreases in tandem with the construction process until it reaches zero at the project's conclusion. On the standard market product market, however, the price is established following production and is therefore characterized with certainty. It was discovered that the incompatibility of pricing approaches is reflected in outcomes such as variation-related disputes. As such, the results of the model showed a possible way to tie the responsibility for the difference between the contract price and the actual outcome to its cause.

5.2.4 Conclusions About the Research Problem

This study investigated the problem of inadequate understanding as pertains the interconnectedness context within which the concept of construction contractual payments is embedded. Indeed, the inability to recognize how interconnectedness between variables influences occurrences and impact of payment risks is reflected by the existing literature, which presumes a disconnected view. As a result, the link between the application of the standard market product principles in procuring construction projects, especially based on the design-bid-build system is neglected. Additionally, because the applicable practices derive from the interactions between contextual principles, their compatibility with the D-B-B system is also unascertained. As a result, it is also unclear how interdependencies between incompatible practices leads to payment risks.

In addressing the stated problem, a three phased approach was employed. In the first phase, 10 contextual determinants were synthesized from the literature. Based on data from payment dispute cases, a social network analysis approach was used to build private and private subnetworks. These subnetworks demonstrated co-occurrences between contextual determinants, which in turn were found to have connections with contractual practices.

In the second phase, 11 practices were identified by comparing the standard market product with the D-B-B system of procuring construction projects. Data from 12 subject matter experts (SME) was used to rate them. Using a SNA approach, their degree of compatibility was ascertained. It was for example established that the extent of their incompatibility suggested contractor payment risk causing capacities. As a result, their degree of incompatibility was therefore conceptualized in terms of risk practices.

In the third phase, twelve propositions were formulated based on a synthesis between contextual determinants and risk practices. Based on judgements from the SME, a two-mode matrix was built. This output was then used to create an interdependency network model, which was represented in the form of a one-mode matrix and visual graph. In analyzing the model results, 10 interdependency paths to late, underpayments and non-payment risks were identified and described. In this way, the research problem was therefore addressed.

5.3 Contribution of the Research

This study's contributions can be categorized as theoretical, methodological, and policy and practice. These are discussed in accordance with their respective classes.

5.3.1 Contribution to Theory

This research utilized and contributed to the theories of market mixt, transaction cost economics, and principal-agency and complexity by interdependency. These are discussed in detail below.

(a) The Market Mix Theory

This study utilized and advanced the market mix theory. This theory was developed in a manufacturing context from the standpoint of the standard product market (Arditi et al., 2008). In this study, the place, product, price, and promotion elements of the standard product market were used to compare it to the design-bid-build (D-B-B) setting. The comparative examination revealed conceptual and practical distinctions. These findings were then combined with those of transaction cost economics and principal-agency theories. The result was contextual factors, incompatible practices, and risky practices. The contextual factors were validated using payment dispute case data. Data from subject matter experts were used to validate the practices and risk practices.

This study contributed to the market mix theory by illustrating the differences between standard product manufacturing and D-B-B construction procurement settings. And how these differences contribute to risks such as contractor payments.

In the standard product market, for example, "place" refers to the distribution channels between sellers of manufacturing inputs and buyers of product outputs (Skitmore & Smyth, 2007). In construction, however, "place" refers to a fixed site and procurement routes. In the D-B-B, those who have constructed on the site do not have legal ownership rights. Consequently, practices such as payment after satisfactory performance were discovered to have the most impact on payment risks. This result suggests that the 'place' component of the market mix is not fully compatible with the D-B-B setting. This demonstrated the study's contribution to the market mix theory.

(b) The Transaction Cost Economics (TCE)

The study drew from and contributed to the TCE. Its central premise is that a transaction is presumed to have taken place if it crosses two technologically distinct interfaces (Winch, 2001). The separable interfaces were conceptualized as the interdependencies between separated resource ownerships, such as design, construction, and procuring firms. The interactions between these firms were viewed as transactions. According to the Transaction Cost Economics (TCE), these transactions are characterized by transaction frequency, uncertainty, asset specificity, opportunism, and bounded rationality. In order to determine contextual determinants, these factors were combined with those from the market mixture and principal agency. Data from payment dispute cases was used to validate these determinants.

For instance, asset specificity, which describes the effects of irreversible inputs, was discovered to be a contributor to the majority of payment risks. It illustrated the characteristics of a construction site and the roles associated with site ownership. Since, according to market mix, the site also refers to procurement routes, the D-B-B contractors' lack of participation in its formulation demonstrates that it is a significant source of payment risks. It enables skewed process and end-product control in particular. By retaining legal site ownership and the right to appoint a contract administrator, the owner gains greater control over the amount of work paid for and, consequently, the amount of unpaid work. In the context of the FIDIC red book, the control mechanism is exemplified by a combination of design, supervision, certification, and initial dispute resolution point (Besaiso et al., 2018). As evidenced by co-occurrences of payment risk events, this skewness enables the procuring party to exploit contractors. In this way, the study helped advance the TCE by confirming key assumptions.

(c) The Principal-agency Theory (PAT)

The study also contributed to and drew from the PAT. Although there are some similarities between the PAT and the TCE, its concept of information asymmetry contributed to the reinforcement of the contextually derived determinants. According to the principle of information symmetry, information is unequally distributed, which results in some parties being better informed than others (Xiang et al., 2015). The information-disadvantaged party is therefore vulnerable to adverse selection, moral hazard, and hold-up risks (Xiang et al., 2012). In the construction industry, PAT assumes that the project owner/client, also known as the principal, is less informed than his agents, such as consultants and contractors. Therefore, previous research indicates that the principal is more vulnerable to asymmetric risks than his agents.

In contrast, this study revealed a context in which owners are more informed than contractors. The balance is shifted by the practice of hiring a consulting agent who does design, supervision, certification, and first point of dispute resolution (Besaiso et al., 2018). The agent assumes design and supervision responsibilities on behalf of the owner, with the latter two responsibilities presumed to be neutral between the owner and contractors. However, neutrality was deemed unrealistic because the consultant is employed by the owner to protect his interests (Ndekugri et al., 2007). As is the case with the D-B-B, the contractor's lack of involvement in the design implies that he or she is less informed about matters such as the owner's financial capacity. As a result, the certification mechanism is used to manipulate payments. This is shown by factors like delayed certification and intentional under valuations. According to the results of structural holes and structural equivalence, the practices and connections associated with the consultant's position transmit the majority of the payment risks. In this way, this study contributed to and drew from the PAT.

(d) The Theory of Complexity by Interdependency

The study contributed to and utilized the theory of complexity by interdependence. This theory distinguishes between sequential, pooled, and reciprocal interdependencies between entities (Davies & Mackenzie, 2014). Sequential interdependence describes a relationship with a single direction. This is frequently observed in standard product manufacturing settings, such as automotive and electronic, and exemplifies continuous workload flow (Hobday, 1998). In the context of this study, the work constructed by a contractor exemplifies a one-way relationship because it cannot be reversed without full payment. In this manner, the present study utilized and contributed to an aspect of complexity theory.

The pooled interdependence describes indirect relationships between two or more concurrent events (Bankvall et al., 2010). It was demonstrated, for instance, that participation in design and delayed or under-certification payment by the consultant have an indirect relationship. Moreover, when payment risks are deliberate, such measures are planned during the design phase and implemented during the construction phase. The contractor's lack of participation in the design process demonstrates a disconnect, as evidenced by his ignorance of the owner's financing capacities and strategies. However, the majority of payment risks were found to be controlled by a combination of agency and neutral roles. In this way, the current study contributed to the pooled dimension of the theory of complexity.

In conclusion, reciprocated interdependence denotes a two-way relationship with forward and reverse directions (Baccarini, 1996). This was demonstrated, for instance, by the interdependence between payment based on satisfactory performance and failure to match the amount paid to the work performed. The practice skews process control, which exposes the contractor to exploitation via late, underpayment, and nonpayment actions. The interdependency network model developed in this study demonstrates, collectively, that payment risks are contributed by the three types of interdependencies. In this way, this study drew from and contributed to the theory of interdependence-based complexity.

5.3.2 Contribution to Methodology

This research demonstrates two methodological contributions. It begins by illustrating how the system and SNA approaches can complement one another. In addition, it demonstrates how SNA methods can be utilized to investigate payment-related risks. These are discussed in detail below.

(a) Integration of Systems and Social Network Analysis Methods

This research showed that it is possible to combine systems thinking with social network analysis (SNA) techniques in order to address the interconnectedness character within which the payment concept is embedded. This is possible because the two perspectives share significant conceptual similarities. A network is defined as a system of interconnected entities that consists of nodes and lines, which is one of the similarities (Engel et al., 2021). In consequence, nodes were used to represent contextual determinants, practices, and risk practices. On the other hand, the lines represented co-occurrences of payment disputes, the degree of incompatibility between practices, and interdependencies between risk practices. So, it was shown that a line is an important property because it shows how entities depend on each other.

Accordingly, the study confirmed that interdependencies between entities are a central characteristic shared by both system and network perspectives. This property was utilized to indicate whether or not direct lines existed between nodes. The presence of direct lines in network mathematics is represented by an adjacency matrix or a one-mode matrix (Barabási, 2013). The property of indirect lines is additionally represented by an incidence matrix or a two-mode matrix. This conceptualization enables the concept of a network to be utilized as a modeling and analysis tool for systems. This study illustrated modeling through the use of matrices and graphical objects.

Additionally, it was noted that systems dynamic modeling (SDM) is one of the common techniques of modeling systems. However, one of its limitations is that it lacks appropriate analytic metrics. This was evidenced by studies such as Xie et al.

(2019), which as a result borrowed structural equation modeling metrics to analyze the developed SDM model. However, the study confirmed that the structural equation technique is inappropriate for a context of interconnectedness because it is premised on independency assumptions (Sarstedt & Ringle, 2020). It was suggested that SNA is a suitable alternative because its metrics are premised on the assumption of interdependencies. As a result, it was used to conceptualize nodes for example as contextual determinants linked to each other. Based on this approach, it was possible determine the influence of contextual determinants on the co-occurrence of payment disputes. The degree, Eigenvector and Bonacich power centralities were used as the nodal measures. In this sense, this study demonstrated that it is feasible to model and analyze systems using a SNA approach.

(b) Application of Social Network Analysis in the Area of Payment Risks

This research also contributes to modeling and analyzing payment risk approaches. This contribution was necessitated by the realization that the concept of payment occurs in an interconnected setting. Previous payment literature such as Hou et al. (2011) have used system dynamic modeling to capture this environment. It was highlighted, however, that it is typically supplemented by other techniques because it lacks suitable analytical measures. Chen et al. (2018) is the only notable construction payment study to model payment risks and quantify their dissemination capacity using SNA. This shows that research on SNA construction payment is scarce. Therefore, the current work contributes significantly to the field.

The SNA application was depicted in three objectives. In the first, contextual determinants were extracted from the literature and synthesized. The cases of payment disputes were used to collect the data. Payment risk events were conceptualized by their occurrence. A two-mode matrix was used to capture the two dimensions. The contextual determinants were placed in the row dimension, whilst the dispute cases were expressed in the columns. This matrix was then transformed into a matrix with a single mode, where the row and column entities represented contextual determinants. This allowed the influence of contextual variables to be measured using degree, Eigenvector, Bonacich power centralities, and structural hole metrics. Chen et al. (2018) utilized degree centrality and contract price information from only five examples. Objective one of this study adds to the methods by using more metrics and data from 29 private and 22 public payment dispute cases.

In objective two, it was determined that practices are the result of interactions between contextual determinants that are borrowed from the standard market setting. Their compatibility was evaluated within the context of design-bid-build utilizing data from subject matter experts (SME). A two-mode matrix was utilized, with practices entered in the rows and expert ratings entered in the column side. This matrix was then converted to a one-mode matrix, in which both the row and column sides displayed practices. Using structural equivalence, Euclidean distance, and hierarchical clustering, dissimilarity indices were calculated. The dissimilarities were profiled using a blockmodeling approach. According to the available research, there is no evidence that these methodologies have been utilized in construction payment-related studies. Therefore, the second phase of this investigation provides a foundation for future payment-related research.

In the third objective, differences between practices from the second objective were equated with risk factors. These were put together with the contextual factors from objective one to create twelve propositions. The results were presented in a two-mode matrix after being rated by the SME. The ratings were entered into the column side of the table, while the risk practices were displayed in the rows. The two-mode matrix was turned into a one-mode matrix representing an interdependency network. The data was then utilized to generate a graphical representation of the model. The model was analyzed using Eigenvector and Eigenvalues, Flow Betweenness, and Lambda Partitioning techniques. Again, the literature indicates that there is no indication that these methodologies have been utilized in construction payment-related studies. As a result, the third phase of this study provides a foundation for future payment-related research.

5.3.3 Contribution to Policy and Practice

By addressing the inadequacies related with the research objectives, six policy and practice implications are proposed in this study. These are described in the following subsections.

(a) Illustrates how the Link between Strategies and Choice of Contractual Practices can be Profiled

First, it was discovered that existing payment literature pays little attention to the concept of interconnection and incompatibility among its entities. Consequently, the connection between the selection of contractual practices and strategic objectives is not readily apparent. By assessing incompatibility between practices, it was discovered that certain payment risks were linked to the owner's strategic objectives. This is in contrast to the existing payment literature, which neglected the interconnection of variables such as payment risk causes. The result is a failure to account for the payment risks initiated strategically. However, by assessing the degree of mismatch across practices, a method of profiling them in relation to their respective methods was uncovered. It gives the procurement side with a decision-making tool to, for instance, strengthen or relax their strategy. It provides contractors with a justification to decide, for instance, whether to contract and a foundation for negotiating favorable terms.

(b) Demonstrates a Way of Linking Remedies with Appropriate Problem Diagnosis

Second, the failure to establish the connection between practice selection and deliberate payment defaults also results in the selection of unsuitable mitigation measures. By revealing the degree of incompatibility between practices, the study demonstrated a practical method for evaluating the appropriateness of payment default remedies. In this perspective, current remedies for payment default might be examined. Skaik (2017), for instance, noted that a number of policy actions pertaining to payment default remain unrealized. Similarly, Lim (2015) revealed that statutory construction payment related regimes have not completely eradicated the issue of late payments and underpayments.

Nonetheless, evaluation of contractual procedures indicates a technique to differentiate between fortuitous and purposefully launched payment risks. This was demonstrated by tying together the selection of techniques and their underlying ideas. For instance, the D-B-B technique of determining the contract price prior to construction was discovered to be a result of combining concepts of certainty and uncertainty. The assumption of certainty is appropriate for standard market products because the exchange rate is established after production. However, it is inappropriate for the D-B-B arrangement because the construction product does not exist at the time the contract price is set. This analysis offers a method by which industry participants can match policy initiatives with the proper problem.

(c) Demonstrates a Way of Rationalizing Construction Contracts

Thirdly, the study demonstrated a connection between theoretical principles and the selection of contractual practices. As a result, the study identified differences between the general contract principles and those that characterize design-bid-build construction procurement. For instance, it was determined that the functions of an engineer in the FIDIC red book were contradictory with the privity principle. According to the privity principle, obligations and responsibilities exclusively apply to contracting parties (Hughes, 2006). Nonetheless, this logic is challenged by the FIDIC red book D-B-B based contract structure with regard to the engineer's dual agency and neutral duties (Besaiso et al., 2018). Specifically, the roles involve the provision of design and supervision on behalf of the owner, and certification and dispute settlement on behalf of the owner and contractors.

One of the ideas that this combination doesn't take into account is the effect of information asymmetry risks. In this setting, information is unequally distributed, resulting in opportunistic hazards stemming from a situation in which one party is more informed than the rest (Xiang et al., 2012). Because contractors are not involved in design under the D-B-B model, the engineering agent is better informed about issues such as the owner's inadequate financing. Actions such as delayed certifications and under valuations are linked to the practice of shifting project financial liabilities to the contractor because neutrality was determined to be unattainable. In this instance, it was determined that the practice of combining agency and neutral roles violated the contract privity principle. By illustrating how contradictory concepts associated with construction contract processes may be profiled, policymakers can use the technique as a basis for rationalization. Therefore, the study provides a foundation for realigning intermediary roles.

(d) Demonstrates a Way of Linking Market Postures with Construction Contracting Inequalities

Fourth, the study revealed a link between contracting disparities and the varied market postures assumed by the procurement and contractor sides by examining compatibility of practices from an integrated perspective. From a D-B-B standpoint, the procurement side was viewed as employing a combination of proactive and reactive techniques, whilst contractors adopted a reactive stance. In a proactive strategy, the owner specifies the desired objective in terms of characteristics like as cost, quality, and time, and then develops the strategies to achieve it.

In comparison to other procurement methods, the D-B-B emerged as the dominating method of achieving the owner's strategy. Specifically, it enables the owner to design mechanisms that grant them superior command over both the production process and the final product, as compared to the contractors. The separation of legal site ownership from the rights of underpaid contractors, for instance, exposes contractors to termination without recourse to undo completed work. The balance is also tipped by the adoption of mechanisms such as the FIDIC red book engineer, whose duties mitigate owner information asymmetric risks. By advancing the owner's economic interests, strategies such as failure to certify and under-certifications are frequently employed to compensate for the owner's financial limitations. On the other hand, the contractor's strategy is contingent upon circumstances such as a discontinuous workload and the need for work. However, such a reactive approach to the construction market can expose contractors to risks such as late and incomplete payments.

Indeed, by demonstrating how diverse applications of construction market postures result in a two-sided outcome, the study provides a decision-making tool. The procuring party might use the knowledge to either strengthen or weaken their utility-maximizing power. The decision to reinforce their market dominance is a win-lose situation. On the other side, loosening their market dominance will likely result in a win-win situation. Furthermore, the contractor's side might use the data to assess their reactive market posture.

(e) Demonstrates Unambiguous Way of Identifying Cause-effect Interdependencies

Fifth, in payment dispute causations, it was discovered that failing to fully account for interdependence led to a lack of clarity in the analysis of cause and effect. For instance, in Abdul-Malak et al. (2019), the contribution of interactions between contractual conditions and their role holders to contested payments is less evident. Because of this ambiguity, decisions made can sometimes be interpreted in a variety of ways (Schenck & Goss, 2015). This study addressed this gap by demonstrating a less ambiguous technique of connecting causes and consequences. This was accomplished by demonstrating how practice incompatibility results in payment risks. By looking at these practices as causes for payment default and connecting them to the role holders, the study showed a clearer way to see how causes and effects are linked. If adopted, the reported increase in contested arbitral decisions resulting in litigation can be minimized (Barman & Charoenngam, 2017).

(f) Complements the Proposed Blockchain Decentralization Measures

Lastly, it was shown that a failure to fully comprehend the nature of interdependence might result in mismatched responsibilities and ineffective mitigation strategies. For instance, Hamledari and Fischer (2021) contend that decentralizing ineffective central roles to the periphery can lower payment risk. However, they assumed sequential interdependence and disregarded the influence of pooling and reciprocal typologies (Fellows & Liu, 2012). By recognizing the impact of a network of practices on payments, it is feasible to provide a method for identifying which interdependencies should be decentralized.

Indeed, the study discovered that the majority of payment risks are initiated and transmitted by intermediary functions located at the network's center. This position establishes a brokerage position by bridging the indirect ties between the owner and his contractors. Consequently, this position produces a condition of unequal information distribution. In the case of the D-B-FIDIC B's red book, such a role is held by an engineer, who is, nevertheless, more knowledgeable than the owner and contractor. And, as a result, controls the flow of information between them. This conclusion may explain why such a brokerage position is frequently cited as the major cause of disagreements (Zhu & Cheung, 2020). The blockchain technology has been suggested as one of the countermeasures (Hamledari & Fischer, 2021). However, blockchain payment research has yet to demonstrate how brokerage position interdependencies may be characterized. The analytical technique utilized in this study shows how that gap can be addressed. In this way, it complemented how the proposed blockchain methods can decentralize unreliable interdependencies.

5.4 Recommendations

5.4.1 Recommendations of the Study

Based on the findings, this study makes the following recommendations.

a) The research has revealed a link between specific practices within the D-B-B procurement system and the cost-saving technique employed by the owner. The aforementioned link is widely observed in projects within the private sector and serves as a substantial factor in the exposure of contractors to payment risks. In order to achieve a fair equilibrium between the commercial interests of both parties, the study recommends the use of practices that facilitate the sharing of risks between them. The promotion of collaborative practises and ideals, such as social capital, can facilitate the attainment of this objective.

b) The practice of separating legal ownership of a site from contractual possession has been observed to contribute significantly to the spread of payment risks. The study recommends an evaluation of the effectiveness of current payment default remedies in addressing the challenge of the inseparability of the site from the final product in order to protect the rights of contractors who have not been paid. The utilisation of mechanisms such as the mechanic lien can facilitate the attainment of this objective.

c) The research revealed that the majority of payment disputes are instigated by intermediaries operating in the capacity of a consulting entity. The ability to transfer these risks is facilitated by the implementation of a system that integrates design, supervision contract administration, and first point dispute resolution services between owners and contractors within the consulting unit. The research revealed that the utilization of this particular combination results in a consultant who possesses a higher level of knowledge and understanding compared to project owners and their contractors. Consequently, the role is occasionally utilised to prioritise personal interests over those of the employer and their contractor. In order to address the potential risks associated with moral hazard, the study recommends the implementation of decentralisation strategies utilising blockchain techniques. The usefulness of the decentralisation measure can be enhanced by integrating it with social network analysis (SNA) methodologies, as it has been observed that the measure currently lacks a mechanism for profiling interdependencies.

d) The research discovered that the overlap between the project procurement phases and their respective roles leads to a lack of clarity in identifying the connections with sources of contractor payment risk. The lack of contractor involvement in the financing and design processes was identified as a substantial factor contributing to disagreements relating to cost variation. Nevertheless, there exists a lack of clarity regarding the manner in which the interplay between divergent responsibilities gives rise to the manifestation of disputes pertaining to payment. The study suggests that practitioners involved in claim and dispute resolution can employ social network analysis (SNA) approaches to examine causality.

e) The research revealed that the integration of agency and neutral roles inside the consulting unit has a tendency to undermine the principle of impartiality. The study revealed that the consultant has a primary responsibility to prioritise the interests of their principal over those of the contractor. Consequently, the study recommends a separation of agency from neutral roles. The aforementioned goal can be accomplished by separating the responsibilities of design and supervision on behalf of the owner from those of certification and dispute resolution roles. Given this recommendation, it is necessary to rationalise certain construction procurement practises within the design-bid-build (D-B-B) system.

f) Finally, it is worth noting that the study has determined that around 80% of payment risks may be attributed to approximately 20% of practises. Consequently, it is imperative to implement a mitigation strategy that can effectively reduce the majority of these risks. The identification of causal factors that significantly contribute to the majority of payment risks can be accomplished by adopting a network perspective. Consequently, the study recommends the integration of Social Network Analysis (SNA) methodologies into the risk management procedures. SNA technologies provide the capability to effectively map and identify linkages among risk causes. Consequently, they offer an improved approach to profiling the most suitable strategies for risk mitigations.

5.4.2 Recommended Areas for Further Research

Due to the limitations of the study, additional research is required. To begin, the causes of payment risks were conceptualized as proxies for incompatible practices used to build the network model. These practices emerged from the distinctions between design-bid-build procurement systems and the standard product market for products like automobiles. Future research may find it beneficial to develop a network model based on the prevalent causes of late, delayed, and non-payments. The results of such a network can then be compared to the interdependency network developed in this study. The comparison can also be utilized to evaluate the practices of other procurement systems, such as design and build.

Secondly, the literature suggests that the nature and magnitude of payment risks vary by country. Nonetheless, the geographical scope of the data for this study was limited to Kenya. As a result, it may be beneficial to determine if data from other countries can yield different results.

Thirdly, the design of this study was a combination of typical and comparative case studies. The findings were analytically generalized to the study's guiding theoretical principles. For instance, it was discovered that the differences between the place dimension of the market mix theory and the inseparability of a constructed product from its site were connected to contractual inequalities. In addition, the disparities are connected with the practices of initiating and transmitting payment risk. This result was also supported by the process and site asset specificity principles of transaction cost economics. Although the analytical generalization technique was useful for validating the findings, it may be advantageous for future research to also consider statistical generalization-oriented designs, such as surveys.

Fourth, it was discovered that the majority of payment defaults are propagated by the intermediary roles that double in design and contract administration under the D-B-B contracting system. Among the various mitigation measures, payment models related to blockchain technology have been suggested. Nevertheless, a number of their principles are founded on integrated process and protocol maps. It was demonstrated that the interdependencies between the various constraints were not easily discernible. Modeling and analyzing the risk network using the SNA approach demonstrated how to profile and identify interdependencies associated with intermediary functions. Therefore, it is imperative that future research consider including those methods in block-chain-related payment default solutions.

5.5 Concluding Statements

This research aimed at developing a network model of interdependence for analyzing construction contractor payment risks. This was accomplished through a three-step process. In the initial phase, contextual determinants were identified through a literature review and examined using payment dispute case data. A significant finding was that the interactions between determinants mirrored contractual practices designed for the standard product market. Consequently, the second phase assessed the practices' compatibility with the design-bid-build system. In the third phase, the resultant deviations were equated to risk practices and used to develop a model of interdependency network.

Importantly, the model identified and profiled ten interdependency paths leading to contractor payment vulnerabilities. Among these, the interdependencies between the practice of payment upon acceptable performance and failure to match quantities paid with the amount or work performed had the most severe impact on payment risk. In this way, the model analysis demonstrated a method for connecting risk causes to their consequences.

Another interesting finding is that approximately 80% of payment risks are initiated and transmitted by approximately 20% of risk practices and their interdependencies. This result demonstrates that the developed network model has a scale-free topology, and is therefore consistent with the power law equation. The 20% risk practices were associated with the consulting unit's intermediary roles, where agency and neutral roles are combined. The agency roles in the context of the design-bid-build FIDIC red book include design and supervision on behalf of the owner. The neutral roles, on the other hand, include certification and serving as the initial point of dispute resolution between the owner and the contractor. Consequently, 80% of payment risks can be mitigated by focusing on 20% of the risk practices.

The study concludes with implications for theory, methodology, and practice. First, in terms of theoretical implications, the study demonstrated how it drew from and contributed to market mix, transaction cost economics, principal-agency, and complexity by interdependency theories. For instance, according to the information asymmetry principle of the principal agency, the contractor is more informed than the project owner/client. However, it was discovered that the practice of delegating control to the consulting agent results in an owner who is more informed than the contractor. Second, the research contributed to the methodology by demonstrating, for instance, the complementarity of systems and SNA methods. Finally, the study outlined six policy and practice implications.

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APPENDICES

Appendix I: Invitation to Participate

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

P.O BOX 62000(00200) NAIROBI, Tel:(067) 58700001-4

Mark Obegi Kenyatta,
Email: mark.kenyatta@jkuat.ac.ke
Tel: 0720 561126/0737921672

Supervisors:
Dr. Abednego Gwaya
Prof. Sylvestor Masu &
Dr. Patrick Ajwang'

March 18th 2021,

Dear Participant,

Invitation to participate in a research titled "Development of an Interdependency Network Model for Analyzing Construction Contractor Payment Risks in Kenya"

I am a PhD candidate at the Sustainable Materials Research & Technology Centre (SMARTEC), within the college of engineering and technology. As part of my PhD study, I am investigating construction contractor payment risks in Kenya. Therefore, i would like to invite you to participate in this research.

Note that your participation in this research is completely voluntary. As such you are free to withdraw at any time without any adverse consequences. If you agree to participate, I assure you that your privacy and confidentiality will be maintained.

Note that you have been identified as an expert in construction contracting & dispute resolution. You will therefore be participating as a subject matter expert.

This part of the study involves two parts. The first part involves rating the extent to which you think the outlined practices are contributing to contractor payment risks. The second part involves proving judgement pertaining the outlined propositions. The two sessions are expected to last about an hour. The session will be video recorded and your scores will be entered into an excel data sheet.

Thank you.

Yours faithfully,

Mark Obegi Kenyatta
(PhD candidate)

Appendix II: Consent Form

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

P.O BOX 62000(00200) NAIROBI, Tel:(067) 58700001-4

Consent Form

Research title:	**Development of an Interdependency Network Model for Analyzing Construction Contractor Payment Risks in Kenya**
Supervisors:	**Dr. Abednego Gwaya, Prof. Sylvester Masu & Dr. Patrick Ajwang'**
Researcher:	**Mark Obegi Kenyatta**

- I have read and understood the information about this research in the invitation to participate dated 18th March, 2022.
- I have had an opportunity to ask questions and answers provided
- I understand that my interview will be video recorded and responses entered into an excel data sheet
- I understand that I may withdraw from the study at any time without any adverse consequences
- I agree to part in this research
- I wish to get a copy of the final report from the researcher

Participant signature: ....

Participant name: ....

Participant contact details if appropriate

....

....

....

Date:

Appendix III: Interview Schedule for Determining the Extent to which Practices are Incompatible and their Influence on Construction Contractor Payment Risks

Part A. Participant demographic information guide		
1.	Primary qualification e.g., Civil Eng., Quantity surveyor, Construction Manager, Architect and Mechanical etc.	
2.	Type of project e.g., Civil engineering, Building, Manufacturing plants etc.	
3.	Private or public sector projects	
4.	No. of years as a construction arbitrator and or representative	
5.	In which project sector do have the greatest arbitration/adjudication experience?	
6.	What is the approximate number of construction payment-related disputes cases have you determined?	

Part B. Interview questions						
Questions Based on the outlined scale, were, **Do not agree=0,** **Slightly agree=1,** **Agree=2** and **Strongly agree=3,** In comparison with the process of manufacturing standard market products and the design-bid-build procurement system, state the extent to which the following practices contributes to contractor payment risks.			**Do not agree=0**	**Slightly agree=1**	**Agree=2**	**Strongly agree=3**
	Question	**Measurement indicator (s)**				
1	To what extent does a mismatch between continuous and discontinuous production settings lead to skewed resource allocation position and in turn, contractor exposure to payment risks?	i. Tender success rate ii. One-off production nature of the contrition market				
2	To what extent does inseparability between production and buying functions promote the use of repeat business strategies, and in turn contractor exposure to payment risks?	i. The need for work ii. Differences between reactive versus proactive market posture				
3	To what extend does the mismatch between end-product control rights and the practice of payment upon satisfactory performance expose contractors to payment risks?	i. Work-first get paid latter ii. Separation of control and ownership				
4	To what extent does doubling in buying and production leads to an imbalanced process control and in turn contractor exposure to payment risks	i. Contractor switching ii. Completeness of interim payments				
5	To what extent does the concentration of production and buying rights on the client leads to a mismatch between output progress and sums paid	i. Contractor cash flow difficulties ii. Disputes over liability for delayed completions				
6	To what extend does the practice of non-separability of legal site ownership rights and possession expose contractors to payment risks	i. Imbalanced clamancy rights ii. Amount of money at stake				
7	To what extent does the mismatch between intra and inter-organizational governance contributes to deferment of liability for the cost of variations	i. Inaccurate cash flow forecasts ii. Delay in certification of variations iii. Lack of shared understanding				
8	To what extent does the practice of doubling in design and certification by the project integrator (e.g., engineer and architect) contribute to variation costs and in turn contractor exposure to payment risks?	i. Design inaccuracies ii. Provisional sums				

Appendix IV: Interview Schedule on the Interdependencies between Practices and Contractor Payment Risks

Part A. Participant demographic information guide		
1.	Primary qualification e.g., Civil Eng., Quantity surveyor, Construction Manager, Architect and Mechanical etc.	
2.	Type of project e.g., Civil engineering, Building, Manufacturing plants etc.	
3.	Private or public sector projects	
4.	No. of years as a construction arbitrator and or representative	
5.	In which project sector do have the greatest arbitration/adjudication experience?	
6.	What is the approximate number of construction payment-related disputes cases have you determined?	

Part B. Interview propositions and questions guide						
Questions Based on the outlined scale, were, **Do not agree=0,** **Slightly agree=1,** **Agree=2** and **Strongly agree=3.** State the extent to which you agree with the following			**Do not agree=0**	**Slightly agree=1**	**Agree=2**	**Strongly agree=3**
1	The trading imbalances in terms of more bidders than the number of tenders at any one given time exposes the bidders to the vulnerability of not being able to demand protective measures against payment defaults	To what extent does the disequilibrium between demand (tenders) and supply (bidders), promotes dominance of unfair contracts?				
2	The more the strategy of repeat business is used to entice the contractor into agreeing to the owner unfair payment terms, the more the exposure to payment risks	To what extent does the strategy of repeat business contribute to the acceptance of unfair payment terms?				
3	In the absence of advance payments, the requirement of payment upon completing a pre-specified portion of work presumes that the contractor is selling a completed product inclusive of the design and the site	To what extent does the requirement of payment after satisfactory performance assign less end-product contractor control rights?				
4	The higher the unpaid sums owed, the less the contractor control of the process, which in turn increases the likelihood of owner induced termination.	To what extent does the position of doubling as a buyer cum a co-producer reflect less contractor control of the production process?				
5	The cash flow deficiencies as a result of late, underpayments and non-payments expose the contractors to performance breach specifically in terms of failure to progress diligently.	To what extent does failure to progress diligently owing to payment defaults expose the contractor to contractual breach?				
6	The practice of delimiting between contractual site possession and ownership exposes contractors to payment risks.	To what extent does the delimitation between contractual site possession and ownership expose the contractor to payment risks?				
7	The practice of deferment of valuation & certification of some portions of output presumes buyer owned inputs but promotes payment risks.	To what extent does the decisions to defer certification of some portions of output expose contractors to payment risks				

8	The duality of supplying design/cost plans/bill of quantities/specifications with that of contract administration functions such as certification of variations related to the shortcomings of the contract documents underlines a conflict of interest as regards apportionment of liability.	To what extent does the duo functions of the consulting unit contribute to payment default?				
9	The structure where communications between the owner and contractor are through the consulting unit creates an opportunity for the latter to manipulate the flows as reflected in disagreements over the value of work done.	To what extent does the centralization of communication under the consulting unit contribute to the manipulation of payment functions?				
10	The contract price is a simulation or rather a model yet to be tested by comparing it with the actual outcome but which has the potential of transferring the various risks to the contractor, hence vulnerability to payment default	To what extent does the variation between the contract price & the actual output expose the contractor to payment default risks?				
11	The success of a contractor's claim at arbitration or any other third-party forum depends on the completeness of information submitted but which can be hoarded by the consulting unit for the benefit of the owner	To what extent does the extent of visibility of fault for a payment dispute depend on the behavior of the information custodian?				

Appendix V: Connections/Interdependency Matrix

	Links	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
		P1–2	P1–3	P1–4	P1–5	P1–6	P1–7	P1–8	P1–9	P1–10	P1–11	P2–3	P2–4	P2–5	P2–6	P2–7	P2–8	P2–9	P2–10	P2–11	P3–4	P3–5	P3–6	P3–7	P3–8	P3–9	P3–10	P3–11	P4–5	P4–6	P4–7	P4–8	P4–9	P4–10	P4–11	P5–6	P5–7	P5–8	P5–9	P5–10	P5–11	P6–7	P6–8	P6–9	P6–10	P6–11	P7–8	P7–9	P7–10	P7–11	P8–9	P8–10	P8–11	P9–10	P9–11	P1 0 P1
1	P1-P2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	P1-P3	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	P1-P4	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	P1-P5	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	P1-P6	1	1	1	1	0	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
6	P1-P7	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0
7	P1-P8	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0
8	P1-P9	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
9	P1-P10	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	1
10	P1-P11	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
11	P2-P3	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	P2-P4	1	0	1	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	P2-P5	1	0	0	1	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	P2-P6	1	0	0	0	1	0	0	0	0	0	1	1	1	0	1	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
15	P2-P7	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	1	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0
16	P2-P8	1	0	0	0	0	0	1	0	0	0	1	1	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0
17	P2-P9	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
18	P2-P10	1	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	1
19	P2-P11	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
20	P3-P4	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	P3-P5	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	P3-P6	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	1	1	1	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
23	P3-P7	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1	1	0	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0
24	P3-P8	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	1	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0
25	P3-P9	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	1	1	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
26	P3-P10	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	1
27	P3-P11	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
28	P4-P5	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	P4-P6	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
30	P4-P7	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0
31	P4-P8	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0
32	P4-P9	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	1	1	1	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
33	P4-P10	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	1
34	P4-P11	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
35	P5-P6	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
36	P5-P7	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0
37	P5-P8	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	1	1	0	1	1	1	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0
38	P5-P9	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
39	P5-P10	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	1	1	1	0	1	0	0	0	1	0	0	0	1	0	0	1	0	1	0	1
40	P5-P11	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
41	P6-P7	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
42	P6-P8	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	1	1	1	1	0	0	0	1	1	1	0	0	0
43	P6-P9	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	1	0	1	1	0	1	0	0	1	0	0	1	1	0
44	P6-P10	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	1	0	1	1	1	0	1	0	0	1	0	0	1	0	1	0	1
45	P6-P11	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0	0	1	0	1	1
46	P7-P8	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	1	1	1	1	1	1	0	0	0
47	P7-P9	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	1	1	0	0	1	1	0
48	P7-P10	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	1	0	0	1	0	1	1	0	1	0	1	0	1	0	1
49	P7-P11	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	1	1	1	0	0	0	1	0	1	1
50	P8-P9	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	1	0	0	1	1	0	0	0	1	1	1	1	0
51	P8-P10	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	1	0	1	0	1	0	1	0	1	0	1	1	0	1
52	P8-P11	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	1	0	0	1	1	0	0	1	1	1	0	0	1	1
53	P9-P10	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	1	0	0	1	1	0	1	1	0	0	1	1
54	P9-P11	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	1	0	1	0	1	0	1	1	0	1	1	0	1
55	P10-P11	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	1	0	0	1	1	0	1	1	1	1	0

Appendix VI: Private Sector Payment Dispute Excerpts

	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10
C1		With regard to the first interim certificate the appellant admitted that it had made part payment thereof of Kshs.20,000,000. However, the respondent was not entitled to the balance thereof due to the sub-standard work.	architect refused to issue an interim certificate for the said amount. architect refused to issue an interim certificate for the said amount.		In its defence the appellant imputed that the contract sum for the project had been grossly exaggerated by the respondent in collusion with the quantity surveyor As far as the appellant was concerned, the second interim valuation was irregularly issued			Pursuant to the aforementioned terms the architect issued an interim certificate number 1 (first interim certificate) on 13th August, 2012 indicating the sum payable to the respondent as Kshs.37,918,142.52. It is not in dispute that the appellant partly paid the said sum in instalments aggregating to Kshs.20,000,000. According to the respondent, the appellant indicated it was looking for financing to settle the balance. When it became apparent that the appellant was unable to get financing to pay the outstanding amount the respondent had no choice but to suspend the construction in accordance with the contract.		

C2		The appellant's defence had been that due to the respondent's unprofessionalism, he had to pay over and above the agreed amount and that respondent did a sloppy job in total disregard to the architectural plan ending up with the building being unfit for human habitation. The result was that the appellant had to undo what the respondent had done so as to bring the house to a habitable condition.		The letter written by the respondent was forwarding a schedule of rates for variations one and two requested by the appellant. It was respondent's evidence that appellant frustrated him and took away keys to all the doors and refused to let him conduct a handing over			The appellant brought in additional works which were not in the initial quotation – those additions amounted to kshs. 201,112. Further additional works of kshs. 225,797 were again introduced, thus increasing the costs by kshs. 397,025/37cts The cost of the extra work was ascertained after completion and in the presence of an engineer hired by the appellant			
C3					it did not pay the sum in the final certificate, Certificate No. 6 issued by the lead consultant, Professional Consultants, appointed by the appellant, in the sum of Ksh.21,976,123.18, a sum later revised to Ksh.19,082.192.88. at a meeting held on 30th March, 2010 resolved that a new Quantity Surveyor be appointed by the appellant to measure the works and re-evaluate the final accounts	The variations were executed without formal approval; The variations were executed without formal approval;	for finding in favour of the respondent on the issue of payments in respect of variations and additional works for finding in favour of the respondent on the issue of payments in respect of variations and additional works			

C4			Whereas a misunderstanding has arised (sic) between the two parties as to quantity, extent and percentage of works completed, after consultative meeting … it has been decided to establish the following: 1) A comprehensive list of works to be completed and agreed upon and attested by the two parties.								they hired another contractor, Chirag Builders Limited (second contractor) who had an ongoing business relationship with Mario. Somewhere along the line, disagreements between Mario and the second contractor arose culminating in the said contractor halting works on the suit premises.
C5	A certificate was expected to be issued within 14 days i.e. by 29th November 2016 but it was not until 26th January 2017 the certificate for the grossly reduced amount of Kshs. 3,409,030.50 was issued The Main Contractor continued to execute works and once again made another application for interim payment number 03 for Kshs. 3,503,712.64 on 12th April 2017. The certificate was yet again grossly delayed being issued on 7th July 2017 for 2,069,697.60. However the contractor immediately presented it to the Employer. It was not however paid within the 14 days provided in the contract.		Upon commencing works in October 2016 the Main Contractor executed works and made application for interim payment number 01 amounting to Kshs. 6.233,210.33 on 15th November 2016.		Whether or not a certificate has been improperly withheld or is not in accordance with these conditions.				However the contractor immediately presented it to the Employer. It was not however paid within the 1`4 days provided in the contact. 2. The Contractor sent reminders on 10th January 2017 and in (a) meeting as indicated in (the) architect('s) email dated 9th March 2017. 3. Meanwhile the Contractor continued to execute works	

C6	The parties thereby agreed to value the works carried out by the Defendant per the disputed Interim Certificate at Kshs. 31,653,120.87; and that the Defendant was to hand over the Project Site and all keys to the Plaintiff upon the signing of that Agreement. At Clause 3 thereof, an agreed schedule was set out as to how the Plaintiff was to pay the aforesaid sum over a period of 90 days from the date of handover of the Project.	From a perusal of the Defence filed in herein, it is clearly evident from paragraphs 22 to 28 thereof that following the handing over of the Project Site, the Plaintiff suspended all payments vide a letter to the Defendant dated 15 July 2016, contending that the works were incomplete	It was further averred that the Plaintiff, through its Quantity Surveyor, had rejected the Defendant's Interim Payment Application No. 21 for Kshs. 23,876,961.39 which was submitted on 18 October 2015 and the Interim Payment Application No. 22, which was submitted on 8 April 2016 for Kshs. 16,227,140.39 by issuing a total valuation of Kshs. 340,970.80 for both payment applications.	It was thus the contention of the Defendant that it would suffer irreparable loss and damage if the Plaintiff proceeded to take possession of the Project Site.						
C7					The Defendant's letter dated 19th March 2014 to the Plaintiff Exhibit marked "FBR 2" that was annexed to the Defendant's Further Affidavit shows that the Defendant terminated the contract as the Plaintiff was said to have abandoned the works and failed to meet the necessary contractual requirements in accordance with Clause 12 and 13 of the Agreement.					
C8	The Plaintiff also raised nine interim certificates of accounts for payments and all were partially paid.					It was also PW1's testimony that the contract was not completed on time due to additional works and variations made by the Defendant				

C9			Without prejudice to our rights, we are prepared for a joint measurement and valuation of our work done and by a copy of this letter request the Quantity Surveyors and Architects to inform us of the date of the said exercise.	when West Mount terminated the JBC Agreement and had Tridev vacate the construction site. The termination was contained in a letter dated 7 October 2013. On 8th October 2013 Tridev penned a couple of letters to the project Architect as well as to West Mount. The letter to the project Architect, UDesign Architects & Interior Designers, contested the termination and forceful takeover of the site						
C10	It was not until 23 March 2010 that the Defendant put the Plaintiff in the know that it had raised queries with Professional Consultants in connection with the Final Certificate of Payment and attached copies of correspondence in that regard, in which the Defendant contended that the re-measured works were inconsistent with the works actually executed on site		He added that although a Revised Final Certificate No. 6 dated 26 May 2010 (at page 16 of the Plaintiff's Bundle of Documents marked Plaintiff's Exhibit No. 1) was prepared and forwarded to the Defendant for payment, the Defendant persisted in its refusal to honour the same, in spite of several reminders	The Plaintiff has claimed interest on the aforesaid sum of Kshs. 19,082,192.88 at 18% from 24 June 2010 till payment in full on the basis that this was a commercial transaction; and that the Defendant has refused and/or failed to settle the same for a long period of time and therefore kept the Plaintiff out of the funds for a awhile. The Defendant's response to this was that the only clause that would have been relevant for this purpose is Clause 34.6 which was however crossed out by consent and the deletion countersigned for by the parties	It is plain from the aforestated clause that it was therefore the responsibility of the Architect, and not the Plaintiff, to seek and obtain prior approval for the variations from the Defendant. There is absolutely no evidence to show that the variations were implemented against the advice or instructions of the Architect The Defendant has not given any explanation at all why it has not paid the difference that is not in contention	It was further the contention of the Defendant that the Plaintiff carried out unauthorized variations to the works, in contravention of the clear provisions of the contract, which required that such variations be approved by it in writing prior to execution. It was therefore the Defendant's posturing that the Plaintiff is not entitled to the sum claimed				

C12			That the Plaintiff's claim arises out of unpaid Certificates Numbers 15 and 16 which were duly certified by the Project Architect and approved by the Quantity Surveyor The Defendant further averred that, while the Quantity Surveyor had expressly admitted in writing that the Final Account had substantial errors, it had declined to recall or suspend the Final Certificate which is the foundation of this suit.					[a] That the Plaintiff's claim arises out of unpaid Certificates Numbers 15 and 16 which were duly certified by the Project Architect and approved by the Quantity Surveyor; [b] That pursuant to Clause 34.5 and 34.6 of the Contract, Interim Certificates Numbers 15 and 16 were payable by the Defendant within 14 days from the date of presentation; and that in default simple interest would be charged on the unpaid amount for the period it remained unpaid at commercial banks' lending rates in force during the period of default; [c] That pursuant to Clause 34.9 of the Contract, it was mutually agreed between the Plaintiff and the Defendant that the amount stated as due in the Interim Certificate be the total		
C13		On the 2nd September, 2011 the Plaintiff submitted an Application for payment giving sufficient details for payment valued at Ksh.16,330,807/13 and requested for the first interim certificate to be prepared for payment. The Project Architect did not prepare the Certificate but instead served the Plaintiff with a Notice of Default dated 26th September, 2011					The revised drawings had an immediate impact of varying the cost of the project upwards from the initial Ksh.74,398,684/-. The Bill of Quantities was prepared and priced at Ksh.117,258,727.75 but the first Defendant herein intimated that it had only made a provision for Ksh.85,000,000/- for the project.		Under clause 34.5 of the Agreement the plaintiff was entitled to payment of the final interim certificate within fourteen days of its presentation to the 1st Defendant but in breach of its obligations under the contract the 1st Defendant has failed and/or refused to pay the sum of Ksh.13,547,430/-.	

C14			The plaintiff then moved to court and filed the present suit for payment of the sum in dispute as set out in the pleadings							
C15			Replying Affidavit, copies of correspondence in relation to the fact that the Defendant, in his words, had ignored the said Certificate and/or correspondence going way back to June 2009. The said Certificate had never been settled, despite the clear provisions of the Contract							
C16			The Defendants disputes the quantum both in relation to liability and quantification and prays in aid particular clauses of the contract. The Plaintiff carried out the construction to completion and the Defendants were issued with the Final Certificate for payment of the balance of Kshs.78,891.254.72 which remains owing and due to the Plaintiff.							

C17		The project had been started by another contractor and it is his evidence that the project was between 35% to 40% complete The wall behind the garage was done without the foundation and it has a crack as it was built on an existing wall without its own foundation. The garage was to be built some metres from the perimeter wall but it was built on the existing wall. Collection points for storm water for the entire building is missing. The shower for the swimming pool is missing. The windows have no mosquito nets. The door locks are not working					The plaintiff was working on all the blocks and not on the specific blocks as per the payment schedule. It is therefore difficult to state when each block was completed as the contractor did not follow the schedule. Due to that aspect, he found it wise to advance money to the contractor		There is a prayer for an injunction to restrain the defendant from dealing with plot No. 20120 Mambrui until the above payments are made in full	

C18	The 1st defendant has been presented with various certificates which have remained unsettled for periods in excess of fourteen days		Since the plaintiff had withdrawn construction due to the outstanding debt the 2nd defendant issued a professional undertaking to pay to the plaintiff a sum of Kshs.185,000,000/= which has not been paid to date. Ndung'u Gethenji did not agree with the final account prepared by the project consultants as shown in the supplementary affidavit of Mr. Raghwani. However, Mr. Raghwani contended that the final account was properly done defendant had suspended carrying out construction works at the 1st defendant's residential project due to the fact that the 1st defendant had defaulted in paying certified payments. By a letter dated 6th June, 2011 the 1st	The 1st defendant has disposed of to third parties 51 units out of the 55 unites and there are only four residential units remaining, 5L, 15D, 32D and 41D. If those units are disposed of all the residential houses constructed by the 1st defendant shall have been transferred to third parties against whom the plaintiff cannot seek payment for the work done and the defendant may evade payment of the debt. Once all the residential units are transferred the 1st defendant shall have no known assets since the 1st defendant was incorporated as a special vehicle to carry out the construction of the residential estate.				The 2nd defendant was also instructed to issue a professional undertaking to pay to the plaintiff a sum of Kshs.185,000,000/= from the proceeds of the sale. However, before the sale could materialize there arose a misunderstanding between the 2nd defendant and the 1st and 3rd defendants and as a result the 2nd defendant ceased to act for the two defendants.		

C19	As was explained by both PW1 and PW2, the outstanding sum of Kshs. 6,759,238/= was the subject of the Payment Certificate No. 1, in respect of which a schedule was supplied at page 73 of the Plaintiff's Bundle of Documents. That the Certificate comprised of three segments, namely: the Main Contractor's payment, as well as sums due to the sub-contractors for electrical cabling and installations and air conditioning and mechanical installations. These three components including VAT yielded the total sum of Kshs. 10,477,971.08, which is the equivalent of the total sum specified on the Payment Certificate No. 1. The Payment Schedule at page 73 further shows that, of the aforesaid sum set out in Payment Certificate								"Payments would be made on the basis of delivery notes or invoices. Any sums over Kshs. 1 million are done by RTGS. I have not seen any document to show that the Defendant made a payment of Kshs. 9,033,239.94 to Tulsi or the certified sum of Kshs. 10,477,971.08. I do not have any document here to prove the payment of Kshs. 6,759,238 that the Plaintiff claims in this suit...The only reason the Plaintiff was not paid is because we did not receive the invoice..."	
C20	The Sum Certified through Interim Payments Certificates 1 and 2 of Kshs. 59,239,458.00; (b) Interest on delayed payments as at 17th August 2015 in the sum of Kshs.6,712,471.00			The Plaintiff wishes to be paid and is exercising a lien over the building works it has completed.	The Architect had issued Payment Certificates 1 and 2. They were not paid on the due dates. Rather than pay the sums due, the Defendant is alleged to have demanded the Plaintiff leave the site,			As indicated in the meeting, Fechim has been honest from the start and did not in any way mislead Parklane as to our capacity to pay for all certificates for the work done to completion; we genuinely beleved we had secured funding and we regret that the finances did not come through		

C21		However the Defendant via its Consultants raised disputes on plaster and walling works and thus refused to honour payments due to the Plaintiff The Respondent avers that some of the works done by the Applicant is defective and does not accord with the specifications thus constraining the architects to issue orders for rectification.	However by September 2015 dispute arose over plastering and walling works and thus some payments due was withheld.	The Defendant to give security of kshs.100 million to be deposited on an interest earning account in joint names of the firms of parties advocates pending the hearing and determination of the arbitration.						
C22			"the Defendants seeking payment of the contractual sums and also of its intention to sue in default. It is over two years since this dispute arose and the Defendant has been using the ruse of settlement meetings to delay the recovery of sums due to the Plaintiff."							

C23	The Respondent concludes that its officials refused to sign minutes of a meeting held on 18th June 2019 as it was not a true reflection of what transpired and that despite the actions by the Applicant, the Respondent has been willing to settle the matter and had communicated its choice of negotiators to the Applicant, but that the Applicant has frustrated the commencement of the negotiations		The Architect did call for the meeting on 8th June 2019 whereby it was agreed that the Respondent would vacate the site after a joint measurement exercise is taken and at times understated the certificates	The Respondent contends that the Applicant's application is meant to secure an eviction against it without payment of its dues The Respondent finally argues that if the court is minded to grant the prayers sought, then the applicant has to give a suitable bank guarantee in the sum of Kshs.350,000,000/= or alternatively grant vacant possession on payment of	The Respondent argues that it proceeded regularly and diligently contrary to the allegations by the Applicant and that it made application for payment but in breach of the contract the consultants delayed the evaluations of the applications The Respondent further argues that as at the purported termination of the contract, the value of work had been understated by approximately 265,201,046/= which put the Respondent in extreme financial stress and that the Applicant has not paid fully as alleged.					
C24			whereby it discussed the ongoing parties consideration of the account and in some of those correspondence the Respondent declared disputes The Respondent by its letter dated 26th January 2017 stated that the Applicant had failed to respond to its outstanding payment		failure by the Quantity Surveyor to prepare a final account for that part of the work carried out by the Contractor as required by clause 38.4.3 of the contract within a reasonable time after the joint inspection					

C25		Disputes arose on money payable by PUEA to ELsek, on material used and workmanship Disputes arose on money payable by PUEA to ELsek, on material used and workmanship									
C26			The parties to the contract had a dispute which was referred to a sole arbitrator, John Okerosi, who gave his final award dated 7th March 2016. By that award, the arbitrator found Comfort Homes liable to pay Gem Ksh 3,547,811.70.	Disputes arose on money payable by PUEA to ELsek, on material used and workmanship							

C27	Indeed the Respondent had even put it in writing the difficulties it was encountering in the project due to non-availability of funds.	The Arbitrator made an award in favor of the Respondent, awarding Ksh. 50, 682,585/- inclusive of a valuation of Ksh. 43,630,373 an amount that the applicant stated was wrong because the works were completed by the applicant			The applicants terminated the contract on the 6thJanuary 2014 and proposed that the respondent attends the site to evaluate the work done before leaving. The applicant then proceeded to complete the works It is contended that the tribunal made a reasoned analysis of how payments would be done and found that the claimant was continuously in breach of the contract in relation to agreed timelines in availing finances. Consequently the Respondent would not be expected to remain on schedule in contract delivery		The respondents' on their part sought payment of Kshs. 35,799,046.50 which sum was to be subject to variations upon site measurements. As regards agreed timelines of the contract in availing finances, the tribunal found that the initial contract sum was Kshs. 89,919,181.80 and Kshs. 13,553,250.25 for the additional floor and the amount due to the Respondents on the 19th September 2013 was Kshs. 20,961,053.20 with no evidence of payment According to the minutes of site inspection on 14th October 2013, the claimants board of Directors acknowledged receipt of request for payment from the Respondent for Kshs.		Respondents stated that they had not abandoned the works as alleged but only suspended the same due to non payment. CW3 admitted on cross examination that by the time of purported termination, the Kshs. 9,200,000/= plus the 20,961,053 which was about 30 million was owing to the Respondent.	
C28			The final account was issued on 29th June 2017 which revised the contract sum to Kshs.37,462,482. Based on the final account, the architect issued the final certificate on 29th September 2017 and though served on the applicant, the applicant failed to pay the amounts specified therein as well as other payments which had been certified as due in previous certificates							

C29			The Applicant objected to payment of certificates No. 13 and 14 due to outstanding works and lack of a proper breakdown of the final account.		the delays are all attributed to the Consultants and none to the Contractor. Consultants being agents of the Employer, the Employer takes responsibility for their actions and omissions.	Regarding variations to the contract, Mr. Ikiunga was able to identify instructions for variations either from the Architect or from the Employer. In these instances, he had no objection to the Contractor being paid for the work.		Regarding breakdowns and details of build-up of certain specific items it has been explained above that the Respondent contributed greatly to the state of affairs when he declined to settle outstanding professional fees. The general complaint was that the Consultants were not acting in the best interest of the Employer. In evidence, he repeated more than once that the Consultants had attempted to blackmail him into paying them money that was not due to them. He went as far as to term it a "fraudulent scheme		

Appendix VII: Private Sector Payment Dispute Excerpts

	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10
C1									Thirdly, the Interim Certificate amounting to Kshs 46,000,000/= was not signed by the Resident Engineer unlike the Interim Certificates Nos 1, 2, 3, 4 and 5, Substantial Completion Notice, Summary Bills of Quantities that had been attached in the Defendant's Replying Affidavit	
C2							The appellant paid the sum of Kshs.194,087,963.51 commensurate with the 100% contractual works completed. However, the respondent, in its plaint dated 13th March, 2012 claimed a further sum of Kshs.7,882,793/= from the appellant, made up as follows;- by holding that there was an outstanding sum of Kshs.7,882,793/= when there existed documents to prove that the full contractual sum had been paid by the appellant			

C3	Under the first contract, works were completed and payments substantially made. A balance of Kshs. 483,891.20 however remained unpaid. Under the second contract, funding for the project encountered problems and the contract was "abandoned". An amount of Kshs. 663,298.50 that had been certified as at 2nd October 2002 was not paid.									
C4			He added that the appellant remained put on the site until it handed over possession on 11th May, 2017. By his own assessment, which he set out in a schedule produced in court, the total outstanding amount of extra works at the time he was giving evidence was Kshs.38,187,693 and he prayed for the same.			It appears that the appellant noticed there was some variance with respect to measurements as set out in the design and on the ground As a result, the appellant filed a suit in the High Court seeking inter alia, a sum of Kshs.21,970,494 allegedly being the amount of unpaid extra works and Kshs.920,000 paid to the 1st respondent's officer.	Kshs.21million as opposed to 38 million. Expounding further, he submitted that the contract sum of Kshs.11,762,395 had to be revised upwards taking into account the adjustment made to the construction works due to the damage caused by perennial floods.			

C5		it was reiterated that part of the parties contractual obligations were that the Respondent was to construct and install the works in accordance with the specifications and drawings issued by the Appellant; while the Appellant was to pay the monies due within 30 days of generation of a Payment Certificate. It was further submitted on behalf of the Appellant that a								
C6					the plaintiff claimed for payment of an amount which constituted the total amount for alleged breach of payment on four civil engineering contracts awarded to it by the 1st defendant, with an allegation that					
C7			He further admitted the defendant was given final certificate and statement of final account. The amount shown as due and payable to the plaintiff was shown as			He further agreed there was variation of the contract to include Exchange and Data intelligent Network Centre and that as of now the defendant is using the facilities.				
C8			It was further the averment of the Plaintiff that upon completion of the works as aforestated, it applied for the issuance of final accounts, and, after making the usual contractual calculations and measurements, the figure of Kshs. 234,736,214.69 was finally agreed on as being due and owing from the Ministry of Local Government as at 31 October 2011; and that this was well over 3 years after the							

C9			The Applicant accused the Respondent of failing to make payments in							
C10			The Plaintiff said that it was entitled to claim for variation of price (hereinafter referred to as "VOP") of products during the pendency of the contract under Clause 70 of the Contract. It forwarded a Certificate of VOP amounting to Kshs 46,000,000/= to the Defendant which the Defendant reviewed downwards to Kshs 26,000,000/= to which the Plaintiff protested.			It averred that the Defendant had never expressly disputed the Certificate of Variation for the sum of Kshs 46,000,000/= or contended that the same was not in compliance with Federation Internationale des Ingenieurs(hereinafter referred to as "the FIDIC") Conditions of Contract				

C11	There is no evidence that the Applicant renounced the payment certificates or recalled them for cancellation Hence it is my considered view that there is no dispute between the parties capable of being referred to arbitration. It is now clear that the Applicant's Application is intended to delay the Repondent from realizing the fruits of its labour		That the claim as against the Defendant is purely for payment for work done	I am therefore convinced that the present suit is purely for the enforcement of the settlement as the Respondent is merely pursuing its right to payment after being issued with the payment Certificates by the Applicant	That upon termination of the contract herein as envisaged in the contract document, the Defendant issued payment certificates indicating the amounts due for payment which sums have not been refuted by the Plaintiff/Respondent and by dint of Clause 34 of the contract agreement That upon payments falling due, the Plaintiff/Respondent served demand notices to the Defendant, the content of which were not responded to, nor any Application for Arbitration made within 90 days of the demand notice or termination of contract by the Defendant/Applicant as they ought to have done by dint of Clause 34 of the agreement aforesaid. It is not in dispute				.	
C12	Certificate No.1 for Kshs. 1,810,349.45 issued on 14/11/2008 and paid on 15/2/2010. There was a delay in payment of 458 days Certificate No. 5 for Kshs. 5,390,990.95 dated 22/11/2008 and paid on 15/2/2010. There was a delay of 450 days									

C13		The cost of the Plaintiff's materials on site, which is the main claim by the Plaintiff, is already valued by the site Engineer using rates that the Plaintiff wanted the Defendant to use. The Defendant is not averse to paying the Plaintiff the valued amount. Therefore, the Defendant prays that in terms of paragraph 11 of the consent order, the Defendant be at liberty to forthwith take over, from the Plaintiff, the site of construction of Badasa Dam in Marsabit County	The Defendant to issue the Plaintiff with an appropriate certificate of works done up to the date of disengagement." The Respondent deposed in the Replying Affidavit inter alia at paragraphs 19, 44-45, that, the disagreement relating the values in the final Certificate still lingers It went on to state that the parties with their respective engineers, consultants and legal counsels were to meet, approve and finalize the Final Certificate between the parties from the date of adoption of the said consent	Second consent of 29th January 2014 that effectively allows the Respondent to retain the site until such a time the issue of the Final Certificate is resolved						
C14									Thirdly, the Interim Certificate amounting to Kshs 46,000,000/= was not signed by the Resident Engineer unlike the Interim Certificates Nos 1, 2, 3, 4 and 5, Substantial Completion Notice, Summary Bills of Quantities that had been attached in the Defendant's Replying Affidavit	

C15	There is a statement for payment on account that is dated 25.6.2014 and the valuation of work done by the plaintiff was Kshs 4,624,000/-. This answers the question that the valuation was due for payment. The plaintiff admitted having received payment for the same although after a period of two years.		The plaintiff averred that the defendant undervalued the work done and has unreasonably refused to pay the amounts due			The other issue raised by the Defendant during cross examination was that the variation was not to exceed 15% of the contract sum. However, I note that the contract was not tendered in evidence. Be that as it may, the Defendant cannot argue that the plaintiff is not entitled to the variation amount because the documentation provided had not been controverted by the defendant, who failed to produce contrary evidence or call witnesses to present its case.	From the variation notes, there are site visits on 15.4.2014 that speak to the recommendations made by the clerk of works and district works officer of Matungulu. It is noteworthy that if the plaintiff did part of the work and failed to complete the same due to obvious delay in payment, he was not to blame.			
C16						The original contract for the upgrading of the road was Kshs. 2,564,748,836.20. However, due to reasons beyond the control of both parties the project was appraised in April 2011 to reduce the works and end at Km 19+600 instead of the initial Km 50+000 at a contract sum of Kshs. 1,606,612,965.00.				

C17			That a dispute arose as between the parties since the Respondent was claiming additional payments and since the Contract contained an adjustment clause				the Applicant and the Respondent sought to review the terms of the Contract by inter alia extending the scope, cost, and time for completion of the project. That by an addendum to the Contract dated 7th April 2009 executed by the parties herein the scope of works was changed and the contract price increased to Ksh 1,023,403,480.21and the contract period increased by a period of 11 months			
C18			on behalf of the Contractor wrote a letter claiming a sum of Kshs.23,120,099.98 allegedly on account of non-payment of the sum of Kshs.8,475,493.00 that was to be paid to the Contractor after completion of the works							

C19	The applicant avers that it prepared interim certificates for payments as the work progressed and they were duly paid as invoiced through the Resident Engineer. However, there remained an outstanding balance of Kshs. 609,893,199.32, which the Respondent has without any reason and/or explanation whatsoever, declined to pay to-date, and/or has declined to give direction on the whole construction.						In response to the grounds of opposition, it was submitted that, the delay was caused by the Respondent who misled the Applicant to believe that, the money would be paid. Further that when the Respondent referred the Applicant's claim the pending Bills Committee, the Respondent created the impression that, they were acting in good faith and would settle the matter only for the Government to reject the claim after first offering to pay Kshs. 11,000,000 only.		The Applicant argues that, it contracted services of other suppliers for supply of equipment and as a consequence of the Respondent's failure to pay it has defaulted in paying the supplies inspite of request sent to the Respondent on 4th June 2011 for payment of the final certificate which has not been honoured to date	

C20	On variation of works, Mr. Malebe submitted that there were unlawful variations to the contract which did not accord with the provisions of section 47 of the PP&DA and regulation 31 thereof, which at the time the contract in issue was in force, provided that variation should not exceed 15% of the initial contract On the value of the work done, Mr. Burugu submitted that the Arbitral Tribunal found that the respondent was entitled to the amount awarded as value of the work that had benefitted the claimant. He submitted that it is not in the interest of justice for the respondent to be denied his money for work done. On the issue of the Arbitral Tribunal		at Section 47 that sets out the strictures on variations of public procurements together with regulation 31 of the regulations, which were violated, but the Arbitral Tribunal ignored those statutory violations variations in reaching its decision On the value of the work done, Mr. Burugu submitted that the Arbitral Tribunal found that the respondent was entitled to the amount awarded as value of the work that had benefitted the claimant. He submitted that it is not in the interest of justice for the respondent to be denied his money for work done. the variation of work done stood at 42% of the original contract price. The respondent was in a legally binding			Arbitral Tribunal found that variation of works was 42% of the original contract sum and that the Arbitral Tribunal should have limited the arbitral award to the dictates of PP&DA	the arbitral award that the parties agreed that the respondents claim on extended preliminaries shall be based on thirty six weeks and that the computation claimed thereof would be Ksh.1,234,908/= Tribunal proceeded to award compensation for the tools, equipment and hoarding in the sum of Ksh. 4,894,071.43 when the issue presented to it was whether the tools and equipment were held unjustifiably. provided that variation should not exceed 15% of the initial contract and that execution must be within the contract period	The valuation of the work done was a matter for approval by the claimant's Tender Committee of which the respondent was not a party. Default on the part of the claimant cannot therefore be placed at the foot of the respondent.		

C21			The office block was handed over and the Respondent made payments but disputed/contested the amount remaining due and owing.				Despite challenges of delay to taking over the site, abandonment of the project, suspension of works, extension and variation of the project, delayed payments etc the building was handed over to the Respondent albeit disputed completion works alleged by the			
C22			The Respondent would, within fourteen (14) days from the date that the award was taken up, pay to the Claimant Kshs 232,228.59 in respect of the value of work completed, together with simple interest thereon at 18% per annum calculated from the date that the award was taken up to the date of payment.				Under Paragraphs 38 and 39 of the Final Award, the Arbitrator clearly set out the requirements of a variation of contract. He found that there was evidence of variation of site tendered during the Arbitration and the matter could not be re-opened for determination or re-evaluation by the court as it had no power or jurisdiction to do so.			

Appendix VIII: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 333372

Date of Issue: 03/December/2020

RESEARCH LICENSE

This is to Certify that Mr.. Mark Obegi Kenyatta of Jomo Kenyatta University of Agriculture and Technology, has been licensed to conduct research in Nairobi on the topic: DEVELOPMENT OF A PROMPT PAYMENT FRAMEWORK FOR THE KENYAN CONSTRUCTION INDUSTRY: A SOCIAL NETWORK ANALYSIS APPROACH for the period ending : 03/December/2021.

License No: **NACOSTI/P/20/8061**

333372

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is Guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014

CONDITIONS

1. The License is valid for the proposed research, location and specified period
2. The License any rights thereunder are non-transferable
3. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research
4. Excavation, filming and collection of specimens are subject to further necessary clearence from relevant Government Agencies
5. The License does not give authority to tranfer research materials
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