

A framework for identifying barriers to implementing Alternative Project Delivery Methods (APDM) in public construction of Bhutan

Kelzang Jigme^{1,2}, Woramol C. Watanabe^{2*}

¹ Ministry of Commerce, Industry and Employment, Royal Government of Bhutan, Thimphu, Bhutan

² Naresuan University, Faculty of Logistics and Digital Supply Chain, Thailand

*Corresponding author E-mail: woramolc@nu.ac.th

Abstract

Alternative Project Delivery Methods (APDM) have become increasingly popular in recent years for private and public construction projects as viable alternatives to the Design Bid and Build (DBB) method. Organizations opt for APDM to enhance innovation, streamline delivery, share risk, integrate experts, and save cost, thereby promoting economy and efficiency. However, despite the benefits of the APDM, the implementation is still low in many countries, including Bhutan due to various barriers. These barriers are complex and interrelated, with each barrier influencing and being dependent on the other. To address these issues, it is crucial to identify, prioritize, and analyze the interrelationships among these barriers. The study aims to identify and provide a structured framework for elucidating these barriers, utilizing Interpretive Structure Modeling (ISM) and Matrix Multiplication Applied to Classification (MICMAC) analysis to demonstrate their hierarchy and classification. By leveraging the ISM and MICMAC analysis, this framework seeks to expedite and systematize overcoming the barriers to implementing APDM in the public construction sector. It intends to raise awareness and inform decision-makers about the barriers that have the most significant impact, enabling them to focus their mitigation efforts effectively. This paper fills the research gap by presenting a framework to illuminate barriers in the implementation of APDM, with a numerical example illustrating the results.

Keywords: Framework, Alternative project delivery methods. Public construction, Barriers, Interpretive structural model, Matric multiplication applied to classification, Bhutan

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1. INTRODUCTION

The primary approach considered for all public construction works in Bhutan is the design bid and build. In this conventional method, a consultant is engaged to design the project, and the contractor is appointed through a competitive tender in sequential (Adnan et al., 2011; Al Khalil, 2002). This DBB method often results in a longer duration of schedule (Davis et al., 2008) and cost overrun (Mosissa, 2006).

The existing paradigm supporting a sole delivery method of DBB hinders the government’s ability to make optimal procurement decisions. The rigid alignment with the DBB method for all natures of public infrastructure limits flexibility that could potentially affect decision-making efficiency (Choden & Lhendup, 2020). Bhutan’s public construction accounts 40.20% time overrun and a 47.32% cost overrun in the financial year 2019-2020, with a 42.50% cost and 24.77% time overrun attributed to changes in design and scopes. This pattern of cost and time overrun has persisted for many years (CDB, 2020).

Public agencies nationwide are now embracing innovative APDM, like Design-Build (DB), Construction Managers at Risk (CMAR), Integrated Delivery (IP), and Public-Private Partnerships (PPP) to enhance project cycle time, level of quality, and cost efficiency (Walewski et al., 2001). However, the implementation of this method remains low in many countries due to numerous barriers (Aldossari, 2020). These barriers encompass financial, organizational, and environmental aspects. The persistence of these challenges and barriers has resulted in the continued use of conventional project delivery methods failing to promote economy and efficiency in public construction sectors, as depicted in Figure 1.

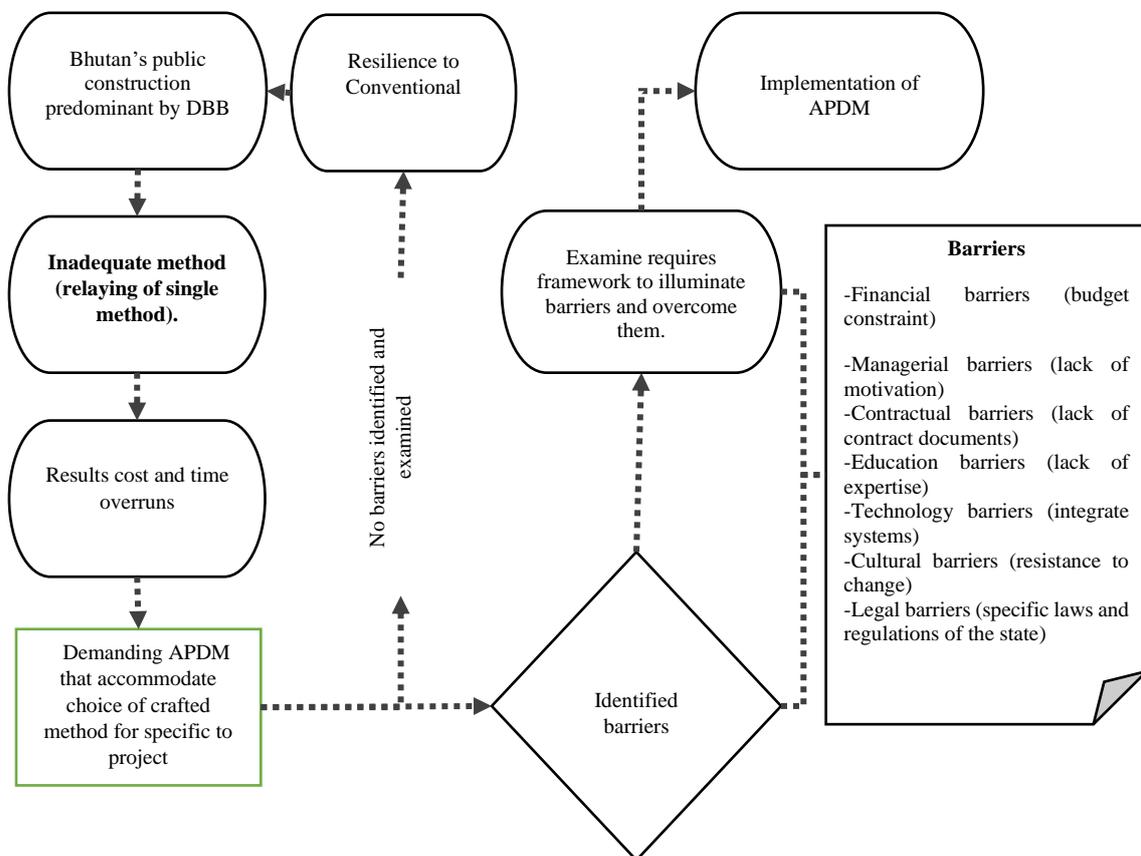


Fig. 1. Demanding implementation of APDM and challenges

The obstacles to implementing APDM in public construction are complex and interrelated, with each barrier influencing the others. It is crucial to recognize significant barriers for the decision makers to formulate strategies to overcome them systemically. To depict the interrelationships and generate significant barriers, the study employed ISM and MICMAC approaches. This paper aims to illuminate a structured framework that hierarchically positions barriers and classifies them based on the strength of driving and dependence powers. The framework enhances the precision in selecting significant barriers for systematic resolution.

2. LITERATURE REVIEW

2.1 APDM and implementation barriers

Alternative project delivery methods (APDM) are a specialized or exceptional situation that supports the deviation from the regular project delivery method DBB (Gibson Jr & Walewski, 2001). These methods, such as Design-Build (DB), Construction Manager at Risk (CMAR), Integrated Project (IP), and Public-Private Partnership (PPP), are increasingly popular in the procurement procedures of rapidly evolving domains of architecture, engineering, and construction industry to enhance project outcome (Chandramowli et al., 2011; Kalach, 2020).

Despite the benefits of the ADPDM in the construction industry, the implementation is still low in many countries due to complex barriers (Aldossari, 2020). These barriers to implementing APDM can be broadly categorized into three macro factors: capital, organization, and environment (Ma et al., 2022). For example, an examination of integrated project delivery implementation in Lebanon revealed complex obstacles in the form of legal, cultural, technological, and financial challenges hindering the adoption (AbouDargham et al., 2019). A framework identifying, prioritizing, and analyzing the interrelationships among barriers would provide a more effective and systematic approach to overcoming obstacles.

2.2 Interpretative structure model (ISM)

ISM is a qualitative research technique invited by Warfield in 1973 for interactive management and structure approach to system design (Warfield & Cárdenas, 1994). Its processing can transform unclear, poorly articulated models of systems into well-defined models (Beikkhakhian et al., 2015). ISM is a logical and mathematical approach that derives and explains the relationships among the parameters allowing us to analyze and understand the whole system (Lohana, 2021). The model so formed portrays the structure of a complex issue or problem in a carefully designed pattern implying graphics as well as words (Attri et al., 2013; Moelyanto et al., 2021).

2.3 Matric Multiplication Applied to Classification (MICMAC)

The MICMAC analysis, developed by Michel Godet and Francois Bourse, is a structured prospective analysis employed for examining indirect relationships (Chandramowli et al., 2011) complementing the ISM approach by delving into constraints that are typically associated with the ISM method (Ahmad et al., 2019). This method is employed as a tool to classify variables according to concealed direct and indirect relationships, as well as their influences on each other (Guo et al., 2020). In MICMAC analysis, variables are categorized into clusters that comprise autonomous, dependent, linkage, and independent quadrants (Agarwal & Seth, 2021; Ahmad et al., 2019; Manjunatheshwara & Vinodh, 2018). This categorization helps in understanding the dynamics of the situation and in formulating plans to address the most influenceable barriers (Kumar et al., 2021). Various researchers have adopted ISM and MICMAC approaches to depict the interrelation among the elements of the issues (Yadav & Barve, 2015).

3. RESEARCH METHODOLOGY

The research methodology compresses 5 steps demonstrated in Figure 2.

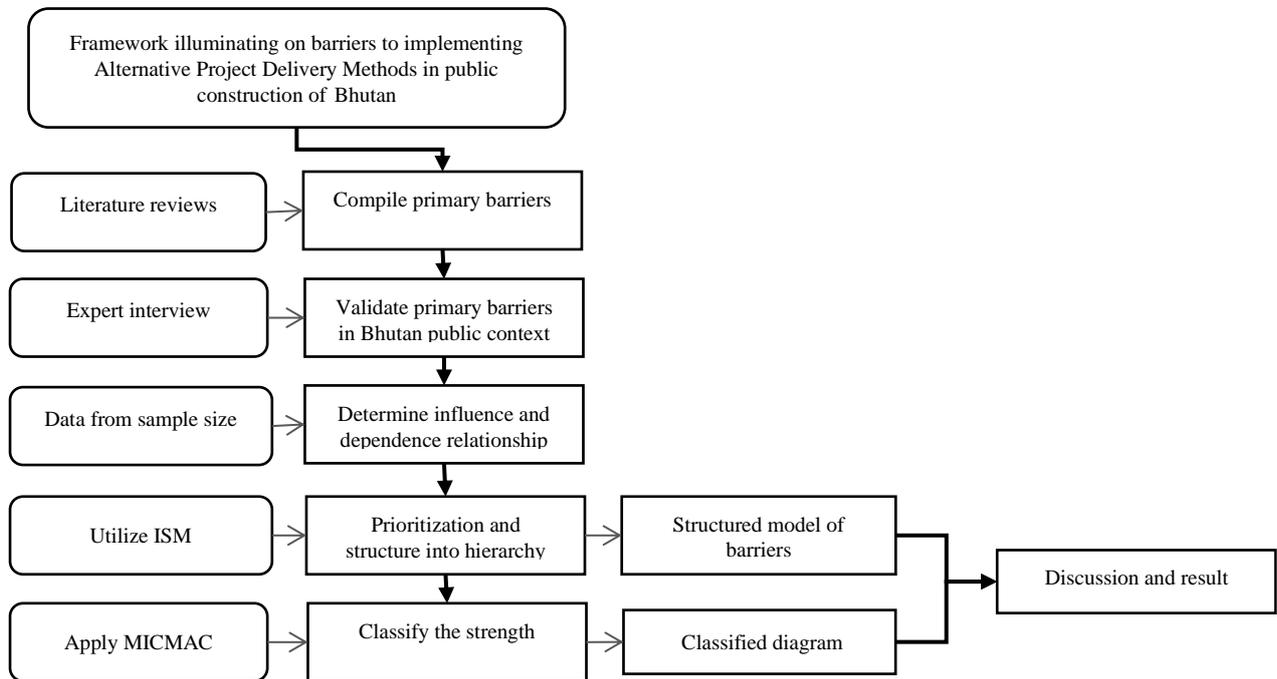


Fig. 2. Methodology

3.1 Compile primary barriers

The initial methods involved conducting a literature review and compilation of primary barriers. The prevalent previous research on the topic of implementing APDM, barriers and challenges to adoption of APDM in the public construction sector, and challenges of implementing each APDM like DB, IPD, CMAR & PPP are reviewed here.

3.2 Validate primary barriers

To customize the context to the public construction of Bhutan, primary barriers are validated by the sector experts using interviews and questionnaires. The key experts include key position holders including chief executives and procurement officers who have a minimum of ten years of experience in the selection of public construction project delivery methods. The procurement officers of Bhutan holding certified members of the Chartered Institute of Procurement and Supply (MCIPS) are included to enrich the opinion. The expert should possess sound experience and expert knowledge of variable studies, The Lawshe (1975) formula of a linear transformation of the proportional level is utilized to retain the barriers for validation.

3.3 Determine the influence and dependence relationship

To grasp the interconnectedness, influences, and dependencies among the barriers, pairwise relation data is obtained. The data is gathered through interviews using a dichotomous questionnaire survey. The number of questions $N = N*(N-1)$ is based on the number (N) of barriers to cover all possible combinations. This group of respondent plays an important role and the outcome depends on their inputs. The important aspects for the selection of a sample group are size, expertise, and diversity with sound experience and domain of the issue. The percentage agreement method is employed to evaluate

specific pairwise influential relationships from variable *i* to *j* between each variable. To capture diverse perspectives (Gisev et al., 2013) the lower percentage is considered for study.

3.4 Prioritization of barriers

The Interpretive Structure Molding (ISM) approach (Attri et al., 2013) is utilized to examine the interrelationships influences among barriers to prioritize barriers. The process begins with initializing a structure self-interactive matrix, followed by constructing an initial reachability matrix and transitivity is checked. Finally, a level partitioning is performed. The significance barriers are identified based on the extent of influences.

3.5 Classification of barriers

MICMAC analysis is conducted further to enhance the understanding of dependent and influence relationships among barriers. The process includes creating four cluster graphs to categorize the barriers based on their driving and dependence strength. The four clusters include autonomous, dependent, linkage, and independent barriers. This categorization is determined by calculating the driving and dependence values in the reachability matrix.

4. NUMERICAL EXAMPLE

The numbers and types of barriers depend on the validation for a particular region determined by many factors like cultural differences, economic conditions, legal and regulatory frameworks, infrastructure and technology capabilities, education levels, and historical contexts.

To grasp the understanding of the framework, it is exemplified with 7 identified barriers, suppose pairwise relationship barriers (barrier *i* influences on barriers *j*) are obtained from the sample size as illustrated in Table 1.

Table 1 Barriers and pairwise relationship.

<i>i/j</i>	Legal	Technology	Education	Contractual	Managerial	Financial	Cultural
Legal barrier	-	No	No	No	No	Yes	Yes
Technology barriers	No	-	Yes	No	No	yes	No
Education barriers	No	Yes	-	No	No	No	No
Contractual barriers	No	No	No	-	Yes	No	No
Managerial barriers	Yes	Yes	No	No	-	No	Yes
Financial barriers	No	No	No	No	No	-	No
Cultural barrier	No	No	No	Yes	Yes	No	-

To depict contextual relationships between barriers based on the pairwise data obtained in Table 1, the Structure Self-Interactive matrix (SSIM) is initiated. The SSIM is a pairwise comparison of barriers $n \times n$ cells where *n* is the number of barriers. The form is filled *n* by *n* matrix with four-letter codes V, A, X, and O as shown in Table 2.

V: Barrier *i* influences barrier *j*

A: Barrier *j* influences barrier *i*

X: Bidirectional relationship where barrier *s i* and *j* influence each other

O: No relationship between barriers *i* and *j*

To depict contextual relationships between barriers based on the pairwise data obtained in Table 1, the Structure Self-Interactive matrix (SSIM) is initiated. The SSIM is a pairwise comparison of barriers nC2 cells where n is the number of barriers. The form is filled n by n matrix with four-letter codes V, A, X, and O as shown in Table 2.

V: Barrier *i* influences barrier *j*

A: Barrier *j* influences barrier *i*

X: Bidirectional relationship where barrier *s i* and *j* influence each other

O: No relationship between barriers *i* and *j*

Table 2 Structured self-interactive matrix

i/j	Legal	Technology	Education	Contractual	Managerial	Financial	Cultural
Legal	X	O	O	O	A	V	V
Technology		X	X	O	A	V	O
Education			X	O	O	O	O
Contractual				X	V	O	A
Managerial					X	O	X
Financial						X	O
Cultural							X

Translating the four symbols of SSIM into binary representations (1s and 0s), the reachability matrix is constructed and the transitivity is checked for the final reachability matrix to conclude with driving and dependence power as shown in Tables 3 and 4 respectively.

Relationship for V: $V_{ij} = 1, V_{ji} = 0$

Relationship for A: $A_{ij} = 0, A_{ji} = 1$

Relationship for X: $X_{ij} = 1, X_{ji} = 1$

Relationship for O: $O_{ij} = 0, O_{ji} = 0$

Table 3 Reachability matrix

i/j	Legal	Technology	Education	Contractual	Managerial	Financial	Cultural
Legal	1	0	0	0	0	1	1
Technology	0	1	1	0	0	1	0
Education	0	1	1	0	0	0	0
Contractual	0	0	0	1	1	0	0
Managerial	1	1	0	0	1	0	1
Financial	0	0	0	0	0	1	0
Cultural	0	0	0	1	1	0	1

Table 4 Final reachability matrix

i/j	Legal	Technology	Education	Contractual	Managerial	Financial	Cultural	Driving power
Legal	1	*1	*1	*1	*1	1	1	7
Technology	0	1	1	0	0	1	0	3
Education	0	1	1	0	0	*1	0	3
Contractual	*1	*1	*1	1	1	*1	*1	7
Managerial	1	1	*1	*1	1	*1	1	7
Financial	0	0	0	0	0	1	0	1
Cultural	*1	*1	*1	1	1	*1	1	7
Dependence power	4	6	6	4	4	7	4	

For the level partition, reachability and antecedent sets are identified for each parameter, assigning them to intersection sets. Parameters with matching reachability and intersection sets are placed at the top level. This process continues, removing variables to uncover additional hierarchy levels until all variables are accounted shown in Table 5.

Table 5 Level Partition

Barriers	Reachability (R) set (Row)	Antecedent (A) set (Colum)	Intersection set ($R \cap A$)	Level
Legal	1, 2, 3,4,5,6,7,	1,4,5,7,	1,4,5,7,	3
Technology	2,3,6,	1,2,3,4,5,6,7,	2,3,	2
Education	2,3,6,	1,2,3,4,5,6,7,	2,3,	2
Contractual	1,2,3,4,5,6,7,	1,4,5,7,	1,4, 5,7,	3
Managerial	1,2,3,4,5,6,7,	1,4,5,7,	1,4,5,7,	3
Financial	6,	1,2,3,4,5,6,7,	6,	1
Cultural	1,2,3,4,5,6,7,	1,4,5,7,	1,4,5,7,	3

Finally, MICMAC analysis is conducted further to enhance the understanding of dependent and influence relationships among barriers shown in Figure 4 in the result and discussion. The influencing power for each barrier is the total number of barriers including itself which may contribute to overcoming it. On the other hand, dependence power is the total number of barriers including itself which may need to be overcome (calculation shown in Figure 4). MICMAC validates the barriers within the ISM model to support and draw conclusions.

5. RESULTS and DISCUSSIONS

In this example, the result is demonstrated by the structure framework model showing the hierarchy level, and classification digraph shown in Figures 3 and 4 respectively.

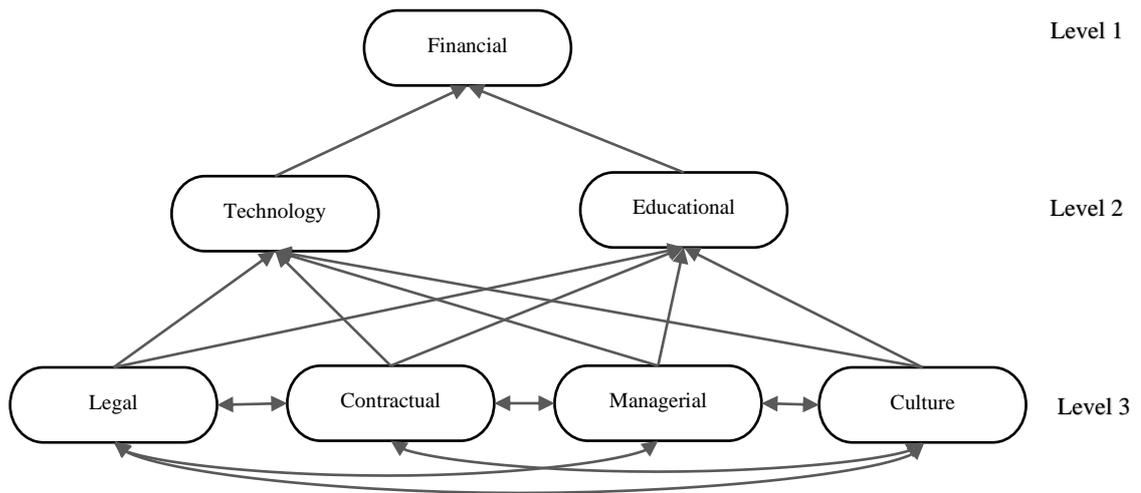


Fig. 3. Structure level of barriers

Figure 3 illustrates the hierarchical structure among the seven barriers. The lack of financial support within the organization positions at the top level to be the prioritized barrier. To secure the financial support for implementing APDM, the organization must address technology barriers such as integration of the system, upgradation of ICT facilities, and educational needs like having experts in the organization, positioned at 2 levels. Legal barriers (lack of regulation and statutory not allowed for organization), Contractual barriers (lack of contractual document, guideline), management barriers (support from the managerial heads), and cultural (resistance to change) are at the bottom of the hierarchy. These barriers form the foundation for addressing the lack of education and technology. It is evident that the organization needs to start overcoming the 4 linkage barriers at first hand and the goal should be securing funds for APDM implementation. Further analysis and validation of these are classified using MICMAC as shown in Figure 4.

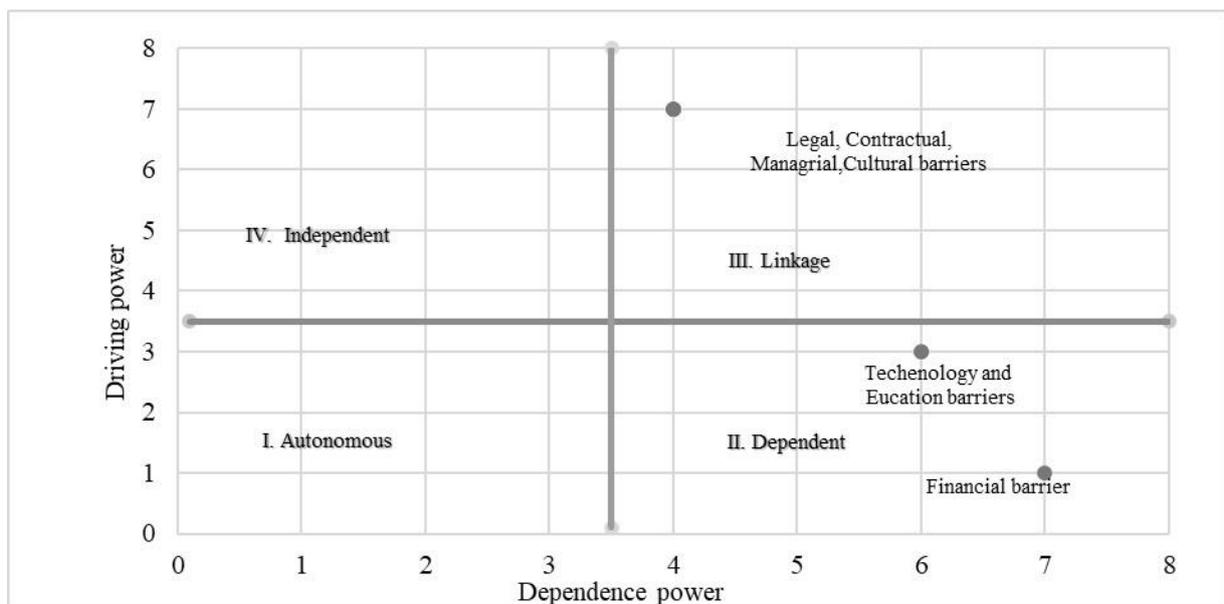


Fig. 4. Classification of barriers

Figure 4. Clearly illustrates that financial, technology, and education are dependent barriers. Among these, financial barriers have a higher dependence power of 7 and driving power of 1 indicating it is prioritized at level 1. Technology and Education barriers have a dependence power of power of 6 and a of 3. Legal, contractual, managerial, and cultural barriers are categorized as linkage barriers with a high driving power of 7, serving as the foundation to overcome other barriers. The higher the driving power of barriers, ease in to overcome other barriers systematically.

The finding concludes that while financial requirement poses a significant barrier to implementing APDM, it is heavily influenced by other barriers. Mitigating education and technology barriers can help overcome financial barriers. Additionally, addressing legal, contractual, managerial, and cultural barriers should be the initial focus for the organization seeking to overcome barriers to implementing APDM. Importantly, none of the barriers identified in this study operates independently or autonomously.

6. CONCLUSION

The barriers to implementing APDM are complex and interconnected, influencing and depending on one another. By utilizing the ISM and MICMAC, the study has revealed a significant interdependence and influence among the exemplified barriers. This provides a comprehensive perspective on their roles as drivers and the dependence to overcome them. The example provided in this study concludes that financial barriers are prioritized barriers, relying on other barriers. Legal, contractual, managerial support, and cultural barriers fall under the linkage barrier at the bottom level which the organization needs to attend first. It's essential for overcoming technology and educational barriers to attend financial barriers. The paper presents a conceptual framework to study barriers to implementing APDM in public construction, and the researcher can incorporate the data for actual conclusion in prioritizing the significant barriers systematically for the development of an action plan to mitigate them.

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