Implementation of suitable information technology governance frameworks for Moroccan higher education institutions

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Article Info	ABSTRACT
	This article aims to present formal governance practices of information technology adapted to the general context of Moroccan universities. The study consists of two main phases: the conceptualization phase and the operationalization phase. During the conceptualization phase, the authors reviewed relevant literature on best practices and their associated frameworks in higher education institutions (HEIs). The results revealed that universities had varying levels of maturity in terms of good practices and often used multiple information system frameworks, which can cause organizational and technical problems. In order to find a solution to this situation, the authors conducted in-depth interviews with chief information officers (CIOs) and university officials from four Moroccan universities during the operationalization phase. These interviews enabled them to propose an effective baseline of best practices and an algorithmic approach to assist managers in choosing between two combinations of frameworks that cover all the mechanisms of the baseline. This solution would enable optimal, agile, and easy-to-implement information technology governance in Moroccan universities while avoiding the multiplicity of frameworks.

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1. INTRODUCTION

To ensure optimal performance and increased efficiency of organizations, it is crucial to keep up with the constant evolution of information technologies [1]. Therefore, universities must regularly improve their information technology governance (ITG) to cope with innovation and change and adapt to new technologies. Several authors recommend the effective use of ITG mechanisms in higher education institutions (HEIs) [2]–[6], such as structure, processes, and relational mechanisms [7]–[9].

Our study focused on evaluating the effectiveness of these mechanisms. To address this gap in terms of efficiency and implementation, we propose a literature review (LR) based on a comparative analysis of different approaches from multiple case studies targeting hundreds of universities in different countries. For this to happen, we identified best practices of the most effective ITG mechanisms in universities, including an information technology (IT) framework that uses multiple standards and norms.

As noted by Othman *et al.* in [10], the implementation of good ITG practices can be challenging with obstacles such as lack of top management support, communication issues, high costs, and resistance to change. Furthermore, the abundance and diversity of standards and norms in ITG often lead to overlaps and contradictions in practices, which can result in inefficiencies, as underscored by Herath *et al.* [11] and

Ahmad *et al.* [12]. The issue of overlaps within the processes of ITG is corroborated by the findings of the study [13], which indicates that about 25% of the activities involved are found in at least two of the three main IT frameworks. Therefore, resolving these overlaps largely depends on the analysis of responses provided by specialists during interviews, requiring meticulous technical processing of these data. Additionally, an algorithm mentioned in [14] was developed to prioritize frameworks to address redundancies and various associated organizational and technical problems. However, the effectiveness of this algorithm is limited because it advocates adopting only one framework at a time. In contrast, the algorithm we designed in our research offers two significant advantages: it directly tackles the overlap problem and proposes an extended range of possible combinations of non-overlapping frameworks. This provides decision-makers in the academic sector with a broader range of choices for selecting the most relevant combination of frameworks.

To overcome these challenges, we examined the following question: "what are the recommended practices and frameworks for ITG in universities?". To answer this, we conducted an exploratory study in four Moroccan universities. This study led to the development of a framework that corresponds to best practices based on semi-structured discussions with the information system managers of these organizations. Using a prioritization algorithm, we identified the two best combinations of ITG norms and standards from this framework that cover all necessary mechanisms and take into account the transformation of higher education institutions. This agile and optimal approach to norms and standards improves the effectiveness of ITG and increases maturity levels, which were evaluated on a scale of 1 to 3 [15]–[17].

The structure of this article is as: section 2 outlines the study's methodology, while section 3 focuses on reviewing the literature regarding the most commonly used and effective mechanisms and frameworks. Section 4 presents a validation using the design science of the proposed ITG baseline within the context of Moroccan universities. Next, section 5 presents the algorithmic approach to be implemented. In section 6, we carefully examine the results we obtained. Furthermore, section 7 discusses the conclusion and perspectives for future research.

2.   METHOD

In order to properly conduct our literature review, we consulted specific online databases such as "ScienceDirect", "Web of Science", "IEEE Xplore", "AIS", "Library", and "Google Scholar". We drew on the work laid by Haes and Grembergen [18] and Almeida *et al.* [19], to identify a list of the most used ITG good practices. Subsequently, this list was used as a reference to carry out research in the literature to identify the most implemented and effective good practices and frameworks in HEIs. We have examined 57 articles on ITG mechanisms within universities, among which 14 were identified as relevant by meeting the search criteria. The research was conducted using specific keywords such as ITG, governance of IT in higher education, use of IT in universities, and best practices. The steps of this research are described in Figure 1.
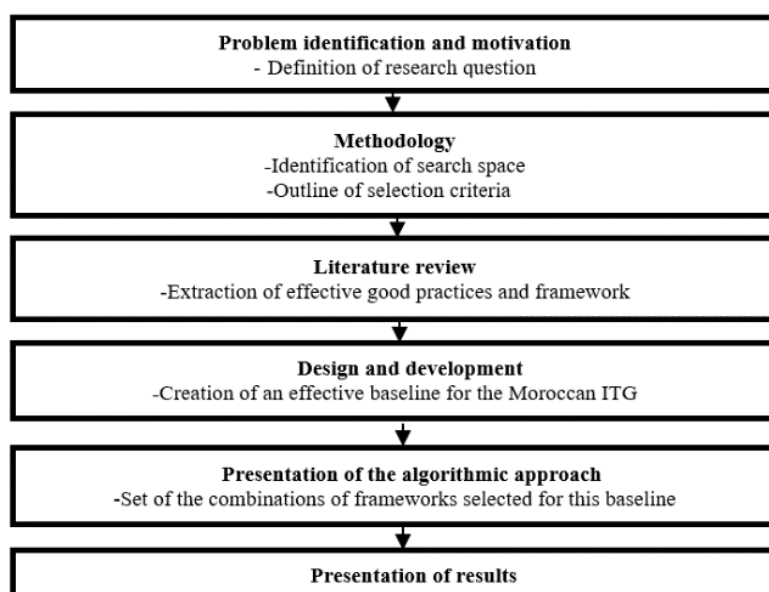

Figure 1. Research steps

3. GOVERNANCE MECHANISMS

Effective ITG is a set of best-practice mechanisms classified into three categories: structure, processes, and relational mechanisms. As demonstrated by Lunardi *et al.* [20], this efficiency is crucial for an organization to achieve its performance objectives. Previous studies have shown that effective ITG relies heavily on the ITG practices of these mechanisms, ranging from decision-making at the board level to the implementation of IT control [2], [21].

3.1. Literature review on the effective implementation of good practices and the frameworks

Table 1 illustrates the diversity of approaches taken by higher education institutions around the world regarding the integration of ITG frameworks, highlighting a trend towards the customization of standardized models such as COBIT and ITIL to meet the specific requirements of each university to improve their operational performance and the security of their information systems. This analysis highlights an inclination towards adopting standardized frameworks, modified to meet the distinct needs of each institution. Table 2, in turn, examines the frequency of use of these best practices globally, providing perspective on the application and reception of IT governance in different national settings. The data collected reveals heterogeneity in adopting and adjusting these practices and frameworks, indicating that although trends towards certain methodologies are present, effective effectiveness requires adaptation that fully covers established best practices. This observation highlights the need to develop a strategy to establish a basic corpus of frameworks capable of synthesizing all optimal practices.

Table 1. Frequency of ITG framework

ITG Framework	Item													
	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[35]
ITIL	x	x	x	x	x	x	x	x			x	x		
PMBOK	x		x	x	x	x								
COBIT	x	x	x	x	x	x	x	x	x	x	x	x		x
ISO 27001						x								
BSC									x	x			x	
PRINCE2						x								
ISO 17799			x	x	x		x							
COBRA			x											
P-CMM			x											
ISO/38500	x				x						x			x
BS7799					x									
OCTAVE					x									
NIST						x								
BISL						x								
ISO 14550												x		
ISO/IEC 27002								x						
Six sigma												x		
SAS70												x		

Table 2. Frequency of good effective practices

Mechanism	Good practice	Item							
		[22]	[24]	[30]	[31]	[32]	[33]	[34]	[36]
Structure	S1: Roles and Responsibilities	x	x		x	x		x	
	S2: IT strategy committee,	x		x	x	x		x	
	S3: IT steering committee,	x	x	x	x	x			
	S4: IT organization structure	x		x	x	x	x	x	x
	S5: CIO on the Executive Committee	x		x	x	x		x	
	S6: Project management office	x						x	
	S7: Business process management office	x							
Process	P1: Information system planning strategy,	x	x	x		x		x	
	P2: Portfolio Management,	x	x	x		x			
	P3: IT budget control and reports	x	x	x		x			
Relational	R1: IT leadership	x	x	x			x		
	R2: Shared understanding of business/IT objectives,	x				x			
	R3: Internal communication	x	x	x	x	x	x		
	R4: Active participation and collaboration between the main stakeholders,	x			x	x		x	
	R5: knowledge sharing on IT governance	x		x	x	x			
	R6: IT staff training	x	x						
	R7: A partnership with the software industry	x							
	R8: Job rotation	x	x						

4. DESIGN AND DEVELOPMENT

The research aims to improve the basic model of ITG practices and framework for Moroccan universities. For artifact creation, an appropriate research methodology is design science research (DSR). This approach involves key elements such as the possibility of discovering new research domains and conducting experiments to validate or construct new theories in the field of information systems.

4.1. Data collection and analysis

Previous studies have examined ITG in the industrial sector, but few have focused on identifying appropriate university ITG practices. For this analysis, the case study method was chosen to examine ITG practices in four Moroccan universities, each of them considered as a case study. Semi-structured interviews were conducted in each of the four universities to establish a baseline for best practices tailored to Moroccan universities and identify the appropriate ITG framework and new practices to be implemented in these universities.

4.2. The scope of framework coverage for each best practice of the baseline before implementing the algorithm

By conducting interviews with Moroccan university officials, a reference base of best practices was created and presented in Figure 2. However, it has been observed that Moroccan universities do not have a governance framework suitable for their academic context. To address this challenge, IT officials have proposed norms and standards for the potential implementation of each good governance practice, as shown in Table 3. Furthermore, the implementation of each recommended practice requires multiple information system frameworks. This situation presents a significant strategic challenge that requires consideration of numerous organizational and technical factors [14].
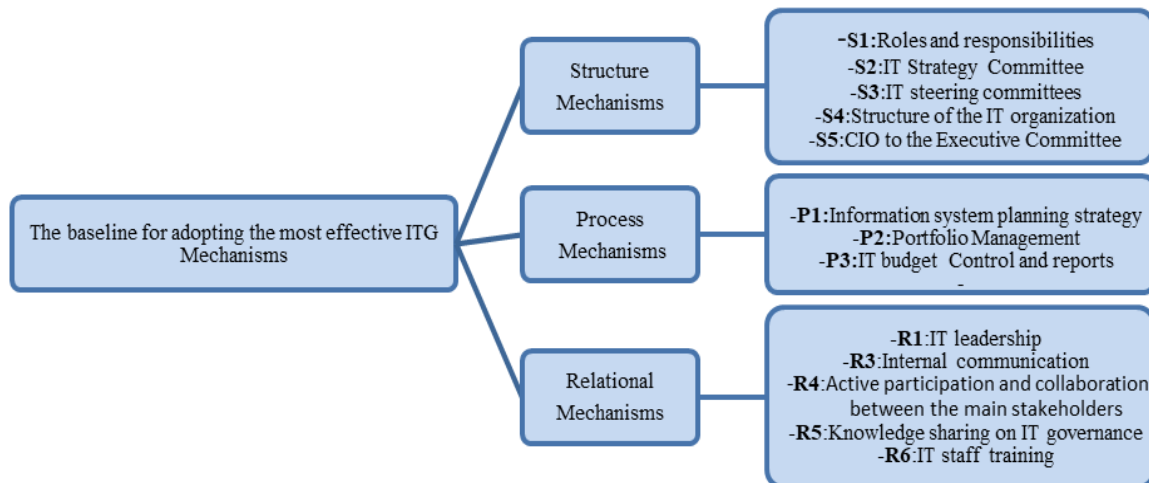

Figure 2. The baseline for adoption of the most effective IT governance mechanisms within Moroccan universities

Table 3. Positioning of the selected frameworks

P4: ITG Framework	Structure					Process			Relational				
	S1	S2	S3	S4	S5	P1	P2	P3	R1	R3	R4	R5	R6
P-CMM	0	1	1	0	0	0	0	0	0	0	1	1	1
ITIL	1	1	1	1	1	1	0	1	1	1	0	0	0
PRINCE2	0	0	0	0	0	0	1	0	0	0	0	0	0
PMBOK	0	0	0	0	0	0	1	1	0	1	0	0	1
Iso27001	1	0	0	1	0	1	0	1	0	1	0	0	0
BSC	1	1	1	0	1	1	0	0	1	0	0	1	1
Cobra	0	1	1	0	0	0	0	0	0	0	0	0	0
ISO 1779	1	1	1	0	0	1	0	0	1	1	0	0	0

According to the study [37], the most effective ITG involve using a minimal number of frameworks with increased integration and collaboration to improve governance and encourage innovation. The COBIT framework was found to be impractical due to its difficulty in application and implementation at all levels of

the ITG process [38]–[40]. An exploratory study conducted in universities [27] showed that COBIT was not used due to its complexity. Therefore, Moroccan HEIs should choose another framework of best practices to implement their objective.

4.3. Definitions of ITG framework
Below are some definitions of best practices selected by Moroccan university officials:

a. CMMI: The capacity maturity model integrated (CMMI) is a tool used to evaluate the level of maturity of IT development within a company. It was developed by the Software Engineering Institute at Carnegie Mellon University in 1987 and is centered on the development and upkeep of computer systems and applications. CMMI aims to improve the performance of engineering companies by providing a framework to assess their level of maturity in this area [41]. They have also proposed a people capability maturity model (P-CMM) to support this model. The P-CMM can be used as a framework for improving how an organization manages its human assets [42].

b. ITIL: The information technology infrastructure library (ITIL) framework empowers information technology (IT) to function as a service delivery agent, rather than solely providing specialized support, it has become the most popular for implementing IT service management (ITSM) [43], [44]. ITIL provides guidelines and best practices to adapt IT actions and budgets to meet business needs and modify them as the company grows or changes direction. The primary objective is to enhance efficiency and attain predictable levels of service [45].

c. PMBOK: The project management body of knowledge (PMBOK) is a project management guide created and published by the Project Management Institute (PMI). This comprehensive guide seeks to establish a stable and structured foundation of current knowledge necessary to manage a project under optimal conditions.

d. PRINCE2: Projects in controlled environments (PRINCE2) is a project management methodology that originated from the British government and is accredited by Axelos. It is based on the best practices in project management and is a flexible approach that can be applied to all companies but only for projects with a defined scope. PRINCE2 is built upon seven principles, themes, and processes which can be customized to meet specific requirements [46].

e. BSC: A model has been developed to enable the representation of a company's strategic vision and its translation into actionable plans. In the literature, two methods for developing strategic scorecards are described, the first is the objectives, variables, action, responsible (OVAR) method, created by three professors from HFC France. The second is an American method developed by Kaplan and Norton in 1992 [47].

f. ISO/IEC 27001: In 2005, the International Organization for Standardization (ISO) published a standard that outlines the requirements for creating an information security management system.

g. ISO17799: The document provides a list of objectives and practices that information security professionals can refer to [48].

h. COBRA: A risk analysis method developed by C&A. Its purpose is to provide organizations with the tools to conduct self-assessments of their own information technology without requiring the assistance of external consultant resources, time, and organizational culture.

5. PRESENTATION OF THE ALGORITHMIC APPROACH
The article presents a new model to assist HEIs in selecting appropriate ITG frameworks for each best practice. The objective is to solve issues of overlap, contradiction, and redundancy by providing a range of framework options that are suitable for the specific environment of each university and cover all necessary mechanisms. This allows university leaders to make informed decisions. In another study [14], a prioritization algorithm was implemented within a small and medium-sized enterprise (SME); however, its effectiveness was not optimal, as it generated only a single framework combination. On the other hand, the algorithm presented below offers a flexible and optimized approach to selecting optimal frameworks combinations, encompassing all available best practices.

The algorithm indicated in Figure 3 aims to find the best combinations of frameworks to cover as many mechanisms as possible. In order to determine this combination, the algorithm uses a binary matrix to identify mechanisms covered by different frameworks. Its goal is to find combinations of frameworks that cover the most mechanisms. The algorithm explores combinations to maximize mechanism coverage, adjusting them based on the already covered frameworks. The final result is a set of optimal coverage combinations. The algorithm steps are shown Algorithm 1.
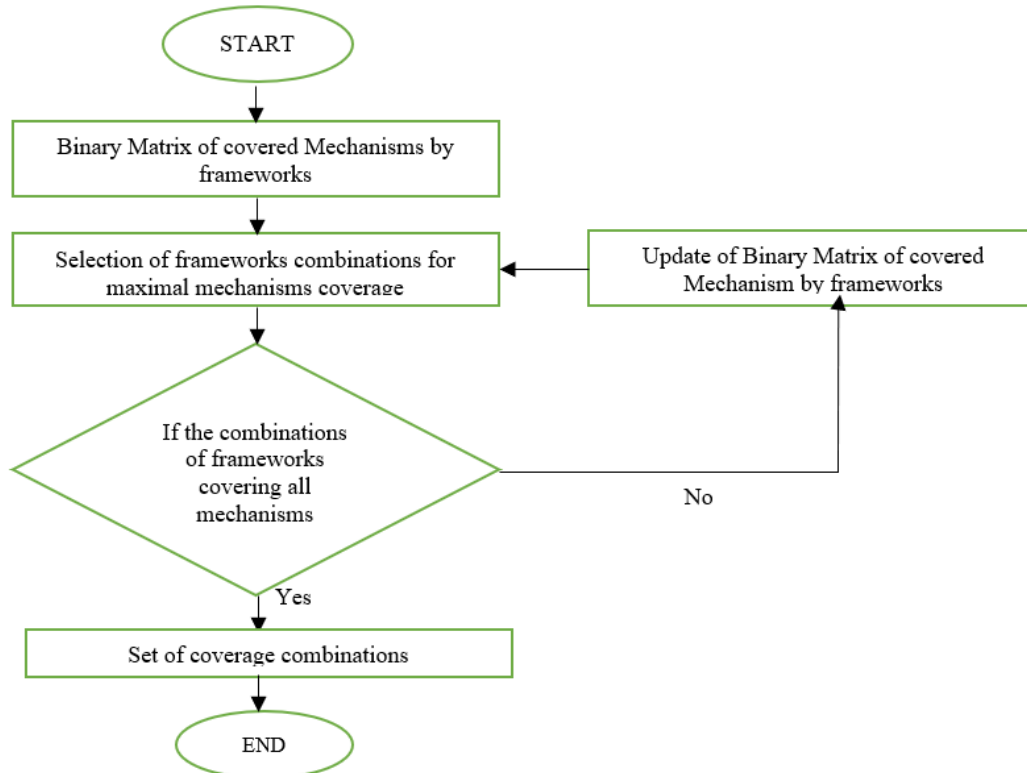
Figure 3. Flowchart of prioritization algorithm based on IT mechanisms coverage

Algorithm 1. Prioritization based on IT mechanisms coverage

```
Input:
P: Binary Matrix of covered Mechanism by frameworks
Output:
Last_coverage: Set of coverage combinations
Function get_coverage (P, C) {
        IF size(C)>0 THEN
                FOR f IN C DO
                        Remove f from P
                END FOR
        END IF
        Max_covered_Mechanism=0
        Combination= E_Vid
        FOR i=0 TO size (P)-1 DO
                FOR J=i+1 TO size (P) DO
                    Covered (Pi, Pj)=OR(Pi,Pj)
                    IF SUM (Covered(Pi,Pj))>Max_covered_ Mechanism THEN
                            Max_covered_Mechanism =SUM(Covered(Pi,Pj))
                            Combination⬚{PiPj:Covered(Pi,Pj)}
                    ELSE IF SUM(Covered(Pi,Pj))=Max_covered_Mechanism THEN
                            Add {PiPj: Covered(Pi,Pj)} TO Combination
                        END IF
                    END IF
                        END FOR
        END FOR
        FOR C IN Combination DO
                IF Number of covered in C < size(P) THEN
                    get_Coverage (P, C)
                ELSE
                                FOR P in Last_coverege DO
                                    IF P In C: return
                        Add C TO Last_coverage
                                    END IF
                                END FOR
                END IF
        END FOR
}
```

6.   RESULT AND DISCUSSION

The implementation of each recommended practice by Moroccan university authorities, as indicated in Table 3, requires the use of multiple information system frameworks, as shown in Figure 4. This situation gives rise to strategic challenges within the university, adversely impacting operational process efficiency. Consequently, it becomes imperative to adopt an approach aimed at optimizing the number of necessary frameworks to cover all mechanisms, in order to address these issues and enhance overall performance.
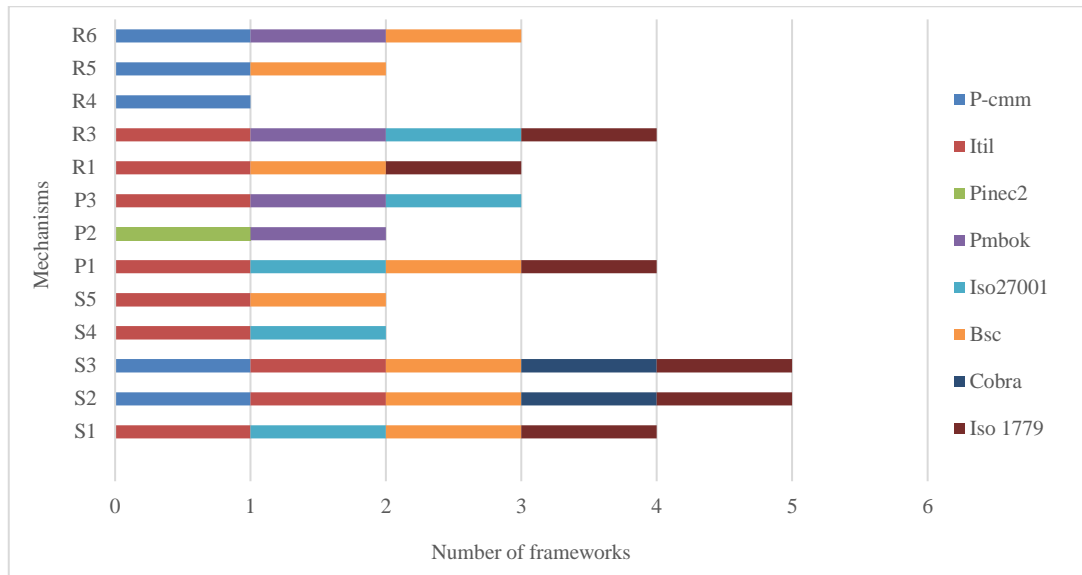
Figure 4. The framework coverage scope for each best practice of the baseline prior to implementing the algorithm

Following the execution of the algorithm depicted in Figure 3, designed to calculate optimal combinations based on mechanism coverage, we arrived at obtaining two final combinations.

Combination1: {PCMM, ITIL, PMBOK}=[1,1,1,1,1,1,1,1,1,1,1,1,1]
Combination2: {PCMM, ITIL, PRINCE2}=[1,1,1,1,1,1,1,1,1,1,1,1,1]

Figure 5 displays the enhanced framework coverage for each recommended practice following the algorithm's application. This algorithm addresses overlap, contradictions, and redundancies by offering two sets of frameworks tailored to the Moroccan university context, ensuring comprehensive coverage of the necessary mechanisms. Figure 5(a) illustrates the coverage achieved with the first set, comprising PCMM, ITIL, and PMBOK, while Figure 5(b) details the coverage from the second set, consisting of PCMM, ITIL, and PRINCE2, for each benchmark practice after the algorithm's implementation.

The algorithm's results led to the selection of two combinations, as shown in Figure 5: P-CMM, ITIL, PMBOK for the first, P-CMM, ITIL, and PRINCE2 for the second. These choices were made with the aim of improving the performance of non-profit organizations such as universities, for which investment in human capital is crucial. P-CMM was therefore considered an essential tool in both combinations, capable of improving personnel management within the organization, creating a conducive environment for motivating human resources, recognizing their skills, and standardizing and improving best practices. ITIL remains the best most used practice framework, given that it is the most suited for IT service management, such as service desk management and incident management, which are more implemented in all universities in order to make services more oriented internally and ensure service quality to students, faculty, and staff.

We can conclude that to implement ITIL and P-CMM broadly or narrowly, it is necessary to have a structured model composed of the best-suited tools and techniques for budget control and project management. The result of the algorithm revealed that building this model based on PRINCE2 and complemented by PMBOK was essential to implement ITIL and P-CMM. Nonetheless, the results of the literature have shown that the level of maturity in using ITG frameworks is still low [15]–[17]. Therefore, ITG management still has a long way to go.
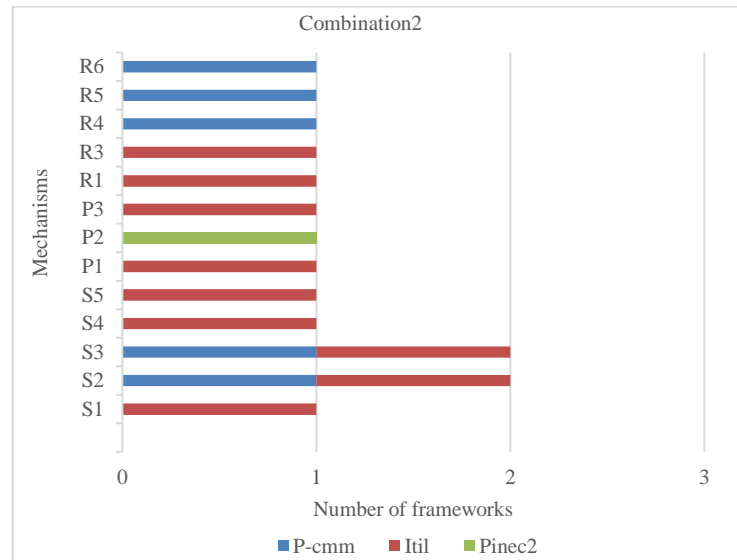
(a)
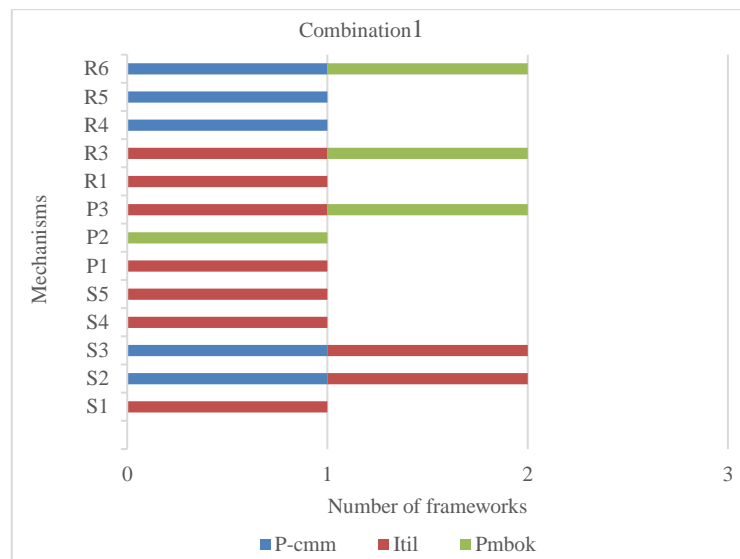
(b)

Figure 5. Represents the first scope (a) and second scope (b) of framework coverage for each best practice of the baseline after implementing the algorithm

All recent academic literature studies in the field of ITG within universities [22], [49]–[55] pact of ITG on performance and strategic alignment. The obtained results from their analysis have not provided a clear vision of the adoption of an ITG framework in HEIs. The diversity of tasks and complex structure of universities do not allow for the selection of a single framework, but the selection of a combination of complementary frameworks, each addressing a specific need. In this sense, R Ben Romdhane and K Ben Slimane confirmed in [56] the difficulty of effectively applying and integrating multiple information system standards. The issue of the multiplicity of governance frameworks appears crucial.

Moreover, Nicho and Muamaar demonstrated in [57] a consensus among respondents in their study that the integration of ITG frameworks is generally slow because the frameworks are long, generic, and difficult to understand. Nonetheless, managers tend to use frameworks without considering the possible effects of their multiplicity. In this context, this contribution addresses a relevant area for practitioners and researchers and proposes solutions to help HEIs adopt optimal and agile combinations. This agility is demonstrated by the ability to integrate or eliminate best practices or frameworks in this algorithm, leading to a new combination to address contingency factors. Among the eight competing governance standards, two combinations were selected. It was found that the adoption of two combinations is sufficient to cover all the

governance mechanisms used in HEIs; the results show that the proposed approach can create more agility in choosing a combination that is easy to implement and use and matches the skills of university leaders. Calculating the framework priorities based on the coverage of IT mechanisms can help HEIs optimize investments in organizational transformation projects and achieve better strategic alignment.

7.   CONCLUSION AND PERSPECTIVES

In conclusion, this literature review's qualitative and quantitative analysis allowed us to identify effective best practices used within universities. However, a mixed situation of the effectiveness of ITG in HEIs was observed. This is due to the maturity of the adopted mechanisms and a lack of consensus on optimal frameworks that cover all mechanisms. To address this situation, a basic model of ITG practices for universities in the form of an effective reference base would be recommended as a guide to adopting ITG mechanisms, and a new approach for the optimal selection of ITG frameworks for this baseline.

The validation of these results within Moroccan universities allows managers to choose between two combinations of frameworks for agile and optimized use of best practice repositories covering all mechanisms. As the main limitation of this research, we mention that the literature only examined certain universities, which prevents any generalization of the results. In future work, we aim to use the AHP method to identify the most critical mechanism by ranking the best practices of each one. This strategic step is of great importance in HEIs and must be carried out to accelerate the implementation of good ITG practices. This will improve the pace and encourage movement towards a better ITG.

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