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Systematic literature review on evaluation models and methods in enterprise architecture research

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ABSTRACT

Several enterprises implemented enterprise architecture (EA) projects to align business and information technology (IT) strategies. The evaluation process is needed to ensure the implementation of EA projects provides effectiveness, efficiency, and feasibility of EA information systems (IS) and assesses previous project experience to avoid future EA project risks. The study aims to present a systematic literature review (SLR) of the models and evaluation methods used or developed, especially in the field of EA research. Based on the inclusion and exclusion criteria, 21 articles were selected for review. The results of the study present an overview of the models and methods used as well as new approaches developed for EA evaluation as well as information based on approaches related to models and methods identified as organizing information and data analysis to broaden future research insights. The literature review also provides additional simple theories related to the implications and techniques of the identified models and methods. The study contributes to company stakeholders to encourage the implementation of EA, identify improvements and enhancements to EA projects as well as further references and insights for practitioners and researchers regarding EA evaluation as an effort to assess the success of achieving enterprise goals.

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1. INTRODUCTION

Enterprise architecture (EA) is a set of documents that describe various aspects of an organization from an integrated business and information technology (IT) perspective. EA facilitates information systems (IS) planning and helps improve the alignment of business and IT [1]. EA generally consists of 4 layers, which include the business, information (data), application, and technology (infrastructure) layers [2], [3] which are interconnected [4]. EA provides the right data and information structures, IS applications, and infrastructure technologies to meet an enterprise's business goals. EA enables companies to achieve desired business goals through IT capabilities and also provides a competitive environment [5], [6].

The use of EA also influences to support of IT investment decisions. Based on studies [7] revealed that organizations that implement EA for IT investment have higher quality than organizations that have not implemented EA so the quality is smaller. Studies [7] show that investment in EA has a positive relationship with the quality of IT investment results. The EA function provides a more strategic view to the organization

during the preparation of an IT investment decision, such as a view of whether an IT investment fits the business strategy, the relationship between future and past investments, and the risks of an IT investment [7].

EA has become a highly dynamic discipline attracting a growing scientific interest [8]. Many public sector organizations have adopted EA in their organizations [9]. Many companies also invest in projects related to EA implementation to improve overall business performance [10]. The concepts of business strategy and EA are so tightly coupled that EA basically cannot exist without a business strategy [1]. As many companies are starting to implement EA, the study by [11] the implementation process is not the last step of an EA project, but companies need to evaluate to ensure that implementing subsequent EA projects benefits from the experience of previous projects [12], [13]. This is called a post implementation review (PIR) and this process is very helpful [14], [15]. The purpose of the PIR process is to evaluate the successful fulfillment of project objectives and the effectiveness of EA project practices [16], [17]. Therefore, this study conducts a systematic literature review (SLR) to examine evaluation models and methods in the field of EA research.

Several studies have been conducted regarding the evaluation of EA. Research by Rouhani *et al*. [18] has even elaborated on the issues and deficiencies that exist related to the EA evaluation model but explained that there is no comprehensive or structured model for EA evaluation so this review attempts to examine further the models and methods used or developed specifically for evaluation in field research EA. In several other related studies with EA, various models, and methods have been used, especially in the evaluation process. An evaluation of success related to the value of achieving a business [19].

Advances in IT encourage companies to implement EA projects to improve business alignment and achieve optimal business goals. However, it is necessary to carry out an evaluation step as a benchmark for the success of an EA project. Based on some of the things that have been described previously, therefore, it is important to review various evaluation models and methods, especially in this case in various research fields related to EA. The purpose of this study is to provide an overview of evaluation models and methods in the field of EA research and provide simple theoretical aspects included in these evaluation models and methods. This study contributes to company stakeholders so that they encourage implementing EA or identify gaps to improve and improve EA projects in achieving corporate/organizational goals, while also contributing to EA practitioners and researchers as a reference to strengthen EA theory, especially in terms of evaluation. This article is organized into several sections, section 2 is a research method that describes the research steps, section 3 is the results and discussion explaining the results and discussion of the review, and section 4 presents the conclusions of the review research.

2. METHOD

The method in the study was carried out by referring to the steps of a SLR based on the guidelines proposed by Kitchenham and Charters for conducting a review [20], [21]. SLR is an important step for the advancement of knowledge especially in science [22]. SLR helps to understand deeper into the details of science and identify further for its exploration. SLR is defined as the process of identifying, assessing, and interpreting research evidence to provide answers to a research question [20]. The method and style of the review are motivated by the study [23], [24]. Based on the guidelines [20], the SLR process consists of 3 successive stages, namely planning, execution, and result analysis. In this section, the focus is on the planning stage by determining the review design and review conducting. The stages of research activities can be seen in Figure 1.

Figure 1. Research stages

2.1. Review design

This section describes the structure of the review conducted by defining the SLR research questions and the keyword search process. The SLR research questions are defined based on research objectives. The research questions are the basis for obtaining research findings. Whereas the search process using keywords is a step to find the closest search based on relevant keywords in several scientific database sources.

2.1.1. SLR research questions

Implementation of EA is an effort that influences the improvement and efficiency of the company in the future. EA is a set of documents that describe various aspects of an organization from an integrated business and IT perspective. EA facilitates IS planning and helps improve business and IT alignment [1]. Organizations or companies that implement EA for IT investments have higher quality than organizations that have not implemented EA, this shows that investment in EA has a positive relationship with the quality of IT investment results [7]. Along with this, an organization or company to evaluate existing EA projects as steps and efforts to improve and enhance the applied EA. As for companies/organizations that have not adopted EA, a review related to EA evaluation can be used as material for planning to adopt EA in the future. Therefore, in this study, SLR RQ were asked regarding the research objectives that were expected to be answered in this study. The research questions set for this study can be seen in Table 1.

Table 1. SLR RQs

No	SLR RQ	Objective
RQ1	What evaluation models and methods have been used in some of the previous areas of EA research?	To identify evaluation models and methods that have been used in several previous EA studies as literature and comparisons for EA evaluation models and methods that will be developed in the future
RQ2	What is the scope of techniques and implications of evaluation models and methods that have been identified as theoretical foundations or references related to EA evaluation?	To review aspects of technical coverage and implications of evaluation models and methods that have been used as theoretical foundations or references related to EA evaluation

2.1.2. Search process

This SLR research focuses on finding several sources and digital scientific databases in the form of scientific journal articles and conference proceedings. The sources used to carry out the SLR search process come from well-known digital scientific databases, including Scopus, Google Scholar, Science Direct-Elsevier, Springer, and IEEE. The terminology used in research is very diverse, so it requires the use of synonyms or a variety of words as keywords in the search process. Search keywords are used to find relevant studies in scientific article titles. Therefore, in this literature search, the keywords "evaluation of enterprise architecture" or "implementation of enterprise architecture" or "enterprise architecture evaluation model" or "enterprise architecture evaluation method" or "enterprise architecture evaluation methodology" or "enterprise architecture evaluation approach" are used. Of the several keywords entered to find the closest and possible search according to the expected target literature. The search results were decided to be limited to the scope of EA, according to the SLR topic targeted in this research.

2.2. Review conduction

This section describes the review rules for performing the SLR concerning the structure of implementing the SLR. Starting from the exclusion process which is based on inclusion and exclusion criteria selected studies are produced through the study selection procedure. Next, a quality assessment (QA) was carried out on the selected study reviews. To strengthen the credibility and relevance of the selected studies, data synthesis was carried out using a digital scientific database that has high credibility.

2.2.1. Inclusion and exclusion criteria

To find research related to research, based on search results through the keywords used and entered, exclusions are carried out based on inclusion and exclusion criteria. The literature used focuses on scientific journal articles and international conference proceedings. The year limit for study articles used was 2013 and after, also with the closest search limit according to the SLR topic which was limited to the scope of EA research. From several digital scientific sources and databases used, duplicate articles were also removed from search results. A summary of inclusion and exclusion criteria can be seen in Table 2.

Table 2. Inclusion and exclusion criteria

Criteria	Identification criteria
Inclusion criteria	– Studies in scientific journals and international conference proceedings – Studies focus on EA-related research areas – Studies in the field of EA research in 2013 and after – The study focuses on the model/method/approach used for EA evaluation
Exclusion criteria	– Studies that are not related to EA-related research fields – Studies in the form of short articles, posters, and the like – Studies that are not related to the research question – Duplicate studies

2.2.2. Study selection

The process for selecting a systematic review study is illustrated in a diagram that can be seen in Figure 2. The procedure for selecting a study is carried out based on a search of digital scientific database sources using keyword searches to assess the actual relevance of the study. The details of the study selection procedure through several processes can be seen in Table 3. Based on these steps, several study articles will be excluded because they are not what is targeted as the SLR literature and with the consideration that the source must meet all the criteria. The final result is obtained as a primary study which will be analyzed in SLR research.

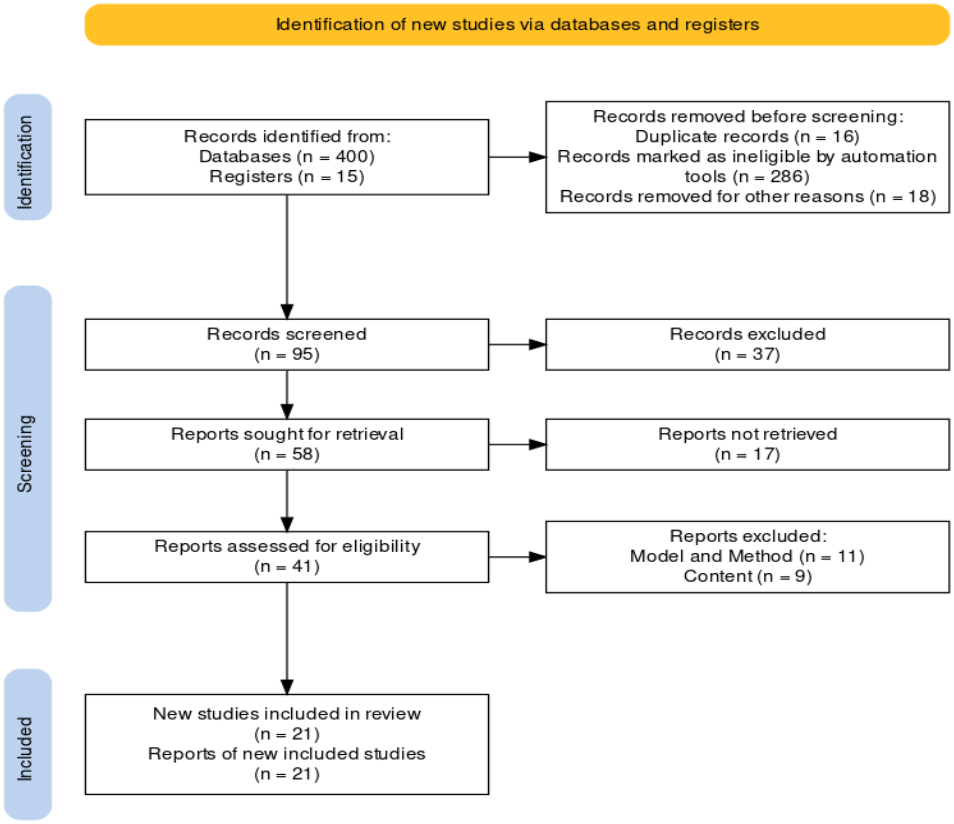

Figure 2. Study selection flowchart

Table 3. Procedure details from the study selection flowchart

Study selection procedure	Details of the study selection procedure
Identification	– Conduct searches from digital scientific database sources using keyword searches and external searches
	– Conduct study exclusions based on predetermined exclusion criteria
Screening	– Identify study articles that cannot be found/cannot be obtained
	– Make exceptions to irrelevant studies based on the identification of the title, abstract, or contents of the full text of the study
	– Making exceptions to studies that do not define the model/method/approach used
Included	– Re-evaluate the results of the study
	– Getting primary studies

2.2.3. Quality assessment

To strengthen the results of the study review and conclusions, an assessment was made of the quality of the selected studies based on inclusion and exclusion criteria. Sourced from the SLR guidelines proposed by [20], there are 4 QA questions that are defined to assess research quality. Table 4 displays the quality assessment criteria established to help check the bias and validation of external and internal reviews for SLRs.

Table 4. Quality assessment criteria for SLRs

No	Quality criteria (QC)
QC1	The research context is specific and clear
QC2	Clearly defined goals and boundaries
QC3	The research design and process support the research objectives
QC4	Results and contributions are clearly documented

2.2.4. Data synthesis

To ensure the credibility of the identified studies and their relevance, data synthesis was carried out in the SLR. Articles were obtained based on keyword searches on digital scientific databases and external sources including Scopus, Google Scholar, Science Direct-Elsevier, Springer, and IEEE. Figure 3 displays a graph of the number of studies selected based on the type of study selected.

Based on Figure 3 shows for journal articles as much as 67% of the total selected study articles. The rest shows 33% for study articles from conferences. The synthesis section also presents the number of study articles selected by year of publication. Figure 4 displays the data where it has been explained that the selected studies focus on the research areas of EA in 2013 and beyond. Figure 4 shows that there has been an increase and decrease in publications in the field of EA research, especially on evaluation topics from 2013 onwards. However, for other fields of EA research, it is felt that there are many spread over certain specific topics.

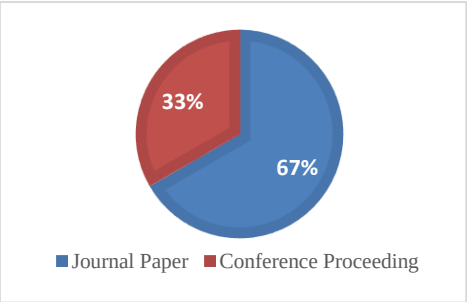

Figure 3. Graph of selected studies by type

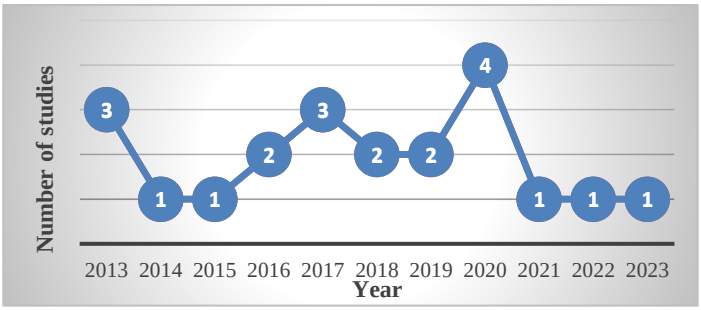

Figure 4. Number of selected studies by year of publication

3. RESULTS AND DISCUSSION

After the primary study was produced, data extraction was carried out on the selected primary study to answer the research questions that had been previously determined. From a total of 414 initial articles obtained from the database, 21 articles were selected that were potentially relevant based on inclusion and exclusion criteria, as can be seen in Figure 2. Of the 21 selected articles, an in-depth review was carried out and presented the results and analysis of the review for the SLR research questions. The results of the review are expected to produce discussions that can answer SLR research questions.

3.1. RQ1: what evaluation models and methods have been used in some of the previous areas of EA research?

To answer this research question. The study identified models and methods used or new developments from the entire EA research field that focused on the topic of evaluation. Table 5 displays the identified models and methods for evaluation in the EA research field.

Based on Table 5 [11], [25]–[44], there are several good models and methods used to develop evaluation models/methods/approaches as well as models and methods as new developments for conducting evaluations related to the field of EA research. The DSR method is the method most often used in study identification, namely in 3 selected studies. DSR is a method proposed by [45] which has four steps in the completion of the evaluation. From Table 5, there are 2 studies that have developed new models/methods for evaluating the EA field, namely the CLE and EAAE approaches. Several benefits of the CLE approach were put forward by the authors and developers in the study [38], among other things, improving the completeness and integrity of the EA layer evaluation, determining the maturity level of each EA layer, improving the EA plan by applying metrics and indicators to the EA plan evaluation process and simplifying the tracking of EA imperfections. A framework for assessing and evaluating EA adoption was also developed which consisted of 4 main layers, namely the governance layer, strategy layer, EA layer, and performance layer. The results of identifying models and other methods from the selected studies suggest a model/method/approach/framework/algorithm for evaluation in the field of EA, including evaluation for EA adoption, evaluation of risks from EA, evaluation of EA attributes, and evaluation of EA from a performance

standpoint, complexity, reliability, and effectiveness. Evaluating EA is indeed one of the main issues in the EA area.

Table 5. Models and methods discussed in the primary study

Models and methods	Study identification	Year of publication	Number of citations	Contribution (implementation or development of new models/methods)
Utility theory	[25]	2013	30	Implementation (propose method)
Stereotyp	[26]	2013	0	Implementation (propose algorithm)
Balanced scorecard (BSC)	[27]	2013	84	Implementation (propose measurement instruments)
Failure mode and effect analysis (FMEA) and fuzzy visekriterijumska optimizacija i kompromisno resenje (VIKOR)	[28]	2014	186	Implementation (propose method)
Fuzzy analytic hierarchy process (AHP)	[29]	2015	6	Implementation (propose method)
Fuzzy EA (FEA)	[30]	2016	0	Implementation (propose evaluation method)
Analysis trade-off architecture method (ATAM) and non-dominated sorting genetic algorithms (NSGA-II)	[31]	2016	3	Implementation (propose method)
Cost-benefit investment	[32]	2017	0	Implementation (propose framework)
Essential element	[33]	2017	43	Implementation (propose framework)
Evaluation of program theory, evaluation of IS, and design science research (DSR)	[11]	2017	34	Implementation (propose evaluation method)
Decision making trial evaluation and laboratory (DEMATEL) and fuzzy analytic network process (ANP)	[34]	2018	0	Implementation (propose approach)
DSR	[35]	2018	5	Implementation (propose a hybrid evaluation method)
	[36]	2020	1	Implementation (propose evaluasi EA framework (EAF) model)
	[37]	2020	6	Implementation (propose EAF model)
Cross-layer evaluation (CLE)	[38]	2019	6	Develop new approaches to CLE
Heterogeneity metric	[39]	2019	2	Implementation (propose models and algorithms for evaluating and analyzing the complexity of EA)
Enterprise architecture adoption evaluation (EAAE)	[40]	2020	13	Develop framework
Mixed method (qualitative and quantitative)	[41]	2020	17	Implementation (propose evaluation method)
The open group architecture framework (TOGAF) and Capability driven approach (CDA)	[42]	2021	4	Implementation (propose method)
Metrology evaluation	[43]	2022	0	Implementation (propose an EA measurement solution model)
DeLone and McLean-structural equation modeling (SEM)	[44]	2023	3	Implementation (developing EA adoption models)

To understand the identified models and methods, it is necessary to know the basis of the model and method approaches to understand the process of organizing information and data analysis. In addition, it can be used as insight into research development which allows for expanding existing research, understanding research trends and changes according to certain fields of science as well as insights for solving problems by adapting relevant models and methods. Based on the results of the analysis of the articles, the identified models and methods have various bases, including IT management bases, effectiveness bases, and metrics. Based on this basis, Table 6 classifies the basis of the model/method/approach from the identified articles. The classification of model approaches and methods shows that basic IT management is important for encouraging better development in the field of IT management and must be relevant to the environment and organizational needs to improve organizational performance, optimize resource use, and improve the quality of IT services. In addition, IT management can help organizations manage information risk well, but behind that, all models and methods based on IT management must be able to adapt to changes in the organization and its environment. The basis of effectiveness is also highlighted as having relevance to the context and needs of the organization. The basis of effectiveness depends on the quality of the data and information used, but it can also be influenced by external factors. EA evaluation models and methods based on effectiveness help to see further the results and evaluate the aspects that underlie the success of EA. The metric basis is an

evaluation of the effectiveness of the goals to be achieved and the metrics used to measure success. The reliability of metric-based models and methods also depends on the quality of the data and the validity of the metrics used. Metrics help identify the right balance between a focus on measurement and the need to consider qualitative aspects.

Table 6. Basic model and method approach

Models and methods	Study identification	Approach base	Information base
Utility theory	[25]	Metrics	Involves calculating utility metrics.
Stereotyp	[26]	IT management and effectiveness	Evaluate the performance of the algorithm using a case study comparing it with the previous algorithm.
BSC	[27]	IT management, effectiveness, and metrics	Provides a comprehensive set of performance measures that provide a framework for strategic measurement and management systems.
FMEA and fuzzy VIKOR	[28]	Effectiveness and metrics	The proposed method prioritizes EA risk factors based on effectiveness and metric-based evaluations.
Fuzzy AHP	[29]	Effectiveness and metrics	The proposed approach is metric-based as it involves using quantitative metrics to evaluate architectural complexity.
FEA	[30]	IT management	Use in evaluating the reliability of EA in the context of IT planning, development, and implementation.
ATAM and NSGA-II	[31]	IT management	Use for EA evaluation which is part of IT management to solve multi-purpose problems.
Cost-benefit investment	[32]	IT management, Effectiveness, and metrics	Propose the application of the cost-benefit investment evaluation method that is usually applied to project management for EA evaluation, in addition to discussing various projects in the aspect of value creation in the EA development process.
Essential element	[33]	Effectiveness	Focuses on the essential elements of an EA program and how it contributes to the success of an EA program.
Evaluation of program theory, evaluation of IS, and DSR	[11]	Effectiveness and metrics	Evaluate the goals and products of EA implementation projects using appropriate metrics and incorporate theoretical frameworks such as program theory or IS evaluation into model development to provide a structured approach to the evaluation process.
DEMATEL and ANP	[34]	IT Management and effectiveness	The proposed approach can be used to quantitatively evaluate the qualitative attributes of the EA as well as identify the relationship between the qualitative criteria and weigh the priority criteria, in addition to assessing the security quality attributes in the information communication technology (ICT) master plan.
DSR	[35]	IT management and effectiveness	Discusses the methodology of EA implementation and EA evaluation, both of which are related to IT management and effectiveness in implementation and evaluation using DSR.
CLE	[38]	Effectiveness and metrics	Based on EA's effectiveness in achieving goals and objectives and determining metrics for each evaluation criterion to be measured.
Heterogeneity metric	[39]	IT management and metrics	The methodology is based on the use of entropy measures to analyze the heterogeneity of EAs, which is a metrics-based approach. The proposed approach also aims to guide designers and architects in evaluating and improving EA models, which is an IT management-based approach.
EAAE	[40]	IT management and effectiveness	Developing an EAAE framework based on IT management and used to evaluate the effectiveness of EA adoption.
Mixed method (qualitative and quantitative)	[41]	IT management and effectiveness	Identify the quality attributes of EA and their evaluation indicators within an organization and use mixed methods and address all aspects of EA.
TOGAF and CDA	[42]	IT management, effectiveness, and metrics	The methodology for EA evaluation is an IT management-based approach. The multi-criteria method for metric-based evaluation of IT investments and the information economy method are effectiveness-based approaches.
Metrology evaluation	[43]	Metrics	Focuses on evaluating the metrology quality of the proposed EA measurement solutions.
DeLone and McLean-SEM	[44]	IT management and effectiveness	EA adoption model to explore the factors influencing the acceptance and usefulness of EA for digitizing cities and using statistical analysis in the data analysis.

Understanding the basis of models and methods can help the ability to evaluate and identify models and methods that are suitable for research purposes as well as adequate samples or data. The information generated from Table 6 also has the potential to develop new ideas and innovations in the future related to models and methods for evaluating EA. The theory and further implications of each identified model and method are shown in Table 7 (in Appendix) [11], [25]–[44] as a result of the identification of subsequent research questions.

3.2. RQ2: what is the scope of techniques and implications of evaluation models and methods that have been identified as theoretical foundations or references related to EA evaluation?

To answer this research question, studies are defined and review the implications and techniques of models and evaluation methods in selected EA research fields so that this information can serve as a theoretical basis or reference as insight for future EA practitioners and researchers. Table 7 presents the scope of implications and techniques of the identified models and methods for evaluation in the field of EA research. Several existing evaluation models focus on evaluating the achievement of predetermined EA implementation objectives [16], [46]. Some companies want to investigate the value that will be obtained after developing EA so that effectiveness plays an important role in EA implementation to achieve EA goals [47], [48]. The results of the SLR exploration regarding the models and methods used in the evaluation process related to the field of EA research shown in Table 7 show that the evaluation models and methods were validated in various ways, both case studies, validation with experts/experts, and with other experiments. The results of the exploration also show that there are many techniques in the literature, both empirical and theoretical, although there may be still deficiencies in the process of evaluating EA. However, this can be used as insight for stakeholders in companies, practitioners, and researchers who will further explore related to EA, both in terms of evaluation, adoption, and other management terms of EA by identifying evaluation models and methods that have been used in several studies. The previous EA serves as literature and comparison for the EA evaluation model and method which will be developed in the future. Models and methods can be evaluated more broadly in terms of completeness, simplicity, consistency, ease of use, and the quality obtained from using these methods [48].

Based on the technical identification of models and evaluation methods discussed in this literature review it was also found that most of the studies were conducted with empirical rather than theoretical studies. 67% is an empirical study, relatively larger than the remaining 33% of theoretical studies. This shows that most of the EA evaluation models and methods are carried out oriented toward collecting and analyzing empirical data through case studies, experiments, and surveys, while some of the EA evaluation models and methods are carried out by focusing on the development of theories, concepts, or conceptual frameworks.

The model and method for evaluation must be determined not only by considering the performance during the project but also the after-project or post-implementation impact [49]. The evaluation process is a basis for confirming the achievement of the expected benefits [50]. As a research recommendation related to further evaluation of EA, several studies such as the study by [51] stated the need to consider various stakeholder perceptions of project performance, as well as studies by [44], [52] also suggest involving qualitative feedback from stakeholders involved in EA implementation as a suggestion for future EA evaluation processes, as well as an effort to overcome expectations to increase the likelihood of success of the evaluation process [53], [54]. EA evaluation models and methods help measure the success of EA implementation to meet organizational/company strategic goals. Overall, this SLR study provides a variety of scientific insights on how to evaluate EA in the form of models, methods, and measurements, both existing measurements for EA evaluation and developing new measurements [55]. It is important to consider the relevance and applicability of EA evaluation models and methods in different organizational contexts. The implications and techniques of the identified models and methods should be further explored to improve understanding of their effectiveness and limitations.

4. CONCLUSION

A SLR on evaluation models and methods in the field of EA research that has been conducted provides insight and references to several models and methods that can be used in the EA evaluation process both in terms of post-implementation evaluation, evaluation for EA adoption, evaluation of EA project risks and so on. In addition, the results of the review provide several models and methods or approaches that have just been developed as new models and methods for evaluating EA. The identified models and methods are classified based on the model and method approach to understand the process of organizing information and analyzing data. In addition, it can be used as insight into research development which allows for expanding existing research, understanding research trends and changes according to certain fields of knowledge as well as insights for solving problems by adapting relevant models and methods so that they are following research objectives as well as adequate samples or data. The literature review also provides additional simple theories regarding the implications and techniques of the models and methods identified in the literature review. This can be used by stakeholders in the company to encourage the implementation of EA or identify gaps for improvement and improvement of EA projects in achieving company/organizational goals in the future. In addition, this study can also be a reference and further insight to practitioners and researchers, especially in terms of EA evaluation. The evaluation step is a measure of the success of an EA project where the EA becomes a facilitator in planning IS and helps improve the alignment of business and IT. The development of

further studies can explore a wider range of evaluation models and methods in terms of completeness, simplicity, consistency, ease of use, and quality of models and methods. Based on the results and discussion of the review, an EA evaluation can also be carried out by involving qualitative feedback from stakeholders involved in the EA implementation as well as an effort to address expectations to increase the likelihood of success from the EA evaluation process.

APPENDIX

Table 7. Scope of the theoretical basis of models and methods discussed in the primary study

Models and methods	Implications	Technique/method	Reference
Utility theory	Proposes a systematic way to evaluate EAs by balancing several quality attributes against each other to obtain the best architecture. The use of utility theory can help decision makers to evaluate and select the most preferred architectural scenario based on a set of preferences and can help organizations make decisions about organizational EA based on systematic evaluation of various quality attributes.	Utility theory is an EA evaluation approach that provides a systematic way to balance several quality attributes against each other to obtain the best architecture. This approach involves calculating utility metrics that reflect a set of stakeholder preferences to select the most profitable architectural scenario. The end of the process provides an example of comparing two quality attributes on two architectural scenarios using utility theory and calculating a decision maker's overall utility metric on both quality attributes.	[25]
Stereotyp	Proposed an algorithm using stereotypes in F-unified modeling language (UML) diagrams that can be used to evaluate EA performance. Algorithms can help organizations reduce system complexity and increase efficiency and flexibility as well as provide practical solutions for evaluating EA performance.	Object-oriented algorithms use stereotypes to increase reliability by considering additional components in parallel and using redundancy techniques to maintain a minimum number of components. The algorithm is implemented in the case study and compared with the previous algorithm.	[26]
BSC	The right method for measuring the performance of enterprise systems (ES) in both the private and public sectors. The BSC approach provides a balance between qualitative and quantitative factors and measures organizational performance in four balanced perspectives; finance, customers, internal business processes, and learning and growth. The results provide a framework for evaluating ES investment performance and identifying areas for improvement.	The EA evaluation technique uses the BSC approach developed by Kaplan and Norton. The BSC approach helps organizations to translate mission and strategy into a comprehensive set of performance measures that provide a framework for strategic measurement and management systems. The technique of measuring organizational performance in four balanced perspectives; finance, customers, internal business processes, learning, and growth.	[27]
FMEA and VIKOR fuzzy	Proposes methods that can be used by organizations to identify and evaluate EA risks and can help organizations make informed decisions and take appropriate actions to reduce risks. The proposed method provides a practical approach for organizations and is effective in identifying and evaluating EA risks.	A new approach to identifying and evaluating EA risks by integrating knowledge and experience gained from professional experts can improve the accuracy and effectiveness of risk evaluation. The use of fuzzy VIKOR allows experts to use linguistic variables, which can improve the quality of risk evaluation.	[28]
Fuzzy AHP	Proposes a validated method to evaluate EA complexity and provide insights for decision making for organizations that have complex IT structures and systems. The fuzzy AHP approach method can help organizations better manage structures, IT systems and business environments, as well as facilitate the integration of strategy, personnel, business and IT towards common goals.	EA evaluation technique with steps: determining the EA complexity level, determining decision or judgment sub-indicators, determining sub-indicator weights, determining aggregate sub-indicator weights to get indicator weights, and aggregate indicator weights to get layer weights then calculating the complexity score for each layer. Uses a case study from the Higher Institute of Applied Engineering IGA to demonstrate the reliability of the approach.	[29]
FEA	Propose a method that can be used to evaluate the reliability of EA when in the planning process. Application of the method to several real systems allows evaluation and anticipation during the planning process and is used to evaluate the reliability of a component in an EA.	This method involves converting a FEA product into a fuzzy petri net and performing a reliability evaluation with an executable model.	[30]

Table 7. Scope of the theoretical basis of models and methods discussed in the primary study (continue)

Models and methods	Implications	Technique/method	Reference
ATAM and NSGA-II	Proposes a new method/approach to prioritize qualitative scenarios in EA evaluation, which can help organizations focus on higher priority and more important scenarios, and reduce implementation costs. The proposed method is more accurate and faster than previous methods that use genetic algorithms.	Use the NSGA-II and consider more detailed criteria to prioritize qualitative scenarios in the evaluation process. The proposed algorithm is evaluated in two case studies in the field of EA and software architecture.	[31]
Cost-benefit investment	Provides a framework for evaluating EA applied to project management. The study discusses various projects, namely multi-projects, project portfolios, project programs, roll-out projects, and large projects, in the value-creation aspect of the EA development process. EA's goal is to promote IT-business alignment, standardization, and reuse of existing ICT assets and to share common models for project management and software development across the organization.	The EA evaluation technique is a complex ICT project and is evaluated by applying the cost-benefit investment evaluation method which is usually applied to project management. The ISO/IEC/IEEE 42010 standard architectural methodology is used to describe the basic organization of a system contained in its components, their relationships with each other and with the environment, and the principles that guide their design and evolution.	[32]
Essential element	Provides a framework for organizations to understand and navigate the various EA frameworks available, helping managers who want to develop an EA foundation by providing a more systematic way to evaluate and compare different frameworks.	The EA evaluation technique involves eight key elements (scope, objectives, stakeholders, framework, process, information, technology, and culture) of EA programs to evaluate and compare different EA frameworks, including technical, operational, and strategic EA. Critical elements provide a more systematic way to evaluate EA frameworks and shift attention from maturity models to the specific EA elements implemented by the organization.	[33]
Evaluation of program theory, evaluation of IS, and DSR	Proposes a hybrid evaluation method that practitioners can use to evaluate the effectiveness and functionality of EA implementation projects. The method is lightweight, holistic, and supports functionality and effectiveness, so it can be applied to all types of businesses and can be used to evaluate implemented EA artifacts and support every aspect related to the development process.	Incorporating theoretical frameworks such as program theory or IS evaluation into model development provides a structured approach to the evaluation process. Validation through case study analysis shows promising results for achieving successful results when using the proposed method.	[11]
DEMATEL and ANP	Proposes an approach that stakeholders can use to quantitatively evaluate the qualitative attributes of EA and assess ongoing projects. The proposed approach can be used to assess security quality attributes in information and communication technology master plans of Iranian cities. This approach can be used by organizations to improve the quality of EA and make better decisions in multi-criteria decision-making.	Using a combination of DEMATEL and fuzzy ANP techniques. The DEMATEL technique is used to identify the relationship between qualitative attributes and their influence on each other, while fuzzy ANP is used to assign weights to priority criteria. The proposed approach is evaluated using a case study of a city information and communications technology master plan in Iran, where security quality attributes are assessed and measured.	[34]
DSR	Develop hybrid evaluation methods for EA implementation and evaluate EA frameworks. The developed hybrid evaluation method can be used as an additional consideration to evaluate EA implementation and help organizations to better align IT strategy with business processes and increase competitiveness.	DSR methodology to improve the evaluation of EA implementation by testing the evaluation of the EA framework. This approach consists of 4 steps, namely problem identification and motivation, the definition of solution goals, design and development, and evaluation.	[35]–[37]
CLE	A CLE approach is proposed which can be easily incorporated into any enterprise at a moderate cost and offers great insight into EA. The proposed approach can help organizations to improve their EA evaluation process and avoid failed EA projects as well as help organizations to design more consistent and effective EA.	The CLE approach considers all layers of EA from strategy to technology architecture and involves three phases: Recognition, Analysis, and Mapping. The Recognition phase involves identifying the EA components and their relationships. The Analysis phase involves evaluating the EA components based on the proposed evaluation criteria. The Mapping phase involves mapping the EA components to evaluation criteria and identifying the strengths and weaknesses of the EA.	[38]

Table 7. Scope of the theoretical basis of models and methods discussed in the primary study (continue)

Models and methods	Implications	Technique/method	Reference
Heterogeneity metric	The proposed methodology can help designers and architects to evaluate and improve EA models by providing a metric-based approach to analyzing enterprise architectural complexity as well as providing a practical approach to evaluating and analyzing enterprise architectural complexity, which can help organizations to better manage IT systems and improve software development processes.	The EA evaluation technique refers to the following steps: – Presents EA components regarding agility and complexity metrics. – Identify and apply heterogeneity metrics to EA components and relationships. – Detect changes in EA and update relevant metrics.	[39]
EAAE	An EAAE framework is proposed that can be used by healthcare organizations to evaluate the implementation of EA and identify areas for improvement so that it can help healthcare organizations in the region understand the challenges and objectives of EA adoption and develop strategies to overcome these challenges.	Using the technology acceptance model (TAM) framework to develop the EAAE framework. The EAAE framework consists of four dimensions: i) drivers of EA adoption, ii) barriers to EA adoption, iii) outcomes of EA adoption, and iv) EA adoption process. The EAAE framework was used to evaluate the implementation of EA in healthcare organizations in the Asia-Pacific region.	[40]
Mixed method (qualitative and quantitative)	Presents an EA evaluation model that has 7 key quality attributes (alignment and integrity, quality of EA products and services, security, maintainability and portability, reliability, reuse, and scalability) and 30 indicators that address all aspects of EA. Through this model, organizations can evaluate the quality of the EA implementation or the AS-IS status of the EA and take steps to improve it. The proposed evaluation model is comprehensive, structured, and validated to evaluate EA status or EA implementation success, which considers all EA layers.	The technique is based on a mixed methods approach, which includes both qualitative and quantitative methods. The qualitative section involves a SLR to identify indicators for evaluating the EA, while the quantitative section involves collecting survey data using a prepared questionnaire based on the qualitative section. exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are performed in the quantitative section.	[41]
TOGAF and CDA	Proposing a new technology evaluation method in the container shipping industry based on the EA approach, such as the TOGAF and CDA methodology combined with Information Economics methods for EA evaluation. The proposed method can help companies in the container shipping industry to evaluate new technologies and make well-considered decisions.	Uses the TOGAF and CDA methodologies for EA evaluation. Propose a multi-criteria method of IT investment evaluation that includes financial, business, and technology criteria, both positive and negative. The TOGAF methodology is supported by the Archimate EA modeling language and Archi modeling tools as well as the control objective for information technologies (COBIT) and information technology infrastructure library (ITIL) international frameworks. The information economy method is used as a multi-criteria method of evaluating the proposed IT investment.	[42]
Metrology evaluation	Provides a metrology evaluation method for evaluating EA measurement solutions that can assist EA practitioners in understanding the limitations of proposed measurement solutions and selecting solutions with more robust designs.	Based on evaluation theory, metrology guidelines, and best practices from the measurement software literature. Involves three steps: identifying the components of a metrology coverage method, defining criteria and guidelines for assessing metrology coverage, and applying the method to evaluate EA entities. The evaluation identified strengths and weaknesses in the theoretical and empirical design of the proposed EA measurement solution for each of the four EA entities (EA architecture, project, program, and framework).	[43]
DeLone and McLean-SEM	Provides EA evaluation techniques as a means to manage enterprise complexity and align business and IT capabilities, providing an understanding and identification of factors influencing the acceptance and usability of EA in smart cities to help IT practitioners and urban researchers develop effective strategies for EA adoption as well as improving the design and implementation of EA frameworks in smart cities can lead to better management of complex ICT landscapes and improved urban services.	This study develops an EA adoption model based on the DeLone and McLean IS success model, which includes factors such as service quality, system quality, and information quality. This study uses a survey questionnaire to validate the model hypothesis developed and applies the SEM statistical analysis technique to analyze the data.	[44]

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