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Diffusion of ERP in the Construction Industry: An ERP Modules Approach: Case Study of Developing Countries

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Abstract: The risk–benefit analysis of ERP implementation is worth investigating to optimize the efficiency of ERP deployment in the construction sector. This study investigates the factors affecting the dissipation of ERP through diffusion models in developing countries. Moreover, it suggests a strategy to adopt ERP modules that optimize process integration and project efficiency through the priority factors method. According to the study, the internal model best describes the studied modules, and it suggests that imitative behavior and word of mouth significantly influence ERP adoption in the Africa and Middle East regions. This research concludes with an optimized order for deploying ERP modules based on the importance, urgency, and ease of implementation of each module. It is as follows: work progress (500), budgeting (405), procurement (343), site operations (280), planning and scheduling (270), accounting (252), inventory management (126), document control (90), and tendering (6). Therefore, it can be concluded that this study fills the research gap of ERP module adoption using diffusion models and priority factors within the construction industry, specifically in the specified regions. However, considering dynamic influence factors might provide more precise predictions, while involving a greater number of companies' owners might highlight a greater importance of external factors.

Keywords: enterprise resource planning systems; ERP; ERP modules; diffusion; diffusion models

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1. Introduction

Over the past three decades, enterprise resource planning (ERP) systems have become essential for organizations willing to achieve distinction in operation management. Knowledge management (KM) positively impacts operational performance, with ERP systems serving as precursors to KM [1]. ERP systems are comprehensive software solutions that include various modules required for operations such as production, procurement, work progress, inventory management, site operations, and human resources, thereby structuring business processes and functions [2]. The specific modules adopted in an ERP system depend on the type of business and the organization's particular needs at the time. Currently, ERP systems are applied across diverse industries including manufacturing, education, and banking, having emerged as a significant development in corporate IT use in the 1990s [3]. The primary objective of ERP systems is to enhance organizational performance [4–8].

The construction sector has seen a considerable evolution in the use of Enterprise Resource Planning (ERP) technologies in recent years. Construction companies have historically been slow to adopt advanced digital technology, but ERP solutions have become more popular because of their capacity to combine diverse business processes, enhance data accuracy, and improve project management. The construction industry in industrialized nations, including major important companies all over the world, is using ERP systems more and more. The desire to increase project management effectiveness, financial transparency, and departmental cooperation is what is driving this adoption [2,4]. Building information modeling (BIM) and ERP systems are being integrated in industrialized nations to foster a more cooperative building environment. Real-time updates on project progress, cost tracking, and resource management are made possible with BIM data integration. ERP solutions are increasing productivity and decreasing project delays by using mobile and Internet of Things (IoT) technology to give real-time tracking of supplies, equipment, and workers on-site [7].

There is a difference between the state of ERP systems in developing and developed countries' construction industries. Although the use of ERP systems is growing in emerging economies, there are certain obstacles in their installation, and their sophistication is not as high as in wealthy nations. In developing nations, adoption is less rapid and broad, particularly among small and medium-sized construction companies. Because of infrastructure and financial limitations, many businesses continue to use outdated or disjointed software solutions.

Additionally, despite the potential advantages of ERP systems, numerous challenges and obstacles persist. These barriers can be classified into organizational, social, and technological [9]. To be effective, an ERP system in construction must incorporate industry-specific functionalities such as percent completion, project progress, scheduling, budgeting, procurement processes, and reporting, as noted by Shi and Halpin [8]. Additionally, the unique characteristics and size of construction companies are crucial factors when implementing an ERP system. However, as Luo and Strong [10] observed, user resistance to change has slowed ERP integration within the construction sector. Moreover, ERP system usage is predominantly seen in large construction enterprises [11].

Given that ERP systems have the potential to improve industry performance, these findings highlight the need for practitioners and scholars to investigate the issues setting back their adoption and dissemination in the construction sector in developing nations. Developing plans for the effective implementation of ERP modules is also crucial.

Hadidi et al. [11] highlighted that the construction sector must explore the adoption of tendering, budgeting, procurement, work progress, inventory management, site operations, document control, planning and scheduling, and accounting modules. Hewavitharana and Perera [12] identified these nine modules as some of the most crucial in the construction industry. Examining the diffusion pattern of these modules can benefit practitioners targeting to successfully deploy these systems in their companies.

Thus, the following research issues are intended to be addressed by this study:

- How quickly are modules tailored to ERPs being adopted in developing nations?
- Which groups do the people who use these systems belong to?
- What elements affect ERP system adoption in the construction industry in developing countries?
- What tactics can be used to guarantee successful implementation and adoption?

While previous studies have focused on the acceptance of ERP systems in the construction sector in general, this study's main objective is to examine the diffusion of each ERP module that has been adopted independently in developing countries from 2000 to 2023. The research concludes with proposing a framework approach for optimizing the diffusion pattern of these modules and achieving an optimized deployment.

The current paper is structured as follows: Section 2 presents a review of the relevant literature. Section 3 outlines the methodology used in the study. Section 4 details our findings. In Section 5, we provide an analysis and discussion of the results. Finally, Section 6 offers the conclusions of the study, along with its implications, limitations, and suggestions for future research.

2. Literature Review

2.1. Diffusion Innovation Theories

The diffusion of innovations theory describes how and why new ideas and practices are adopted. Various models compute the cumulative number of human beings who adopt an innovation and its pattern over time and space [13]. The speed of innovation diffusion depends on how the innovation is conveyed within society. According to Rogers [14], the five key stages in the diffusion process are knowledge, persuasion, decision, implementation, and confirmation. At any stage, the acceptance of the innovation can be affected positively or negatively by perceived benefits or barriers. Rogers categorizes imitative behavior within society as internal influence factors, while external influence factors include direct impacts on innovative behavior, such as changes in regulations and consulting firms' recommendations.

A main factor in innovation diffusion is imitative behavior. It was considered by Mansfield [15] and elaborated in the internal model. This model is represented by Equation (1)

$$dN(t)/dt = aN(t)[m - N(t)] \tag{1}$$

where $N(t)$ represents the cumulative number of adopters at time t; m represents the total number of potential adopters in the social system; a indicates the probability that each adopter would independently reach a nonuser; $(t)/dt$ is the first derivative of $N(t)$ representing the rate of diffusion at time t ($a \geq 0$).

In contrast, the external model denies the presence of any communication or interaction among the society members. It states that the media, the client demands, and governmental regulations are factors that affect the adoption of new technology [16]. This model is represented by Equation (2)

$$dN(t)/dt = b[m - N(t)] \tag{2}$$

where b is the coefficient of external influence in each period ($b \geq 0$).

Finally, the mixed model considers both the internal and external factors and employs parameters from both models. This model proposes that the diffusion pattern of an innovation is achieved by both imitative behavior and external forces [16]. It is represented by Equation (3).

$$dN(t)/dt = [b + aN(t)][m - N(t)] \tag{3}$$

The previously described models were applied by several researchers in different novel technologies. Ahmed and Kassem [17] showed that external factors such as financial support and government initiatives are the key to information technology diffusion. Zhao [18] used the mixed model to assess the diffusion of the increase in renewable energy price policies. The interaction among generation enterprises and the external influence of government behaviors helped in increasing the renewable portfolio standards [18]. Thneibat et al. [19] proved that mass media and external incentives are the most crucial factors leading to an increase in the diffusion of value management in construction projects using the mixed model. Recently, El Hajj et al. [20] studied the adoption of BIM functionalities within the construction sector in the MENA region. The mixed model best represented the results of the BIM functionalities diffusion patterns. Imitative behavior acted importantly even though both internal and external factors are considered [20].

2.2. ERP Systems

After a decade of the Material Requirement Planning (MRP) systems' takeoff in the 1970s, the evolution of MRP II took place, eventually leading to the development of Enterprise Resource Planning (ERP) systems in the 1990s. ERP systems integrate various processes and departments within a company, providing real-time data accessibility and consistency. As more modules were added, many non-industrial sectors began adopting these systems [21]. The integration of ERP systems within the construction sector has been shown to improve the supply chain, enhance flexibility, aid decision-making, and reduce costs and project completion times [8,22]. Khouadjia et al. [23] identified obstacles to ERP implementation as organizational, social, and technological. Similarly, Luo and Strong [10], Fleming et al. [24], and Kwak et al. [25] noted that most barriers to successful implementation are user related. Zhu et al. [26] developed a model using the Technology-Organization-Environment theory to explain ERP implementation success, finding that organizational preparation and ERP quality significantly impact post-implementation success. Several studies have investigated the gaps in ERP modules needed within the construction sector. Hewavitharana and Perera [12] examined gaps in inventory management, finance, site operations, estimating and tendering, subcontractor management, petty cash, asset management, human resources, purchases, and project management. They emphasized that customization is crucial for the success of ERP systems in construction. The adoption of an ERP system involves several stages, beginning with defining the need and system components. Next, the essential functionalities and modules must be established. Then, the integration and implementation of ERP modules are carried out. Finally, the success factors and benefits are attained and assessed [27].

2.3. ERP and Diffusion Innovation Theories

Decisions regarding the implementation of an ERP system depend on the senior managers and neglect the end-users. The end-users are directly involved in the failure or success of the system adoption [28]. Several studies have elaborated on user-related factors as critical risk factors for ERP deployment [10,29]. Several diffusions of innovation studies have targeted ERP systems and stated their importance in adoption, implementation, and dissipation. The diffusion of innovation theory claims that the adoption of new technology such as ERP systems pursues a trend affected by innovation, communication, social networks, and perceived benefits. Nevertheless, some challenges might be encountered such as resistance to change, uncertainty about technology, and the return on investment. Thus, to develop a better understanding of the ERP systems and evaluate their adoption, the theory of innovations is used. The possible attributes that affect the adoption are relative advantage, compatibility, complexity, trialability, and observability. Rogers' theory is used as a platform for setting the rational reasons corresponding to packaged software adoption [14]. This method is helpful to identify the "less sensible" reasons. However, the research objective was studied by the interpretive and critical traditions to add better insights since Roger's theory has some limitations. It does not take into consideration the particularities of complex information technologies. The findings show that the attributes of an innovation are preferably not to be used as the perception of agents in the diffusion process. Wrong perceptions can guide toward bad assumptions [30]. Having the same purpose but adopting a more relevant and reliable method, a study in 2012 was conducted by Kwak et al. [25]. The technology acceptance model (TAM) proposed by Davis [31] is used and extended to obtain relationships between project management practices and end-users' perception of a project-based sector. The key finding shows that users prefer a system customized rather than changing the business processes. However, ERP vendors prefer to reduce the amount of customization unless the company builds the ERP system based on the client's needs. Based on these results, the implementation approaches, the modules to be included, the degree of customization required, and its challenges are important to be taken into consideration in further studies [25]. Another group of researchers tried to detect the relationship between the diffusion of innovations theory and the implementation team for a successful ERP system. Qualitative and quantitative methods are used. The data are collected through interviews and questionnaires and then, they are analyzed based on the literature. The analysis finds that the selection of the implementation team is highly sensible for the successful implementation of the ERP system [21]. A study conducted in 2020 investigates the diffusion of innovation of ERP systems while having a transition from an existing on-premises method to a cloud-based system. This research is conducted using the technology-organization-environment, diffusion of innovation, and the model of innovation resistance frameworks. Factors such as regulations, organizational culture, advantage, and trialability have a major influence on the will to adopt a cloud-based ERP. However, complexity, data security, and customization do not influence the aim to adopt cloud-based ERP [32].

The previous literature pointed out the critical success factors for technology acceptance. Therefore, Kale and Arditi [33] applied the diffusion model (internal, external, and mixed) to CAD technology. Their results showed the mixed model as the best exploratory one while highlighting the importance of internal factors over external ones. Hence, a recent three-phase systematic review process was completed in 2023 by identifying and analyzing 35 articles by Nnaji et al. [34]. The analyses show that the key factors affecting the intention to accept construction technology are perceived ease of use, perceived usefulness, social norm, attitude, perceived behavioral control, and facilitating conditions. The authors identify three models as popular choices for developing hybrid models: the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and the Unified Theory of Acceptance and Use of Technology (UTAUT). Among the previously mentioned methods, the UTAUT has a higher predictive power [34].

Although many researchers investigated the diffusion pattern of the technologies and ERP systems within the construction field, the diffusion of ERP modules is still not clear. Hence, the main objective of this study is to investigate the diffusion of ERP modules diffusions in this field to extract the main factors leading to its propagation. Then, a framework needs to be suggested to help reach a successful implementation. Table 1 below indicates the main contributions of this study with respect to previous outputs.

Table 1. Main contributions of the current study.

Previous Studies	Current Study
Factors affecting the: Diffusion of CAD technology [33]. Diffusion of BIM technology [20]. Diffusion of ERP system [25,31]. Diffusion of ERP systems from on-premises to a cloud-based system [32]. Systematic review with different techniques to use while investigating the diffusion pattern of a technology [34].	Factors affecting the diffusion of 9 different modules separately within the ERP system in the construction industry, in developing countries (Middle East and Africa).
Identifying obstacles to ERP implementation as organizational, social, and technological [23,25].	Identifying the specific factors affecting the dissipation of ERP modules to prevent the failure of their implementation.
Establishing essential functionalities and modules within the ERP system is one of the critical steps prior adopting it [27].	Prioritizing the required modules and proposing a framework for modules implementation to reach successful implementation.

3. Materials and Methods

This study considers the diffusion pattern of ERP modules separately within the construction sector in developing countries in the Middle East and Africa. While previous research has targeted ERP systems as a whole, the examination of individual modules remains unexplored. This study aims to fill that gap, offering insights for practitioners and project managers on factors affecting the adoption rate of ERP modules. By understanding these factors, decision-makers can optimize resource allocation to maximize the impact of ERP module adoption. To aid in this, a module deployment strategy is proposed, utilizing the priority factor technique to decide the optimal order of ERP module deployment based on urgency, importance, and ease of implementation.

The first part of the literature review corresponds to data collection. Scholars gathered articles from several major electronic databases, including ScienceDirect, Scopus, Taylor and Francis Online, and ASCE Library, using specific keywords such as "enterprise resource planning systems", "ERP modules", "ERP benefits", "ERP barriers", and "diffusion innovation theories". A total of 105 articles were initially collected, which were then screened to remove duplicates and non-English papers, resulting in 84 studies. Further refinement based on criteria related to ERP and diffusion innovations, as well as citation analysis, left 57 papers for detailed data analysis. Based on the literature [11,12,35,36] and stakeholder experience, a list of essential ERP modules for the construction sector was established. These modules include tendering, budgeting, procurement, work progress, inventory management, site operations, document control, planning and scheduling, and accounting. In-depth interviews with general managers and construction company owners validated this list, forming the basis of a survey designed for this study.

This survey's main goals are to determine the trends in the adoption of ERP modules over time, categorize adopters into distinct groups, look at the major variables affecting adoption right now, and rank the standards by which modules should be chosen. The theoretical framework was developed, and the survey was created in accordance with it using information that had previously been gathered from the literature and in-depth interviews. First, the question is closed to respondents who have never used an ERP system. After collecting demographic data, questions on ERP adoption are asked. These include questions about age, education, place of employment, year of initial use of each applicable module, perceived benefits, and adoption barriers [20]. To provide an organized and thorough approach, these topics are covered in separate sections of the survey. A pilot study is conducted through direct contact with 25 participants including experts in the field and engineers to ensure that the questions are clear, the format works, to discover any technical issues and thus, improve the survey prior to its final distribution.

The final survey, designed to collect quantitative data [37], includes a summary stating the study's goal and five main sections. The first section concentrates on the characteristics of the participants by asking about their years of experience, education, current work status, the regions they worked in, the departments they worked for, and whether they have already used an ERP system or not. If the participant has used at least one module in an ERP system, then they continue to the following sections. The second section is a general one that investigates whether the ERP utilized is customized or not and then investigates the first year they started using the ERP system in general. The third section examines the first year the participant has used each of these modules: tendering, budgeting, procurement, work progress, inventory management, site operations, document control, planning and scheduling, and accounting. The options start with the "Prior 2000" option until "2023" along with a "Non-Applicable" (NA) option. Data collected are analyzed using the most recognized models: the internal influence model [15], the external influence method [16,38–40], and the mixed influence model [16,41] to interpret the diffusion pattern of ERP modules in the construction sector. These models require the estimation of 3 parameters where various approaches exist to approximate them. Finally, a method that can predict the diffusion parameters and show reliable results is applied to the Statistical Package for the Social Sciences (SPSS). The method is the Levenberg and Marquardt method of Nonlinear Least Squares (NLS) [14,16,20,38,42–45]. The goodness of fit of the three methods is compared to elaborate on the best model that explains the pattern of ERP module diffusion. The fourth section has eight Likert-scale questions varying between 1 (low) and 5 (high) and four close-ended questions (Yes/No) to identify the functionalities and benefits corresponding to the usage of the ERP modules and the presence or absence of regulations for ERP adoption. The questions investigated the ease of use of the ERP system, and the presence of improved flexibility, stability, and performance. It also targets the existence of a better workflow, security, and mobile application while generating good documentation and reporting. Likert-scale questions capture the performance and attributes of human behavior. They can assess the frequency of use, the difficulty, and the value of the module. They can measure the attitude in an accepted and validated manner [46]. The close-ended questions interrogated the participants about the presence of a reliable upgrade, the presence of continuous support, and the presence of strict measures to use the

ERP. Also, it rates whether they have less or more work to achieve after the ERP adoption. The last section includes a matrix investigating the rating of the modules concerning the importance, the urgency, and the easiness of the deployment of each module. It evaluates and ranks variables based on the mentioned criteria to ensure that decisions are made based on clear priorities. The priority factor method assesses the factors quantitatively by assigning numerical values to each criterion. A rating of 1 indicates that the module is the least important, the least urgent, and the hardest to be deployed. On the contrary, a rating of 10 indicates that the module is the most important, the most urgent, and the easiest to deploy. The average ratings of all the respondents are calculated. Then, the factor is obtained by multiplying the ratings of each module separately. These numbers will give the priority factor showing the priority in which the modules are suggested to be deployed. Additionally, importance can be considered as a driver of interest while urgency might appear due to competitive pressures or requirements. However, the easiness of deployment depends on the users being trained to use the system and the friendliness of the system.

The survey was distributed via email and LinkedIn to reach a diverse audience of general managers, project managers, and end-users in construction companies. Targeted distribution efforts included contacting companies in developing countries, mainly in Africa and the ME regions, and using LinkedIn to identify potential respondents. A list of employees' emails is shared by several managers of construction companies through direct contact while a search on LinkedIn by keyword: ERP, Construction is completed to reach the maximum number of respondents. By making it possible to compare the group of potential respondents with the people who took part in the survey, the employee lists that the companies offer help assess the validity of the findings. This ensures that the final sample is representative of the intended population and aids in identifying any anomalies, such as non-response bias. Emails that were not on the supplied list were cross-referenced on LinkedIn to confirm the respondent's legitimacy and authenticity. Spreading the survey online allows the flexible design of various question types, reduces the cost, and releases the necessity of being present on-site. Since the construction industry is unique and cannot be standardized, collecting data to identify the users' characteristics of ERP systems helps deliver realistic data [37] and credible results [38,39]. Figure 1 sketches the methodology adopted in this study.

Figure 1. The methodology adopted in this study [14,38,44,45,47–50].

4. Results

The survey was distributed among civil engineering companies and shared on LinkedIn and by email. The data were collected from different firms in different countries to ensure the sample was representative of the construction sector. A total of 300 questionnaires were sent. 137 responses were received, which indicates that the sample adequately represents the population with a 95% confidence level and 5% confidence interval.

4.1. Participants' Characteristics

33.3% of the participants are currently working in Ivory Coast and 31.3% in Lebanon. The remaining participants are distributed between KSA, Benin, UAE, Egypt, Congo, Nigeria, Algeria, and other countries. All the participants are civil engineers. 20% of the participants have less than 5 years of experience, 24% have between 5 and 10 years of experience, 46% of the participants have between 10 and 15 years of experience, and the remaining 10% have over 15 years of experience. These results show that the results are reliable since the participants are experienced in the field. The participants varied among general managers, project managers, structural engineers, civil engineers working in the cost control department, contractors, roads and infrastructure engineers, and planners.

4.2. Benefits

Concerning the functionalities and benefits of the ERP system, the respondents were asked to rate several functionalities and to state the benefits that appear after the ERP system's adoption as stated previously. 74% of the responses prove that while adopting the ERP system, users have less work to do than prior to utilizing the system. Concerning the reliable upgrade and continuous support, they agreed on that by 85% and 80%, respectively. 91% of the participants stated that their companies established strict modes of regulation to adopt the system. Table 2 shows the percentage of the participants that rated the ease of use, flexibility, stability, performance, workflow, security, documentation and reporting, and mobile application by 4 or 5 in the Likert scale questions. A rating of 4 out of 5 indicates that the functionality is good. Security has the highest percentage of 81%. Following this, ease of use, flexibility, and documentation and reporting have a percentage of 78%. The lowest percentages belong to stability and mobile application, respectively (64% and 59%). These results prove that ERP usage is easy while improving security, achieving better flexibility, performance, and workflow. Most importantly, it enhances documentation and reporting techniques.

Table 2. Percentage rating greater than or equal to 4 per functionality.

Functionalities	% Rating $\geq$ 4/5
Ease of Use	78
Flexibility	78
Stability	64
Performance	73
Workflow	70
Security	81
Documentation and Reporting	78
Mobile Application	59

4.3. Adoption Rate of ERP Modules

Apart from the benefits and functionalities listed above, the modules used in the ERP system are examined. These modules include tendering, budgeting, procurement, work progress, inventory management, site operations, document control, planning and scheduling, and accounting. These modules incorporate most of the operation procedures in the company. The results of Table 3 show that 83% of the users employ the work progress module and 75% adopt the inventory management module. The lowest module adopted belongs to the tendering module with a 47% adoption rate. The modules' selection was validated by several managers who stressed their importance and need.

Table 3. Percentage adoption of each ERP module.

Modules	Number of Users	% From ERP Users	% From All Participants
Tendering	47	47%	34.31%
Budgeting	70	70%	51.09%
Procurement	73	73%	53.28%
Work Progress	83	83%	60.58%
Inventory Management	75	75%	54.74%
Site Operations	72	72%	52.55%
Document Control	71	71%	51.82%
Planning and Scheduling	59	59%	43.07%
Accounting	62	62%	45.26%

4.4. Diffusion Model and ERP Modules Diffusion

Furthermore, the participants were asked to specify, if applicable, when they started using each module for the first time. Figure 2 shows the cumulative adoption of each module over the years starting from the year 2000.

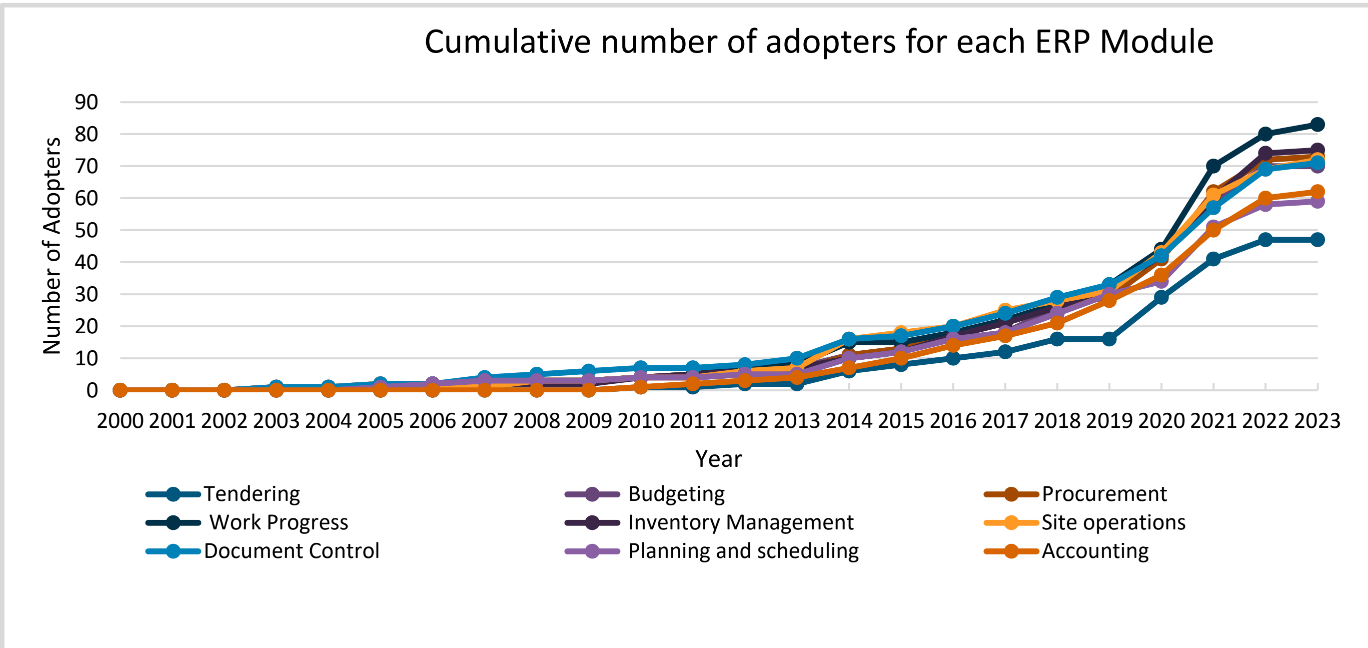

Figure 2. The cumulative number of adopters for each ERP module.

The results can be divided into three categories for the nine modules. A gradual increase from the year 2000 until 2013 with the slowest growth over time. From 2013 up to 2019, a steeper slope appears for all the modules. Finally, the last category after the year 2019 shows the steepest slope for all the modules. The procurement module, the inventory management, and the document control modules were the first modules to be adopted in 2003. They were followed by the planning and scheduling module in 2005. Then, one year later, they were followed by the work progress and site operations modules. The tendering and accounting modules are the latest modules to be adopted, starting in 2010. The authors considered the year 2000 as the first year in the suggestions since ERP systems showed up to be the most significant development in the corporate use of IT in the 1990s [3].

The following analysis will consider the previously described results to assess the diffusion pattern of the ERP modules by comparing the significance of the three diffusion models and their goodness of fit to the data collected.

Using the Statistical Package for the Social Sciences (SPSS) software Version 26, the R-squared of each module for each model is computed using nonlinear regression. The models internal, external, and mixed are represented by Equation (4), Equation (5), and Equation (6), respectively.

$$N(t) = \mathrm{m}/((1 + ((m - n)/n)) \times exp(-amt)) \tag{4}$$

$$N(t) = m \times (1 - exp(-bt)) \tag{5}$$

$$N(t) = (m \times (1 - exp(-(b + a)t))/(1 + (\mathrm{a}/b) \times exp(-(b + a)t)) \tag{6}$$

These equations are the result of the integration of Equations (1)–(3), where n is the number of adopters in the initial period; $N(t)$ is the cumulative number of adopters at time t; m represents the total number of potential adopters in the social system; a indicates the probability that each adopter would independently reach a nonuser; and b is the coefficient of external influence in each period.

The external model had the worst fit. It has the lowest R-squared values and the highest AIC values. The lowest R-squared is 0.39 for the work progress module with an AIC value of 207.334. The highest R-squared is 0.469 with an AIC value of 178.215, and it corresponds to the procurement module. The remaining modules have values between these records. Hence, the external model is excluded from the analysis. However, the other two models show more precise approximations of the required parameters. Both models can estimate the parameters needed.

R-squared adjusted is a measure of how well the time in a regression model explains the variation in the module's adoption. A higher R-squared indicates a better model fit. Also, the Akaike Information Criterion (AIC) is calculated for the models. AIC is a statistical measure used for model selection and is often used in the context of regression analysis. The AIC values are computed using Equation (7).

$$AIC = n \times ln(SSE/n) + 2k \tag{7}$$

where n is the sample size, SSE is the sum of squared errors, and k is the number of estimated parameters.

The authors evaluate the reliability of estimations at a 0.05 level of significance for the listed modules. None of them has a p-value less than 0.05. Hence, they are statistically significant. A low p-value (typically < 0.05) indicates that the predictor variable is likely to have a significant impact on the dependent variable, while a high p-value suggests that the predictor may not be significantly related to the dependent variable in the context of the model.

Table 4 presents the parameters of the internal and mixed models. For the nine modules investigated, the adjusted R-squared and Akaike's information criterion (AIC) values are computed to check, respectively the goodness of fit and the approximation of the anticipated distance between the fitted model and the unknown true process that produced the real data. The greater the adjusted R-squared is the better while the lower AIC value presents better results.

The results indicate that the mixed model failed to approximate m for 7 out of 9 modules which are budgeting, procurement, work progress, inventory management, site operations, document control, and accounting, while the internal model shows better and more accurate results. For the two remaining modules, the R-squared adjusted and AIC values were compared. These modules have higher adjusted R-squared and lower AIC values for the internal model. Therefore, the internal model proves to be more accurate and precise for the tendering and planning and scheduling modules.

Table 4. Parameters of the internal and mixed models.

	Model	N (Survey)	m	a	b	R-Squared Adjusted	AIC Value
Tendering	Internal	47	51	0.008	N.A.	0.9243	366.70
	Mixed		42	0.152	0.124	0.8945	324.37
Budgeting	Internal	70	77	0.007	N.A.	0.9856	455.41
	Mixed		92	0.350	0.002	0.9834	457.41
Procurement	Internal	73	75	0.006	N.A.	0.9813	462.28
	Mixed		99	0.304	0.003	0.9588	477.10
Work Progress	Internal	83	85	0.006	N.A.	0.9673	487.81
	Mixed		115	0.313	0.002	0.9669	489.81
Inventory Management	Internal	75	88	0.005	N.A.	0.9734	472.78
	Mixed		105	0.303	0.003	0.9896	466.58
Site operations	Internal	72	79	0.005	N.A.	0.9734	460.14
	Mixed		98	0.289	0.003	0.9752	462.14
Document Control	Internal	71	70	0.003	N.A.	0.9815	448.02
	Mixed		113	0.241	0.004	0.9690	450.02
Planning and scheduling	Internal	59	62	0.006	N.A.	0.9592	367.54
	Mixed		50	0.286	0.053	0.9425	369.54
Accounting	Internal	62	60	0.006	N.A.	0.9754	367.67
	Mixed		40	0.033	0.309	0.9547	369.67

4.5. Phasing ERP Modules Adoption

Besides the diffusion of ERP modules, the phases of ERP module deployment need proper planning to reach successful implementation. Thus, this research utilizes priority factors to help decision-makers select the order of ERP module deployment. Three criteria were identified as impacting the adoption decision of the module: the importance of the module to the practice, its urgency, and the easiness of its deployment. The survey sought the opinion of respondents regarding the three criteria. The urgency highlights the necessity and pressure to adopt the ERP modules. It might be affected by competitive pressures, regulations, market trends, etc. The more urgent a module is to deploy, the higher the chances to deploy it at initial stages. Moreover, the importance of the module indicates its significance in adoption. The module will attract the attention of the decision-makers and drive them towards faster adoption. It helps emphasize the awareness and interests of the module within each department. However, the easiness and complexity of module adoption have a key role in the deployment. The easier the module is, the more effortless the adoption is. Also, the training, the age, the level of education, and the support are important to be considered in the deployment phase. Therefore, linking these three criteria will result in a priority factor to gain insights and extract strategies for successful module implementation. The results of the survey pointed out interesting findings corresponding to the priority factor affected by the urgency, importance, and easiness of the deployment.

The result of the survey indicates that the most urgent, important, and hardest module to deploy is work progress. It has the highest ratings compared to the other modules for the three categories, which are 10, 10, and 5, respectively. Thus, its priority factor is 500. The budgeting module follows the latter with a priority factor of 405. It is the second most urgent, important, and complex to deploy by having the following ratings, respectively: 9, 9, and 5. The third most urgent module is procurement with a rating of 7, while the third most important modules are procurement, inventory management, and accounting, having a rating of 7. The hardest modules to deploy are work progress and budgeting, having a rating of 5. They are followed by tendering and document control modules with a rating of 6. However, the least urgent and important module is tendering, having a rating of 1 for both pillars. Finally, the easiest module to deploy is planning and scheduling, having a rating of 9. Thus, the modules are distributed as follows: work progress (500), budgeting (405), procurement (343), site operations (280), planning and scheduling (270), accounting (252), inventory management (126), document control (90), and tendering (6).

The results extracted from the last section of the survey are outlined in Table 5. These results suggest the deployment of ERP modules as follows: work progress, budgeting, procurement, site operations, planning and scheduling, accounting, inventory management, document control, and tendering. Even though work progress and budgeting modules are the hardest to deploy, they remain the top priority modules to deploy due to their importance and urgency ratings having the highest factors and affecting the overall factor.

Table 5. Modules Rating and Priority Factor.

Modules	**URGENCY (A)**	**IMPORTANCE (B)**	**EASINESS (C)**	**FACTOR (A × B × C)**
Tendering	1	1	6	6
Budgeting	9	9	5	405
Procurement	7	7	7	343
Work Progress	10	10	5	500
Inventory Management	6	3	7	126
Site Operations	5	7	8	280
Document Control	5	3	6	90
Planning and Scheduling	5	6	9	270
Accounting	6	6	7	252

5. Discussion

Based on the survey, the user's rating for the functionalities and benefits of the ERP modules implementation proves that security is highly achievable with the highest percentage. 81% of the participants rate it as significant. Ease of use, flexibility, and documentation and reporting follow this benefit with a percentage of 78% of the participants' votes. Also, 74% of the participants agreed that they had less work to accomplish after the system adoption. Complementing these advantages with a reliable upgrade and continuous support, users encourage the usage of the system. Therefore, the results comply with the successful factors for ERP adoption and diffusion. They indicate that the advantages extracted from the ERP adoption affect the end-users directly. Therefore, the end-users are directly involved in the success or failure of the system [10,28,29].

The work progress module presents the highest number of user adoptions. This might be explained by the minimum required modules previously stated in the literature. The work progress module is presented among the minimum required modules framework suggested by Jawad et al. [51]. Thus, most companies might decide to adopt and apply it during the early phases of ERP system implementation. Adopting such a module allows for the data collection, project follow-up, and monitoring. Hence, showing the highest percentage of adoptions is explainable. While the least adopted module is the tendering module. The latter is considered a new module added to the standard modules elaborated in the ERP systems. The construction industry is more specific than any standard industry. The work progress module, procurement module, and inventory management are not new in terms of modules for the ERP in general [2]. However, the tendering module is a new concept specific for the construction industry, which explains its lowest percentages of adoption. The unique traits of the construction sector and the increasing trend of ERP systems moving from traditional industries into the construction industry lend additional validity to this [21].

91% of participants reported that their companies implemented strict regulations when adopting the system. This is an external factor applied by the owners or general managers of the company; however, the results show that the internal factors are of greater importance. Hence, the regulations are important in the pre-adoption stage of the system. The previous statement conforms with the results elaborated on BIM adoption by El Hajj et al. [20].

The tendering module has the highest probability that each adopter would independently reach a nonuser (0.008). It is followed by the budgeting module (0.007). Then, the procurement, work progress, planning and scheduling, and accounting modules have the same coefficient of 0.006, while the inventory management and site operations modules have a coefficient of 0.005. The lowest coefficient belongs to the document control module (0.003).

In addition, the dominance of internal factors over external factors is most likely explained by the specific needs of growth and development of each company rather than the external pressures. This is proven to be true since the module's adoption varies among the businesses and the needs of each company [12]. The construction industry in Africa and the ME region is more likely affected by internal factors such as word of mouth rather than external pressures. External factors might affect the decision-making of adopting an ERP system while word of mouth and the needs of the company affect the module adopted.

The imitative behavior observed can be verified by the rational efficiency hypothesis. Blayse and Manley [52] mentioned that the benefits of adopting innovation in the construction sector are obtained through communication channels. Firms might become aware of these modules through exhibitions, trade shows, gatherings, and others. The main interest of rational efficiency belongs to the capability of recognizing the profitability and efficiency of the users at a given point of the diffusion process. Some benefits are directly tangible, such as better reporting techniques, on-time data collection, and better project follow-up; however, better image and reputation and customer satisfaction might require some time to appear. They might dissipate a few months after the deployment of the ERP module. This fact leads to additional benefits in the long term. Hence, the technical profitability of the ERP modules needs further investigation since it cannot completely justify the diffusion of ERP modules in the construction sector.

Moreover, having several ERP modules might give the impression that the firm is qualified and legitimate to clients. Also, the fear of losing clients in a world full of competition might push the firm to adopt ERP modules to gain an advantage over the competitors. The latter can be explained by the bandwagon hypothesis [53]. This theory takes into consideration the previous number of adopters and the reputations to adopt the technology regardless of the presence or absence of profitability information.

Hence, the bandwagon theory might be considered a better explanation for the ERP module's diffusion in the construction industry. Nevertheless, additional examination of this theory's pressures might be investigated deeply in further studies.

Finally, the results show that the work progress module is considered the highest priority module to be deployed while having the highest factor (500). It is followed by the budgeting module (405) and then the procurement module (343). Hence, it is suggested to implement the work progress module at the beginning. Then, it is suggested to adopt the following modules, respectively: budgeting, procurement, site operations, planning and scheduling, accounting, inventory management, document control, and tendering. This framework will increase the chance of successful adoption due to the importance, urgency, and easiness of adoption of each module. These findings comply with previous findings stating the importance of deploying the ERP system in different stages [27,51]. Monitoring daily progress came up as a critical concern for the engineers since it helps with daily tracking of the activities accomplished, extracting cost performance index and schedule performance index by comparing the actual work to the scheduled and budgeted work. Moreover, it is among the minimum required modules to adopt in the initial stages to reach successful implementation as stated by Jawad et al. [51].

6. Conclusions

This study assessed the diffusion patterns of ERP modules within the construction sector in Africa and the Middle East. Notably, the construction sector in the developing regions, specifically in the Middle East and Africa, has proven significant development in recent years. A comprehensive literature review was conducted to assess the status and diffusion patterns of ERP systems within the sector. Based on insights from previous studies, a survey was designed to investigate the benefits of ERP systems and the diffusion patterns of ERP modules. The selected modules, which are frequently mentioned in the literature, represent key components of the operational chain in the construction sector.

Data collected from the survey were analyzed using SPSS, using the Levenberg and Marquardt method of Nonlinear Least Squares (NLS) to explore the diffusion of innovation patterns. The results were further evaluated using diffusion models: external, internal, and mixed. This study provides valuable findings into the adoption and implementation of ERP systems in the construction industry, showing key factors influencing their diffusion and offering recommendations for optimizing ERP deployment in these regions.

The implementation of ERP systems enhances organizational functionalities by improving flexibility and performance, increasing stability and security, and fostering better workflow throughout the enterprise. Additionally, ERP systems enhance documentation and reporting capabilities, all within an easy-to-use user interface. Acceptance of these systems also reduces the workload for workers while granting reliable upgrades and continuous support.

The study's findings indicate an increase in the adoption of ERP modules, with the steepest slope occurring after 2019. This surge was preceded by a gradual increase up to 2013, followed by a steeper incline between 2013 and 2019.

The findings detect the internal model as the most appropriate for justifying the diffusion of ERP modules. Imitative behavior and word of mouth are more dominant than regulations and external factors in the diffusion process of ERP modules. This supports the significance of the bandwagon hypothesis in the ERP modules' diffusion pattern in Africa and the Middle East regions. However, regulations can still push decision-makers into the pre-adoption phase of ERP modules.

Furthermore, the highest priority factor is credited to the work progress module, followed by the budgeting and procurement modules. This suggests an optimal order for deploying ERP modules based on their importance, urgency, and ease of deployment, thereby enhancing the overall deployment of ERP systems.

6.1. Implications

The results of this study show that the adoption rate of ERP modules is steadily increasing across all modules, with a notable increase of rate in recent years. While each module has a specific deployment rate among participants, all exhibit a rising adoption trend over time. Approximately one-fifth of adopters are considered early adopters, having less than five years of experience. This highlights the importance of incorporating younger employees within each department to ensure the maintained use and continuity of these technologies.

Additionally, 70% of the contributors are experienced staff who confirm the significant benefits derived from using these modules. Improved documentation and reporting are evident, with around 80% of participants noting these improvements. Internal communication and dissemination within companies are also highly effective, largely due to the major benefits previously mentioned.

The findings of this study provide valuable insights for decision-makers, construction firm owners, and general managers. Encouraging the implementation of ERP modules within their departments can help construction companies remain competitive in Africa and the Middle East and assure clients of their capability for quick decision-making through real-time data collection over the project duration. ERP systems also enable timely project accomplishment and adherence to budget constraints through effective daily follow-up.

Finally, the study recommends the deployment of the work progress module, followed by the budgeting and procurement modules, to enhance the integration of ERP systems in construction companies. This strategic order of deployment helps decision-makers optimize the adoption and utilization of ERP systems within their firms.

6.2. Limitations and Future Research Lines

Despite the importance of this research study, several limitations are apparent. First, the diffusion pattern within construction companies is unique, yet the patterns used do not account for this specificity. Future research should consider this issue to enhance model accuracy. Second, the external and internal factors are treated as constant over time, which may reduce the precision of the results. Models that incorporate dynamic influence factors could provide more adequate predictions.

Additionally, a time lag between receiving information, becoming convinced of the modules' benefits, and adopting them might occur. However, the current models assume immediate adoption upon receiving information. Therefore, a deeper analysis of the decision-making mechanisms for ERP module adoption is needed. Finally, gathering input from a larger number of owners and managers about the factors driving ERP system integration might reveal that external factors play a more significant role in the initial adoption phase.

Furthermore, it would be beneficial, in future work, to assess how emerging technologies, such as artificial intelligence and the Internet of Things, are incorporated into ERP systems in the construction industry and how this influences innovation and operational effectiveness.

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References

1. Faith Acar, M.; Tarim, M.; Zaim, H.; Zaim, S.; Delen, D. Knowledge management and ERP: Complementary or contradictory? *Int. J. Inf. Manag.* **2017**, *37*, 703–712. [CrossRef]
2. Chung, B.; Skibniewski, M.; Kwak, Y. Developing ERP Systems Success Model for the Construction Industry. *J. Constr. Eng. Manag.* **2009**, *135*, 207–216. [CrossRef]
3. Davenport, T. Putting the Enterprise into the Enterprise System. 1998. Available online: https://hbr.org/1998/07/putting-the-enterprise-into-the-enterprise-system (accessed on 30 November 2023).
4. Alaskari, O.; Pinedo-Cuenca, R.; Ahmad, M. Framework for implementation of Enterprise Resource Planning (ERP) Systems in Small and Medium Enterprises (SMEs): A Case Study. *Procedia Manuf.* **2021**, *55*, 424–430. [CrossRef]
5. Skibniewski, M.J.; Ghosh, S. Determination of Key Performance Indicators with Enterprise Resource Planning Systems in Engineering Construction Firms. *J. Constr. Eng. Manag.* **2009**, *135*, 965–978. [CrossRef]
6. Mandičák, T.; Spišáková, M.; Mésároš, P.; Kozlovská, M. Design of Economic Sustainability Supported by Enterprise Resource Planning Systems in Architecture, Engineering, and Construction. *Buildings* **2022**, *12*, 2241. [CrossRef]
7. Poirier, E.A.; Staub-French, S.; Forgues, D. Measuring the impact of BIM on labor productivity in a small specialty contracting enterprise through action-research. *Autom. Constr.* **2015**, *58*, 74–84. [CrossRef]
8. Shi, J.J.; Halpin, D.W. Enterprise Resource Planning for Construction Business Management. *J. Constr. Eng. Manag.* **2003**, *129*, 214–221. [CrossRef]
9. Nakayama, M.; Hustad, E.; Sutcliffe, N.; Beckfield, M. Organic transformation of ERP documentation practices: Moving from archival records to dialogue-based, agile throwaway documents. *Int. J. Inf. Manag.* **2024**, *74*, 102717. [CrossRef]
10. Luo, W.; Strong, D. A Framework for Evaluating ERP Implementation Choices. *IEEE Trans. Eng. Manag.* **2004**, *51*, 322–333. [CrossRef]
11. Hadidi, L.; Assaf, S.; Alkhiami, A. A systematic approach for ERP implementation in the construction industry. *J. Civ. Eng. Manag.* **2017**, *23*, 594–603. [CrossRef]
12. Hewavitharana, F.; Perera, A. Gap Analysis between ERP procedures and Construction procedures. *MATEC Web Conf.* **2019**, *266*, 03011. [CrossRef]

13. Xu, X.; Wang, G.; Cao, D.; Zhang, Z. BIM adoption for facility management in urban rail transit: An innovation diffusion theory perspective. *Adv. Civ. Eng.* **2020**, *2020*, 8864221. [CrossRef]
14. Rogers, E. *Diffusion of Innovations*; Taylor and Francis: Abingdon, UK, 1983.
15. Mansfield, E. *Technical Change and the Rate of Imitation*; JSTOR Publisher: New York, NY, USA, 1961.
16. Mahajan, V.; Muller, E.; Bass, F. New product diffusion models in marketing: A review and directions for research. *J. Mark.* **1990**, *54*, 1–26. [CrossRef]
17. Ahmed, A.L.; Kassem, M. A unified BIM adoption taxonomy: Conceptual development, empirical validation and application. *Autom. Constr.* **2018**, *96*, 103–127. [CrossRef]
18. Zhao, D. Peer pressure in BIM-based collaboration improves student learning. *J. Civ. Eng. Educ.* **2021**, *147*, 04020019. [CrossRef]
19. Thneibat, M.; Motasem, T.; Al-Shattarat, B.; Al-kroom, H. Development of an agent-based Development of an agent-based sustainability tool. *Alex. Eng. J.* **2022**, *61*, 747–761. [CrossRef]
20. El Hajj, C.; Montes, G.M.; Jawad, D. Analysis of BIM functionalities diffusion in the construction industry: The case of the MENA region. *Eng. Constr. Arch. Manag.* **2021**, *30*, 415–435. [CrossRef]
21. Nanayakkara, K.; Kusumsiri, N.; Perera, P. Adaptation of Diffusion of Innovations Theory for Successful ERP Implementation. In Proceedings of the International Conference on Advances in Computer Science, Electronics & Communication Technologies, Bangkok, Thailand, 22 January 2016.
22. Junussova, T.; Nadeem, A.; Kim, J.R.; Azhar, S.; Khalfan, M.; Kashyap, M. Sustainable Construction through Resource Planning Systems Incorporation into Building Information Modelling. *Buildings* **2022**, *12*, 1761. [CrossRef]
23. Khouadjia, M.L.K.; Mezghiche, B.; Drissi, M. Experimental evaluation of workability and compressive strength. *Constr. Build. Mater.* **2015**, *98*, 194–203. [CrossRef]
24. Fleming, T.; Lingard, H.; Wakefield, R. *Guide to Best Practice for Safer Construction: Principles*; CRC Construction Innovation: Brisbane, Australia, 2007.
25. Kwak, Y.H.; Park, J.; Chung, B.Y.; Ghosh, S. Understanding End-Users' Acceptance of Enterprise Resource Planning (ERP) System in Project-Based Sectors. *Inst. Electr. Electron. Eng.* **2011**, *59*, 266–277. [CrossRef]
26. Zhu, Y.; Li, Y.; Wang, W.; Chen, J. What leads to post-implementation success of ERP? An empirical study of the Chinese retail industry. *Int. J. Inf. Manag.* **2009**, *30*, 265–276. [CrossRef]
27. Prasetya, A.; Anshori, M.; Andriani, N. Opportunities and Challenges of Enterprise Resource Planning (ERP) in Construction Companies in Indonesia: A Systematic Literature Review. *J. Ilm. Manaj. Kesatuan* **2023**, *11*, 919–926.
28. Wang, E.; Chen, J. The influence of governance equilibrium on ERP project success. *Des. Support Syst.* **2006**, *41*, 708–727. [CrossRef]
29. Bueno, S.; Salmeron, J. TAM-based success modeling in ERP. *Interact. Comput.* **2008**, *20*, 515–523. [CrossRef]
30. Light, B.; Papazafeiropoulou, A. Reasons Behind ERP Package Adoption: A Diffusion of Innovations Perspective. In Proceedings of the European Conference on Information Systems, Turku, Finland, 14–16 June 2004.
31. Davis, K.; Songer, A. Resistance to IT Change in the AEC Industry: Are the Stereotypes True? *J. Constr. Eng. Manag. ASCE* **2009**, *135*, 1324–1333. [CrossRef]
32. Ahn, B.; Ahn, H. Factors Affecting Intention to Adopt Cloud-Based ERP from a Comprehensive Approach. *Sustainability* **2020**, *12*, 6426. [CrossRef]
33. Kale, S.; Arditi, D. Diffusion of Computer Aided Design Technology in Architectural Design Practice. *J. Constr. Eng. Manag.-ASCE* **2005**, *131*, 1135–1141. [CrossRef]
34. Nnaji, C.; Okpala, I.; Awolusi, I.; Gambatese, J. A Systematic Review of Technology Acceptance Models and Theories in Construction Research. *J. Inf. Technol. Constr.* **2023**, *28*, 39–69. [CrossRef]
35. Hallikainen, P.; Kivijärvi, K.; Tuominen, M. Supporting the module sequencing decision in the ERP implementation process—An application of the ANP method. *Support. Modul.* **2009**, *119*, 259–270. [CrossRef]
36. Méxas, M.; Quelhas, S.; Costa, H. Prioritization of enterprise resource planning systems criteria: Focusing on construction industry. *Int. J. Prod. Econ.* **2012**, *139*, 340–350. [CrossRef]
37. Schwab-McCoy, A. Developing a first-year seminar course in statistics and data science. In Proceedings of the Promoting Understanding of Statistics about Society, Berlin, Germany, 19–22 June 2016.
38. Gholizadeh, P.; Esmaeili, B.; Goodrum, P. Diffusion of Building Information Modeling Functions in the Construction Industry. *J. Manag. Eng.* **2018**, *34*, 04017060. [CrossRef]
39. In, J. Introduction of a pilot study. Korean Journal of Anesthesiology. *Korean J. Anesthesiol.* **2017**, *70*, 601. [CrossRef]
40. Coleman, J.; Katz, E.; Menzel, H. *Medical Innovation: A Diffusion Study*; Sage Publications, Inc.: Thousand Oaks, CA, USA, 1996.
41. Bass, F. A New Product Growth for Model Consumer Durables. *Manag. Sci.* **1969**, *15*, 215–227. [CrossRef]
42. Gambatese, J.; Hallowell, M. Factors that influence the development and diffusion of technical innovations in the construction industry. *Constr. Manag. Econ.* **2011**, *29*, 507–517. [CrossRef]
43. Kale, S.; Arditi, D. Innovation diffusion modeling in the construction industry. *J. Constr. Eng. Manag.* **2010**, *136*, 329–340. [CrossRef]
44. Mahajan, V.; Muller, E. Innovation Diffusion and New Product Growth Models in Marketing. *J. Mark.* **1979**, *43*, 55–68. [CrossRef]
45. Bakher Naseri, M.; Elliott, G. The diffusion of online shopping in Australia: Comparing the Bass, Logistic and Gompertz growth models. *J. Market Anal.* **2013**, *1*, 49–60. [CrossRef]
46. Croasmun, J.; Ostrom, L. Using Likert-Type Scales in the Social Sciences. *J. Adult Educ.* **2011**, *40*, 19–22.

47. Creswell, J.W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 4th ed.; Sage Publications: Thousand Oaks, CA, USA, 2014.
48. Dillman, D.A.; Smyth, J.D.; Christian, L.M. *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*, 4th ed.; John Wiley & Sons: Hoboken, NJ, USA, 2014.
49. Rubin, H.J.; Rubin, I.S. *Qualitative Interviewing: The Art of Hearing Data*, 3rd ed.; Sage Publications: Thousand Oaks, CA, USA, 2011.
50. Seidman, I. *Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences*, 4th ed.; Teachers College Press: New York, NY, USA, 2013.
51. Jawad, D.; Boutros, M.-B.; Ghanimeh, S. The Implementation of Enterprise Resource Planning Systems in Roads and Infrastructure Construction Companies in Developing Countries. In Proceedings of the CIC 2023, Atlanta, GA, USA, 13–17 November 2023.
52. Blayse, A.M.; Manley, K. Key influences on construction innovation. *Constr. Innov.* **2004**, *4*, 143–154. [CrossRef]
53. Abrahamson, E.; Rosenkopf, L. Institutional and competitive bandwagons: Using mathematical modeling as a tool to explore innovation diffusion. *Acad. Manag. Rev.* **1993**, *18*, 487–517. [CrossRef]