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A FRAMEWORK FOR RANKING CRITICAL SUCCESS FACTORS OF BUSINESS INTELLIGENCE BASED ON ENTERPRISE ARCHITECTURE AND MATURITY MODEL

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ABSTRACT

Aim/Purpose	The aim of this study is to identify Critical Success Factors (CSF) of Business Intelligence (BI) and provide a framework to classify CSF into layers or perspectives using an enterprise architecture approach, then rank CSF within each perspective and evaluate the importance of each perspective at different BI maturity levels as well.
Background	Although the implementation of the BI project has a significant impact on creating analytical and competitive capabilities, the lack of evaluation of CSF holistically is still a challenge. Moreover, the BI maturity level of the organization has not been considered in the BI implementation project. Identifying BI critical success factors and their importance can help the project team to move to a higher maturity level in the organization.
Methodology	First, a list of distinct CSF is identified through a literature review. Second, a framework is provided for categorizing these CSF using enterprise architecture. Interviewing is the research method used to evaluate the importance of CSF and framework layers with two questionnaires among experts. The first questionnaire was done by Analytical Hierarchy Process (AHP), a quantitative method of decision-making to calculate the weight of the CSF according to the

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	importance of CSF in each of the framework layers. The second one was conducted to evaluate framework layers at different BI maturity levels using a Likert scale.
Contribution	This paper contributes to the implementation of BI projects by identifying a comprehensive list of CSF in the form of a holistic multi-layered framework and ranking the importance of CSF and layers at BI maturity levels.
Findings	The most important CSF in BI implementation projects include senior management support, process identification, data quality, analytics quality, hardware quality, security standards, scope management, documentation, project team skills, and customer needs transformation, which received the highest scores in framework layers. In addition, it was observed that as the organization moves to higher levels of maturity, the average importance of strategic business and security perspectives or layers increases. But the average importance of data, applications, infrastructure, and network, the project management layers in the proposed framework is the same regardless of the level of business intelligence maturity.
Recommendations for Practitioners	The results of this paper can be used by academicians and practitioners to improve BI project implementation through understanding a comprehensive list of CSF and their importance. This awareness causes us to focus on the most important CSF and have better planning to reach higher levels of maturity according to the maturity level of the organization.
Future Research	For future research, the interaction of critical success factors of business intelligence and framework layers can be examined with different methods.
Keywords	business intelligence, critical success factor, maturity model, enterprise architecture

INTRODUCTION

Implementing information technology in senior management is a power acquisition strategy when it leads to data analysis and making decisions (Niño et al., 2020). Business intelligence (BI) helps managers make more analytical and data-driven decisions. Due to the impact that BI has on the performance management of the organization, it has been highly considered by researchers (Zaied et al., 2018). BI is the intelligent extraction, integration, aggregation, and multidimensional analysis of data to find patterns from different information sources (Adjie Eryadi & Nizar Hidayanto, 2020) to improve decision-making and get a competitive advantage.

The BI market grew 7.3% in 2017, generating revenue of up to $18.3 billion (Ain et al., 2019). It was predicted to reach $26.88 billion by 2021 (Moscoso-Zea et al., 2019). Because of the value that BI provides, a lot of investment is made in its implementation. However, more than 70% of BI projects do not deliver the expected returns (Ain et al., 2019). Implementing BI is not just a simple task of buying a set of software and hardware; it requires proper infrastructure and resources over time (Olszak & Ziemba, 2012).

According to Işık et al. (2013), BI success is described as the positive advantages organizations get through the use of their BI. To succeed in BI projects, it is necessary to identify all critical success factors (CSF) of BI (El-Adaileh & Foster, 2019; Pham et al., 2016; Yeoh & Popovič, 2016), ranking the CSF (Zaied et al., 2018), and determining the current state of the BI maturity of the organization (Tavallaei et al., 2015). According to Olszak and Ziemba (2012, p. 136), "CSF can be perceived as a set of tasks and procedures that should be addressed in order to ensure business intelligence systems accomplishment.". In fact, identifying the CSF of BI is a way to reduce the complexity of implementing BI projects and decrease their failure rate. Several studies (Halim et al., 2020; Olszak &

Ziemba, 2012; Subagja et al., 2020; Yeoh & Popovič, 2016; Zaied et al., 2018) have investigated the CSF of implementing BI. However, existing research about CSF in implementing BI projects has not been well analyzed yet and only a few researchers have identified all aspects of BI success factors without considering the importance of CSF (Ain et al., 2019; El-Adaileh & Foster, 2019). The key to the successful implementation of BI is not only based on identifying CSF; ranking CSF from the right perspective also plays a significant role in BI implementation. For example, data quality and senior management support are considered the most important CSF. But comparing them together does not help much. On the other hand, all CSF might not have equal importance at different BI maturity levels in each organization. So, considering the current level of BI maturity of organizations is necessary.

To meet these challenges, a framework with a multi-layered structure can be used to categorize CSF based on layers to reduce complexity. One of the frameworks which can be successful in new technologies such as BI is Enterprise Architecture (EA) (Office of Management and Budget, 2012). According to the Federation of Enterprise Architecture Professional Organizations (n.d.), EA is "a well-defined practice for conducting enterprise analysis, design, planning, and implementation, using a holistic approach at all times, for the successful development and execution of strategy". EA solves some main challenges in a large number of organizations (Moscoso-Zea et al., 2019). EA with its structured thinking covers all aspects of the organization in the form of perspectives or layers. Effective information management, response to change, aligning between business and information technology, and providing a comprehensive view are the main aims of EA.

There is currently no comprehensive framework with separate layers or perspectives to evaluate all BI success factors. To address this gap, a framework is needed to classify all CSF into independent perspectives or layers and rank them based on the perspective to which they belong. In addition, the actions needed for BI project success are different based on the level of BI maturity in each organization. Therefore, the importance of framework layers should be measured at different BI maturity levels to know whether their importance is the same at all BI maturity levels or not. In this paper, the new research scenario for the success of BI projects pursues three goals. The first goal is to propose a framework to categorize all identified CSF in different layers or perspectives using EA. The second goal is to rank the importance of CSF within each perspective of the framework by the AHP method. The third goal is to evaluate the importance of framework perspectives at different BI maturity levels using the Likert scale method.

LITERATURE REVIEW

BUSINESS INTELLIGENCE (BI)

There are several definitions of BI. According to Elbashir et al. (2008), BI systems help organizational decision-making by providing data analysis and analytical reporting that improve the performance of business processes. The BI platform has four important components. The first component is input sources where data is collected from various sources. The second component is data acquisition, which includes the process of Extracting, Transforming, and Loading data (ETL) into a single repository. The third component is the data warehouse where the reliable data source and the information obtained from the ETL are stored. The fourth component is the data reporting and analysis tools (Niño et al., 2020).

Although the implementation of BI has many advantages, the high complexity and a large number of users make implementation difficult. Consequently, the failure rate in BI projects increases (Pham et al., 2016; Villamarín-García, 2020). For this reason, many researchers have identified BI CSF to help them decrease the rate of failure. Various categories have also been proposed for identified CSF based on different perspectives (Ain et al., 2019; DeLone & McLean, 2003; Sangar & Iahad, 2013; Subagja et al., 2020; Yeoh & Koronios, 2010; Zaied et al., 2018). For example, in Subagja et al.'s

(2020) study, the key success factors are classified into two categories: technological and organizational. In Sangar and Iahad's (2013) study, key success factors were divided into three categories before implementation, during implementation, and after implementation of the BI project. In the article by Yeoh and Koronios (2010), success factors were classified into three categories: organizational, process, and technology. In Zaied et al.'s (2018) article, environmental factors were also added to organizational, process, and technology. In the study of Halim et al. (2020), CSF was categorized into three categories: people, process, and technology.

In previous research, the provided models were taken from people's minds and they did not cover all the main elements of the organization. There is a need for a structured framework to cover various dimensions of the organization. Besides, the level of BI maturity should be considered in the ranking CSF because not all factors are necessarily of the same importance at all levels of maturity.

Business Intelligence Maturity

Although understanding CSF contributes to BI project success, the actions needed are different based on the level of BI maturity in each organization. Therefore, identifying and categorizing the CSF is not enough for the success of the BI project alone. Many managers do not know how to use BI properly and their investments lead to failure. To prevent these failures, the project capital should be evaluated and compared to similar systems in other companies to measure and control its economic value (Niño et al., 2020). In addition, by assessing the current BI maturity level of the organization, it is possible to plan to reach the next stage of development and a higher level of maturity.

For this purpose, the BI maturity model can be used to identify the strengths and weaknesses of the organization in general or a specific function (Gudfinnsson et al., 2015). In the Davenport maturity model (Davenport et al., 2010), success factors are measured by five components of Data, Enterprise, Leadership, Target, and Analysts (DELTA), so the absence of each component is an obstacle to success.

The Davenport maturity model has five levels:

> *Level 1:* Maturity (analytical disability): Data is unstable and of poor quality. There is no comprehensive data warehouse and no interest or attitude toward analysis.
>
> *Level 2:* Maturity (local analysis): Analytical activities remain at the local or local level. Business units collect only the basic data needed in their field, and analysts take analytical actions in their field.
>
> *Level 3:* Maturity (analytical passion): Top executives' interest in the analysis is formed. Data is viewed more strategically as organizational resources rather than unit resources. The task of leadership is to articulate perspectives that transform business analysis.
>
> *Level 4:* Maturity (analytical companies): Long-term perspectives on analytics are developed for core business units. Access to functional-level data is replaced by enterprise data warehousing. At this level, leadership is supported.
>
> *Level 5:* Maturity (analytical competitors): Organizations have a strong focus on leveraging their industry-unique data. Level 5 maturity companies have well-defined policies regarding the privacy of customer and employee information. They do not carelessly lose information due to saboteurs and mistakes and do not disclose or sell information without permission. Decisions are made based on facts and analysis. Leadership is motivated by continuous review and analysis.

Organizations are classified into different levels of BI maturity depending on the infrastructure they have. Therefore, in assessing the importance of BI CSF, we must consider the level of maturity of the organization to avoid wasting resources on unnecessary or highly ideal metrics. So there is a need

for a comprehensive framework for ranking CSF to measure success factors individually in perspectives and as a group of perspectives at maturity levels. The EA framework helps to reduce the complexity of BI implementation by dividing the whole organization into layers or perspectives.

Enterprise Architecture

According to Liao and Wang (2021), Enterprise Architecture creates a complete view of the organization to control its complexity and it guides the organization toward the desired business vision and results. Enterprise Architecture (EA) is a map that combines methods and techniques that provide a complete view of the organization through models, frameworks, constraints, principles, and guidelines (Moscoso-Zea et al., 2019). It can be used to manage information systems in alignment with business activities (Gampfer et al., 2018). In fact, EA fills the gap between the current situation and the desired situation through its transition plan. EA is usually known by its frameworks. There are four leading EA frameworks including Zachman, TOGAF, FEA, and Gartner.

The Zachman framework, which is known as the first EA framework, was developed by John Zachman in the 1980s. It is depicted as a two-dimensional classification for architectural descriptions and also it is a basic structure for EA. Zackman's framework only covers architecture and does not include a strategic planning methodology (Rouhani et al., 2015), and also so many elements (30 cells) are explained in detail that causes complexity.

Gartner, an IT consulting organization, developed the Gartner Enterprise Architecture Method which includes the Gartner EA process model and the Gartner EA framework. The Gartner EA process model is iterative and focuses on future architecture, development process, and adequate EA concepts. The Gartner EA framework shows the relationship between business architecture, information architecture, and technical architecture. Gartner follows a top-down strategy to translate business strategy into a set of instructions to be used by the organization (De Vires, 2010).

Gartner also developed Enterprise Information Management (EIM) which includes vision, strategy, metrics, governance, organization and rules, information life cycle, and infrastructure dimensions. But there is little guidance about this model.

The Open Group Architecture Framework (TOGAF) was developed by the Open Group in the mid-1990s. It has current architecture and future architecture and also it provides steps and sub-steps required to develop architecture. It uses the iterative architecture development method with top-down architecture and has more focus on IT development (De Vires, 2010). TOGAF provides broad documents about its method and process but accessing and employing them is time-consuming and it is not easy to use (Rouhani et al., 2015).

The Federal Enterprise Architecture Framework (FEAF) was created for the US federal government at the end of the 1990s. It has current architecture and future architecture. It covers the top-down and bottom-up layers together while other frameworks, like Togaf and Gartner, start only with the top-down architecture (De Vires, 2010).

FEAF contains appropriate guidance for structuring enterprise architecture, while TOGAF is more oriented toward IT architecture. FEAF was improved and renamed to Common Approach to Federal Enterprise Architecture (Common FEAF) in 2012 (Office of Management and Budget, 2012). Common FEAF which is based on FEAF contains principles for using EA to contribute to organizations decreasing waste and duplication, increasing shared services and interaction, and closing performance gaps. Its concepts are simple and have comprehensive artifacts. It has abstract architecture layers to create a logical separation between different dimensions or perspectives. Common FEAF has various levels of scope and it has also six reference models (Office of Management and Budget, 2012):

Performance Reference Model (PRM): used to support architectural analysis and reporting in the strategy sub-architecture view of the overall EA.

Business Reference Model (BRM): used to support architectural analysis and reporting in the business services sub-architecture view.

Data Reference Model (DRM): used to support the foundation for the overall EA with a focus on information that is available for sharing and re-use and information gaps.

Application Reference Model (ARM): used to support architectural analysis and reporting in the applications sub-architecture view.

Infrastructure Reference Model (IRM): used to support architectural analysis and reporting in the host infrastructure sub-architecture view.

Security Reference Model (SRM): used to support architectural analysis and reporting in the host infrastructure sub-architecture view of the overall EA. It focuses on information security and privacy.

EA is useful for new technologies that improve resource optimization, such as BI, cloud computing, mobile technologies, and social media (Office of Management and Budget, 2012). BI projects are facing high complexity, a large user community, and constant changes. To reduce these challenges and complexities, a structured enterprise architecture should be used. Common FEAF provides this opportunity for the success of BI projects with its guidance and comprehensive approach.

PROPOSED FRAMEWORK

In this study, the scattered CSF of many BI projects were collected and analyzed. These factors required a comprehensive and standardized approach to classification. For this purpose, a framework was designed to classify the scattered factors of BI success, which is derived from the Common Federal Enterprise Architecture Framework (Common FEAF) (Office of Management and Budget, 2012). It is easy to use and learn and has abstract architecture layers which create a logical separation between different layers or perspectives. Its concepts are simple and comprehensive and can be used as complete guidance (Office of Management and Budget, 2012). These are the reasons for choosing this framework to classify the BI critical success factors. As shown in Figure 1, the proposed framework consists of ten layers or perspectives which are divided into primary perspectives (horizontal elements) and supportive perspectives (vertical elements). The primary perspectives include perspectives such as strategy, business, data, applications, networks, and infrastructure. The supportive perspectives include layers such as security, project management, configuration and standardization, human capital management, and environmental.

In Table 1, a mapping of the proposed model with Common FEAF is done, which is the result of the definitions of the views of the Common FEAF (Office of Management and Budget, 2012) and interviews with experts.

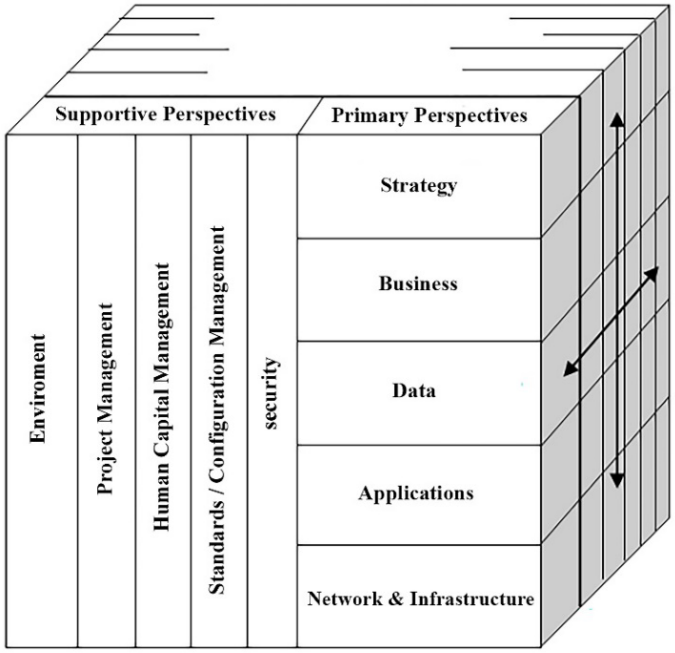

Figure 1. Proposed framework

Table 1. A map of the proposed framework classification with the Common FEAF (Office of Management and Budget, 2012)

Framework layers	Related framework part
Strategy	Strategic plans
Business	Business activities
Data	Data and information
Application	System and application
Network & Infrastructure	Network & Infrastructure
Security	Security/privacy
Project management	Program/project management
Standards/Configuration management	Configuration/asset management
	Standards/configuration management
Human capital management	Human capital management(Office of Management and Budget, 2013)
Environment	Capital planning/portfolio management

In the following, ten layers of the proposed framework are described.

PRIMARY PERSPECTIVES

A primary perspective includes the main layers of the framework from the Strategy layer on top to the network and infrastructure at the bottom. These layers are introduced below:

Strategy layer

In this layer, a clear relationship is established between the BI project and the goals and strategies of the organization. The project is economically justified in terms of business value. Systems and business needs as well as user expectations are well-identified.

Business layer

This layer emphasizes the goals of each business unit, identifying business processes, reviewing how the organization's activities are performed and performing them in a new way, and managing the business performance.

Data layer

The data and information quality include accuracy, precision, relevance, compatibility, comprehensiveness, updates, and speed of access to information. In fact, data is a significant asset in an organization to improve making decisions.

Application layer

Most BI systems' data warehouses and their number of users increase over time. For this reason, BI applications must be scalable, flexible, and integrated to meet new needs. On the other hand, user interfaces have a great impact on system acceptance and effective understanding of data and reports.

Network and infrastructure layer

The hardware platform is the main infrastructure in the BI system and plays an important role in system operation. The selected hardware must meet BI requirements. Online analytical processing server quality and communication networks, such as fiber optic networks and Ethernet networks also contribute to the success of the project.

Supportive Perspectives

The vertical elements or supportive perspectives cover all layers of the primary perspectives. Furthermore, supportive perspectives not only belong to BI projects and can be used in other information systems.

Security layer

Compliance with security standards includes information accuracy, confidentiality, unauthorized access, and security of hardware equipment. It also should prevent data loss. Security must be ensured at all levels of the framework to have accurate information and protect customer privacy as well.

Standards/configuration management layer

Change can occur at any phase of the BI implementation. Configuration management is used to document, report, and control any changes in the implementation. In addition, standards are also used against changes for better management. Standards may relate to data naming and metadata. Metadata is the meaning and concept of information entities that constitute the policies and standards of business data (Moss & Atre, 2003). Metadata can be defined as data about data or information about data (Chuah & Wong, 2012) to understand the process of implementing BI better.

Human capital management layer

This perspective includes users and the project team who are involved in the project and have different roles, responsibilities, and skills.

Project management layer

In previous research, project management has been highly suggested as a CSF in BI projects. In this study, the project management body of knowledge standard (Project Management Institute, 2013), which is one of the most famous standards in project management, is used to understand items better. It covers scope management, cost management, time management, communication management, and procurement management. Procurement management controls contracts with a foreign organization and receives the necessary deliverables. With the coordination of this part, there will be less delay in the construction phase. It has been mentioned in recent articles as vendor selection (Adjie Eryadi & Nizar Hidayanto, 2020; Zaied et al., 2018).

Environment layer

In Arnott's (2008) study, factors such as economic, political, social, and cultural contexts, in addition to the factors affecting data warehousing and data quality were also identified as effective in the success and failure of projects that are outside the organization. On the other hand, the arrival of new technologies such as the Internet of Things can also change the expectations of the system.

Classification BI Critical Success Factors

In Table 2, 38 distinct CSF were extracted from previous literature reviews and placed in the relevant perspectives according to the definitions of the various layers of Common FEAF (Office of Management and Budget, 2012) and specialists' opinions.

Table 2. Classification CSF of business intelligence based on EA (Office of Management and Budget, 2012)

Layers	CSF	References	Short description
Strategy	Business need identification	(Arnott, 2008; Eder & Koch, 2018; Olszak & Ziemba, 2012)	Business problems and needs must be identified (Eder & Koch, 2018).
	User expectations identification	(Adjie Eryadi & Nizar Hidayanto, 2020; Gaardboe & Jonasen, 2018; Olszak & Ziemba, 2012)	User expectations depend on the users' technology experience to some extent for better adaptation of the business intelligence system, these expectations should be known (Gaardboe & Jonasen, 2018).
	Goals and strategies definition clearly	(Adjie Eryadi & Nizar Hidayanto, 2020; Ain et al., 2019; Arnott, 2008; El-Adaileh & Foster, 2019; Olszak & Ziemba, 2012; Yeoh & Koronios, 2010; Zaied et al., 2018)	Implementing a BI system needs a clear strategic business vision and also an effect on the adoption and outcome of the BI system (Zaied et al., 2018).
	Senior management support	(Adjie Eryadi & Nizar Hidayanto, 2020; Eder & Koch, 2018; El-Adaileh & Foster, 2019; Fedouaki et al., 2013; Villamarín-García & Diaz Pinzon, 2017; Yeoh & Popovič, 2016)	Senior management support can vary depending on the level of support in promotion, support in using the information system, financial support, and guarantee in resource allocation (El-Adaileh & Foster, 2019).
	Alignment of business and information technology	(Adjie Eryadi & Nizar Hidayanto, 2020; Pham et al., 2016)	Coordination and integration between business goals and activities and information technology.

Layers	CSF	References	Short description
Business	Clear definition of the goals of each business unit	(Ain et al., 2019; Fedouaki et al., 2013; Pham et al., 2016; Villamarín-García & Diaz Pinzon, 2017)	Business goals and activities are well-defined.
	Well-defined business process	(Adjie Eryadi & Nizar Hidayanto, 2020; Fedouaki et al., 2013; Nguyen et al., 2018; Villamarín-García & Diaz Pinzon, 2017)	Common definitions of what is required of the system must be agreed upon by both the business and technical groups (Nguyen et al., 2018).
	Business performance management	(Pham et al., 2016; Popovič et al., 2010)	Business performance management is a component or methodology that is used to measure the performance of an organization in general (Chuah & Wong, 2012).
	Business process reengineering	(Popovič et al., 2010)	Makes fundamental changes and replacements from the current state toward the desired state.
Data	Data quality	(Adjie Eryadi & Nizar Hidayanto, 2020; Fedouaki et al., 2013; Gudfinnsson et al., 2015; Olszak & Ziemba, 2012; Yeoh & Popovič, 2016)	Refers to accuracy, completeness, relevance, consistency, and usefulness (Yeoh & Popovič, 2016).
	Quality of data access	(Ain et al., 2019; Gudfinnsson et al., 2015; Popovič et al., 2012)	Users can access valid information at any time in different ways.
	Data architecture compatibility with the needs of the organization	(Ariyachandra & Watson, 2010; Ranjbarfard & Hatami, 2020)	The choice of data warehouse plays an important role in the ability of processing and information sharing. It can be used as enabling strategic change or just as a source to support activities (Ariyachandra & Watson, 2010).
Application	Analysis quality	(Davenport & Harris, 2007; Eder & Koch, 2018; Popovič et al., 2012)	The higher the quality of the analysis, the more satisfied the customer will be.
	Flexibility	(Adjie Eryadi & Nizar Hidayanto, 2020; Fedouaki et al., 2013; Işık et al., 2013)	The system adapts quickly to new requirements and the new process adds easily to the data warehouse to meet the needs of future plans (Işık et al., 2013).
	Scalability	(Adjie Eryadi & Nizar Hidayanto, 2020; Ariyachandra & Watson, 2006; Yeoh & Popovič, 2016)	The ability of the system to perform well even with an increased volume of users, complexities, and a large number of demands.
	Evolutionary development	(Arnott, 2008; Gudfinnsson et al., 2015; Pham et al., 2016)	A successful business intelligence system should develop periodically to convert to an effective application (Arnott, 2008)
	Ease of use of the system	(Ain et al., 2019; Olszak & Ziemba, 2012; Sangar & Iahad, 2013)	The higher the graphic and reporting standards and the easier it is for the user to use the system, the more they will want to use the system.

Layers	CSF	References	Short description
	Integration of business intelligence with knowledge management	(Chuah & Wong, 2012)	The method assists the organizations to identify, select, organize, distribute and transfer essential information and experience of experts' expertise (Chuah & Wong, 2012).
	Integration of business intelligence with other information systems	(Fedouaki et al., 2013; Işık et al., 2013; Olszak & Ziemba, 2012; Yeoh & Popovič, 2016)	The ability to communicate between different systems and applications and data with each other, both physically and functionally (Işık et al., 2013).
Network and infrastructure	Network infrastructure and communications	(Adjie Eryadi & Nizar Hidayanto, 2020; El-Adaileh & Foster, 2019; Villamarín-García & Diaz Pinzon, 2017)	Ability to provide information to users at an appropriate level of accuracy and timeliness (El-Adaileh & Foster, 2019).
	Hardware quality	(Eder & Koch, 2018; Trieu, 2016)	Hardware infrastructure deals with large amounts of data so high-quality hardware is one of the main factors in building the right tools for making decisions in uncertainty (Trieu, 2016).
Security	Security standard	(Ain et al., 2019; Eder & Koch, 2018; El-Adaileh & Foster, 2019; Office of Management and Budget, 2012)	Information security must be considered in any strategic goal or activity that depends on accurate information (Office of Management and Budget, 2012).
Standard/ configuration management	Data standards, metadata, platform	(Chuah & Wong, 2012; Eder & Koch, 2018; Moss & Atre, 2003; Wieder & Ossimitz, 2013)	Standards may relate to data naming and metadata. Metadata is the meaning and concept of information entities that constitute the policies and standards of business data (Moss & Atre, 2003).
	Change management	(Eder & Koch, 2018; El-Adaileh & Foster, 2019; Olszak & Ziemba, 2012; Yeoh & Koronios, 2010)	Change management control and report all changes in requirements, strategy, business objectives, project priorities, and improvements during the project.
Human capital management	User involvement	(El-Adaileh & Foster, 2019; Zaied et al., 2018)	With the participation of users, their needs and expectations are better understood. So, the resistance to using new information technology is reduced (Zaied et al., 2018).
	Team leadership	(Adjie Eryadi & Nizar Hidayanto, 2020; Pham et al., 2016; Yeoh & Koronios, 2010)	A person who has high passion and knowledge of the business processes of the organization and also has a good knowledge of technological innovations (Yeoh & Koronios, 2010).
	BICC team	(Niño et al., 2020; Villamarín-García & Diaz Pinzon, 2017)	A team of IT and business analysts who identify business intelligence strategies and bridge the gap between project developers and actual business intelligence system users (Niño et al., 2020).
	Project team skills	(El-Adaileh & Foster, 2019; Fedouaki et al., 2013; Villamarín-García & Diaz	A balance between in-team and individual technical skills and the ability to skill-

Layers	CSF	References	Short description
		Pinzon, 2017; Yeoh & Koronios, 2010)	fully perform tasks in a way that interacts well with other users (El-Adaileh & Foster, 2019).
	User training and motivation	(Adjie Eryadi & Nizar Hidayanto, 2020; Eder & Koch, 2018; Zaied et al., 2018)	Training can be done at all levels from top to down to better understand the performance and operational procedures of business intelligence (Zaied et al., 2018).
Project management	Scope management	(Arnott, 2008; Eder & Koch, 2018; Pham et al., 2016)	In scope management, project hypotheses and constraints are reviewed and objectives are prioritized. The initial plan is determined based on the budgeting of activities, time and resources required.
	Time management	(Olszak & Ziemba, 2012; Pham et al., 2016)	Time management has processes that include defining activities, sequencing activities, estimating the duration of activities based on project scope and available resources, as well as preparing a schedule for project milestones, and controlling the schedule.
	Communication management	(Eder & Koch, 2018)	Communication management meets the information needs of the project and stakeholders, both within the organization and outside the organization (Project Management Institute, 2013)
	Risk management	(Işık et al., 2013)	Risk in the organization is inevitable; people, technology, and processes are involved, so risk management is essential for the success of the organization.
	Procedure management	(Adjie Eryadi & Nizar Hidayanto, 2020; Zaied et al., 2018)	Procurement management provides the necessary processes to purchase or obtain the desired products and services and results outside the project team (Project Management Institute, 2013).
	Cost management	(Arnott, 2008; Olszak & Ziemba, 2012)	Cost management includes cost estimation, cost balancing, budgeting, and cost control in a project.
Environment	Power and politics	(Arnott, 2008; Office of Management and Budget, 2012; Villamarín-García, 2020)	Powerful political institutions by setting different rules can have different effects.
	Organizational culture	(Arnott, 2008; Eder & Koch, 2018; Villamarín-García & Diaz Pinzon, 2017; Zaied et al., 2018)	Organizational culture is described as a pattern of shared values and beliefs which help people provide behavioral norms in the organization (Zaied et al., 2018).
	Competitive pressure	(Adjie Eryadi & Nizar Hidayanto, 2020; Ain et al., 2019; Arnott, 2008; Zaied et al., 2018)	The stress that an organization feels from its competitors in the industry in order to seek a new way to increase its efficiency and profitability (Zaied et al., 2018).

RESEARCH METHODOLOGY

RESEARCH PURPOSE

The purpose of this research is to provide a framework, which has a multi-layered structure, to classify BI CSF into various layers or perspectives based on enterprise architecture, then rank CSF within each perspective and evaluate the importance of each perspective at BI maturity levels as well.

RESEARCH FRAMEWORK

This research provides a framework to classify identified CSFs into ten layers: Strategy, Business, Data, Application, Network & Infrastructure, Privacy, Standard/Configuration Management, Human Capital Management, Project Management, and Environment. The classification is based on the definitions of common FEAF (Office of Management and Budget, 2012) and the expert opinions of those who were interviewed. Each layer contains a number of CSF that are ranked by interview and questionnaire.

The importance of each layer framework is also evaluated at different BI maturity levels through another questionnaire. Most BI maturity models are qualitative and emphasize only specific aspects of BI such as business or technical points (Niño et al., 2020). In addition, there is little detail and guidelines in their documentation. However, the Davenport et al. (2010) maturity model is chosen as the complete model which covers more views of an organization (data, enterprise, leadership, target, and analysts). It is used to examine the importance of the ten layers of the framework at BI maturity levels. For this comparison, a five-point Likert Scale (very low, low, medium, high, and very high) is used.

RESEARCH PROCESS

The theoretical concepts of BI, the CSF of the BI project, and the BI maturity model were examined. In addition, an overview of EA frameworks was provided. A list of distinct CSF is identified through the literature review. A framework is then provided for categorizing the CSF using common FEAF (Office of Management and Budget, 2012). The Davenport BI maturity model is used for evaluating the importance of framework layers at different BI maturity levels as well. The interview is the research method used to map identified CSF to the proposed framework layers and evaluate the importance of CSF and framework layers with two questionnaires among experts. The first questionnaire was done by Analytical Hierarchy Process (AHP), which was developed by T. L. Saaty (1980), and it is one of the most successful methods of multi-criteria decision-making.

AHP is a powerful method that can divide complex decision problems into a simple hierarchy of interrelated elements. It is mostly used to calculate the weights or importance of factors to set priorities. Data is gathered by pairwise comparisons of elements in each level in this method. For examining the importance of each attribute, the attributes of all categories have to be compared (within their own category). The common way of making the comparison is to ask the interviewed group to provide a rate. wAB, regarding the importance of an attribute; A, in comparison to the importance of another attribute of the same category; B, the rate of the importance of attribute B over A, is inversed (and is given by 1/wAB) and also the possibility of potential inconsistencies has to be analyzed because of transitive property (Salmeron & Herrero, 2005).

The problem is formulated in a way that the criteria of the framework are ten independent layers (which include Strategy, Business, Data, Application, Network and Infrastructure, Privacy, Project Management, Human Capital Management, Standard/Configuration Management, and Environment) and the sub-criteria are CSF mapped to each layer. In the first questionnaire, a point scale (1, 3, 5, 7, 9) is used in order to compare each CSF (see Appendix A for more detail). The data from the first questionnaire were gathered among 18 experts who set the priorities for CSF. Local ranking and

incompatibility rate are determined for each comparison between CSF, which is given in Table 5. The incompatibility rate of all tables is less than 0.1, so the questionnaire has good reliability (R. W. Saaty, 1987).

The second survey questionnaire was done for evaluating framework layers at BI maturity levels by the Likert scale (see Appendix B). Most interviews were conducted in person and a small number were conducted via email. The interview included open and closed questions. Open-ended questions were used to examine framework layers and map CSF to the appropriate layer of the framework (with definitions of common FEAF). Closed questions were used for ranking CSF in each framework layer and also ranking layers at different BI maturity levels. Fourteen questionnaires were completely answered by BI and EA specialists. Experts were purposefully chosen based on their knowledge of BI and EA. They consist of university professors of IT and management, IT managers, and specialists working on BI and EA projects. The selection criteria were that they should have appropriate knowledge of BI and enterprise architecture with a Master's or Ph.D. degree. They also have more than two years of working experience in EA or BI (described in Table 3). Although some of them are in the field of ICT, they also have a significant role in enterprise architecture implementation projects and BI development.

Table 3. Expert characteristics

Experts in the first questionnaire (18 persons)							
Education		BI experience		EA experience		Work unit	
PhD	10	Between 2 and 4 years	5	Between 2 and 4 years	11	ICT	10
Master	8	Between 4 and 8 years	7	Between 4 and 8 years	4	Strategy planning	5
		More than 10 years	6	More than 10 years	3	Business development	3
Experts in the second questionnaire (14 persons)							
Education		BI experience		EA experience		Work unit	
PhD	6	Between 2 and 4 years	5	Between 2 and 4 years	11	ICT	10
Master	8	Between 4 and 8 years	5	Between 4 and 8 years	1	Strategy planning	2
		More than 10 years	4	More than 10 years	2	Business development	2

The second questionnaire is designed to evaluate the importance of separate perspectives of the framework differs at different maturity levels using the Likert scale method (at five different maturity levels, from one to five). The maturity model used is derived from the Davenport maturity model in which there are five components of measuring success factors (data, enterprise, leadership, target, and analysts) and five levels of maturity (maturity 1 (analytical disability), maturity 2 (local analysis), maturity 3 (analytical passion), maturity 4 (analytical companies), and maturity 5 (analytical competitors)).

The reliability of this questionnaire is also calculated from Cronbach's alpha coefficient, the reliability of which is 0.89, which is higher than 0.7, so the questionnaire has good reliability. As shown in Figure 2 and Figure 3, the average importance of the primary perspective and supportive perspective is increasing at different rates at maturity levels of one to five.

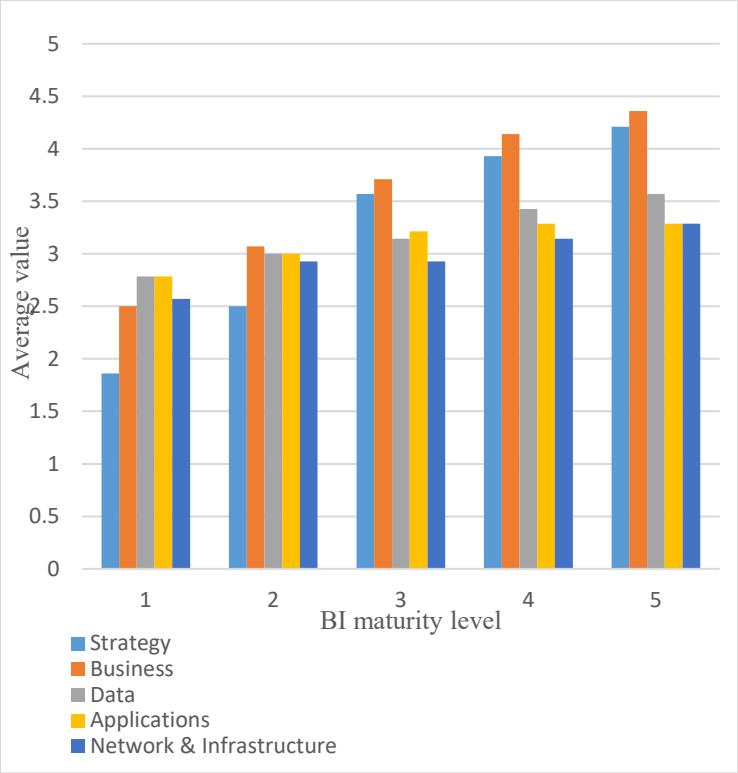

Figure 2. Comparison of the average importance of the primary perspective of success at different maturity levels

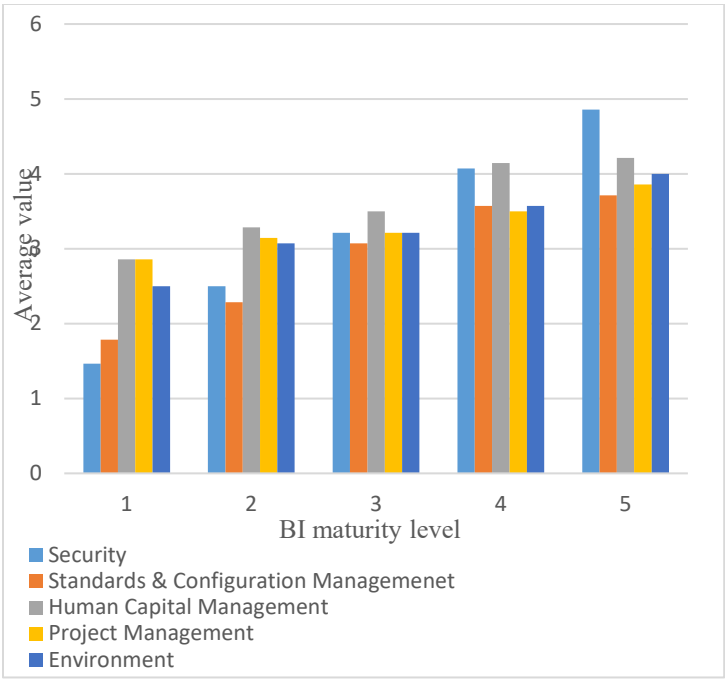

Figure 3. Comparison of the average importance of the supportive perspective of success at different maturity levels

However, just by considering the mean, it cannot be stated with certainty that because the mean shows a higher number at one level of maturity than at another level of maturity, it is necessarily more important. Therefore, the analysis of variance (ANOVA) test was used to determine whether there is a significant difference between the levels of maturity in terms of importance. First, the normality of the data was confirmed by the Kolmogorov-Smirnov test and then two hypotheses were formulated as follows:

Hypothesis 0: The average importance of each framework layer is same at different maturity levels and there is no significant difference between maturity levels.

Research Hypothesis: The average importance of each framework layer is not the same at different maturity levels.

In this test, when the uncertainty coefficient exceeds 0.05, the assumption of significance in maturity is accepted. However, if the uncertainty coefficient is less than 0.05, the perspective is not equally important at different maturities. As shown in Table 4, Sig is 0.000 and it is less than 0.05. So, the importance of strategy layers varies at the BI maturity level. For example, in Table 4 of the ANOVA strategy test, the strategy layer has an uncertainty coefficient where Sig is 0.000 and less than 0.05. So, the importance of the strategy layer varies at the BI maturity level. To detect maturity groups that are not of equal importance, the Tukey pair comparison test is used. Each subset has an uncertainty coefficient higher than 0.05.

Table 5 of the Tukey test of strategy, matures in which the average importance of the strategy is differentiated including three subsets (level 1, level 2) (level 2, level 3) (level 3, level 4, level 5). As can be seen in Table 5, in subset 1, the average importance of the strategy layer at maturity one is equal to the average effect of the strategy layer at maturity two. In subset 2, the average importance of the strategy at maturity two and maturity three is equal. In subset 3 the average importance of strategy in maturity three, maturity four, and maturity five are also equal. Similarly, Tables 6 to 19 can be interpreted, where maturity levels with the same average importance are shown.

Table 4. Anova strategy test

Strategy	Sum of squares	df	Mean square	F	Sig
Between Groups	55.857	4	13.964	12.980	.000
Within Groups	69.929	65	1.076		
Total	125.786	69			

Table 5. Tukey strategy test

		Subset for alpha = 0.05		
V1	N	1	2	3
level1	14	1.86		
level2	14	2.50	2.50	
level3	14		3.57	3.57
level4	14			3.93
level5	14			4.21
Sig		.614	.127	.614

Table 6. ANOVA business test

Business	Sum of squares	df	Mean square	F	Sig
Between Groups	33.057	4	8.264	9.556	.000
Within Groups	56.214	65	.865		
Total	89.271	69			

Table 7. Tukey business test

		Subset for alpha = 0.05		
V1	N	1	2	3
level1	14	2.50		
level2	14	3.07	3.07	
level3	14		3.71	3.71
level4	14		4.14	4.14
level5	14			4.36
Sig		.622	.066	.507

Table 8. ANOVA data test

Data	Sum of squares	df	Mean square	F	Sig
Between Groups	5.657	4	1.414	1.136	.347
Within Groups	80.929	65	1.245		
Total	86.586	69			

Table 9. ANOVA application test

Application	Sum of squares	df	Mean square	F	Sig
Between Groups	2.657	4	.664	.488	.744
Within Groups	88.429	65	1.360		
Total	91.086	69			

Table 10. ANOVA network and infrastructure test

Network and Infrastructure	Sum of squares	df	Mean square	F	Sig
Between Groups	4.086	4	1.021	.950	**.441**
Within Groups	69.857	65	1.075		
Total	73.943	69			

Table 11. ANOVA security test

Security	Sum of squares	df	Mean square	F	Sig
Between Groups	89.657	4	22.414	43.214	**.000**
Within Groups	33.714	65	.519		
Total	123.371	69			

Table 12. Tukey security test

		Subset for alpha = 0.05			
V1	N	1	2	3	4
level1	14	1.6429			
level2	14	2.5000	2.5000		
level3	14		3.2143	3.2143	
level4	14			4.0714	4.0714
level5	14				4.8571
Sig		.053	.156	.053	.093

Table 13. ANOVA standard/configuration management test

Standard/configuration management	Sum of squares	df	Mean square	F	Sig
Between Groups	38.657	4	9.664	7.440	**.000**
Within Groups	84.429	65	1.299		
Total	123.086	69			

Table 14. Tukey standard/configuration management test

		Subset for alpha = 0.05		
V1	N	1	2	3
level1	14	1.7857		
level2	14	2.2857	2.2857	
level3	14	3.0714	3.0714	3.0714
level4	14		3.5714	3.5714
level5	14			3.7143
Sig		.076	.076	.695

Table 15. ANOVA human capital management test

Human capital management	Sum of squares	df	Mean square	F	Sig
Between Groups	18.657	4	4.664	4.202	**.004**
Within Groups	72.143	65	1.110		
Total	90.800	69			

Table 16. Tukey human capital management test

		Subset for alpha = 0.05	
V1	N	1	2
level1	14	2.8571	
level2	14	3.2857	3.2857
level3	14	3.5000	3.5000
level4	14		4.1429
level5	14		4.2143
Sig		.628	.258

Table 17. ANOVA project management test

Project management	Sum of squares	df	Mean square	F	Sig
Between Groups	8.086	4	2.021	1.301	**.279**
Within Groups	101.000	65	1.554		
Total	109.086	69			

Table 18. ANOVA environment test

Environment	Sum of squares	df	Mean square	F	Sig
Between Groups	17.629	4	4.407	3.041	.023
Within Groups	94.214	65	1.449		
Total	111.843	69			

Table 19. Tukey environment test

		Subset for alpha = 0.05	
V1	N	1	2
level1	14	2.5000	
level2	14	3.0714	3.0714
level3	14	3.2143	3.2143
level4	14	3.5714	3.5714
level5	14		4.0000
Sig		.249	.393

RESULTS

IDENTIFIED CRITICAL SUCCESS FACTORS OF BI

First, all framework perspectives (layers) and CSF presented in each perspective were discussed by experts. The human capital management perspective is considered an independent perspective and it was borrowed from Office of Management and Budget (2013). The project management perspective was also divided into different parts (Cost Management, Scope Management, Time Management, Procedure Management, Risk Management, and Communication Management), which are derived from the PMBOK standard (Project Management Institute, 2013). After confirmation of all perspectives (Strategy, Business, Data, Application, Network & Infrastructure, Privacy, Standard/Configuration Management, Human Capital Management, Project Management, and Environment) in the framework, CSFs were mapped to each perspective based on the definition of Office of Management and Budget (2012) and expert opinions. Four new CSF (privacy, transformation of customer needs, emergence of new technologies, and documentation) were added to the previous CSF. Privacy was added to the security perspective, the transformation of customer needs and the emergence of new technologies were added to the environment perspective, and documentation was added to the configuration management perspective as well. They are all in the Common FEAF (Office of Management and Budget, 2012) which is approved by experts as CSF in BI projects. Finally, 42 CSF as shown in Table 20 were categorized into ten layers according to the previous literature review, definitions of perspectives of Common FEAF, and the opinion of experts.

Table 20. Critical success factors of BI

Context	Layer	CSF
Primary Perspective	Strategy	- Senior management support - Define goals and strategies clearly - Identify business needs - Identify user expectations - Alignment of business and information technology
	Business	- Identify processes - Clear definition of the goals of each business unit - Business performance management - Business process reengineering
	Data	- Data quality - Data architecture compatibility with the needs of the organization - Quality of data access
	Application	- Analysis quality - Integration of business intelligence with other information systems - Integration of business intelligence with knowledge management - Ease of use of the system - Flexibility - Scalability - Evolutionary system development
	Network & Infrastructure	- Hardware quality - Network infrastructure and communications
Supportive Perspective	Security	- Security standard - Privacy
	Standards/Configuration management	- Data standards, metadata, platform - Change management - Documentation

Context	Layer	CSF
	Human capital management	- Project team skills - User involvement - Team leadership - User training and motivation - BICC team
	Project management	- Cost management - Scope management - Time Management - Procedure Management - Risk management - Communication management
	Environment	- Organizational Culture - Power and politics - Competitive pressure - Transformation of customer needs - Emergence of new technologies

Ranking Critical Success Factors of BI

In Table 21, the identified CSF of BI projects is shown in order of importance. In the primary perspectives, the support of senior managers with a relatively high difference was identified as the most important factor in the strategy perspective for the successful implementation of BI. In the business layer, the most important factor is the identifying processes, which is followed by the goals of each professional unit with a slight difference, and shows the close relationship between the two. Data quality plays a significant role in a data layer and is considered the main foundation of BI projects. In the applications layer, the quality of analysis received the highest score, which proved that the most important expectation from BI is the quality of analysis and reports that the system provides to senior, middle and operational managers to decide. Then the quality of the hardware became the most important factor in the main perspective.

From the supportive perspectives, security standards, documentation, project team skills, scope management, and evolving customer needs are identified as the most important criteria in each layer. But the importance of layers or perspectives of the framework may not be equal at all levels of BI maturity level. So the relationship between the BI maturity level and the importance of each layer of the framework should be measured.

Table 21. Ranking of BI critical success factors

Layers	CSF in order of importance	Weight	Rank
Strategy (incompatibility rate 0.01)	**Senior management support**	0.332	1
	Define goals and strategies clearly	0.272	2
	Identify business needs	0.218	3
	Identify user expectations	0.108	4
	Alignment business and information technology	0.070	5
Business (incompatibility rate 0.02)	**Identify processes**	0.394	1
	Clear definition of the goals of each business unit	0.379	2
	Business performance management	0.128	3
	Business process reengineering	0.099	4

Layers	CSF in order of importance	Weight	Rank
Data (incompatibility rate 0.01)	**Data quality**	0.471	1
	Data architecture compatibility with the needs of the organization	0.362	2
	Quality of data access	0.1671	3
Application (incompatibility rate 0.01)	**Analysis quality**	0.218	1
	Integration of business intelligence with other information systems	0.151	2
	Integration of business intelligence with knowledge management	0.144	3
	Ease of use of the system	0.134	4
	Flexibility	0.127	5
	Scalability	0.120	6
	Evolutionary system development	0.106	7
Network and Infrastructure (incompatibility rate 0.0)	**Hardware quality**	0.524	1
	Network infrastructure and communications	0.476	2
Security (incompatibility rate 0.0)	**Security standard**	0.569	1
	Privacy	0.439	2
Standards/Configuration management (incompatibility rate 0.01)	**Documentation**	0.447	1
	Data standards, metadata, platform	0.303	2
	Change management	0.250	3
Human Capital Management (incompatibility rate 0.02)	**Project team skills**	0.340	1
	Team leadership	0.246	2
	User training and motivation	0.226	3
	User involvement	0.134	4
	BICC team	0.053	5
Project management (incompatibility rate 0.01)	**Scope management**	0.318	1
	Time Management	0.168	2
	Cost management	0.162	3
	Communication management	0.144	4
	supply Management	0.121	5
	Risk management	0.088	6
Environment (incompatibility rate 0.01)	**Transformation of customer needs**	0.399	1
	Power and politics	0.185	2
	Competitive pressure	0.179	3
	Organizational Culture	0.149	4
	Emergence of new technologies	0.088	5

RANKING FRAMEWORK LAYERS AT DIFFERENT BI MATURITY LEVELS

The results of ANOVA and Tukey tests about the level of maturity of BI and the importance of each layer can be summarized according to Figure 4 and Figure 5. In Figure 4, the importance of perspectives such as data, applications, and network infrastructure is the same regardless of the level of BI maturity, which is shown as a horizontal line on the axis of the level of intelligence maturity. But the importance of strategy and business perspectives was divided into three different subsets. As shown in Figure 4, the importance of maturity one and two is the same in terms of strategy and business which is shown as a horizontal line. The importance of maturity three, four, and five are the same as well; maturity levels one, two, and five made significant differences in the importance of strategy and business perspectives, which are shown in steps. In general, the higher the level of maturity of BI, the more important the business perspective and the strategic perspective. In addition, more investment in these perspectives is also needed to jump to a higher level of maturity to achieve greater profitability.

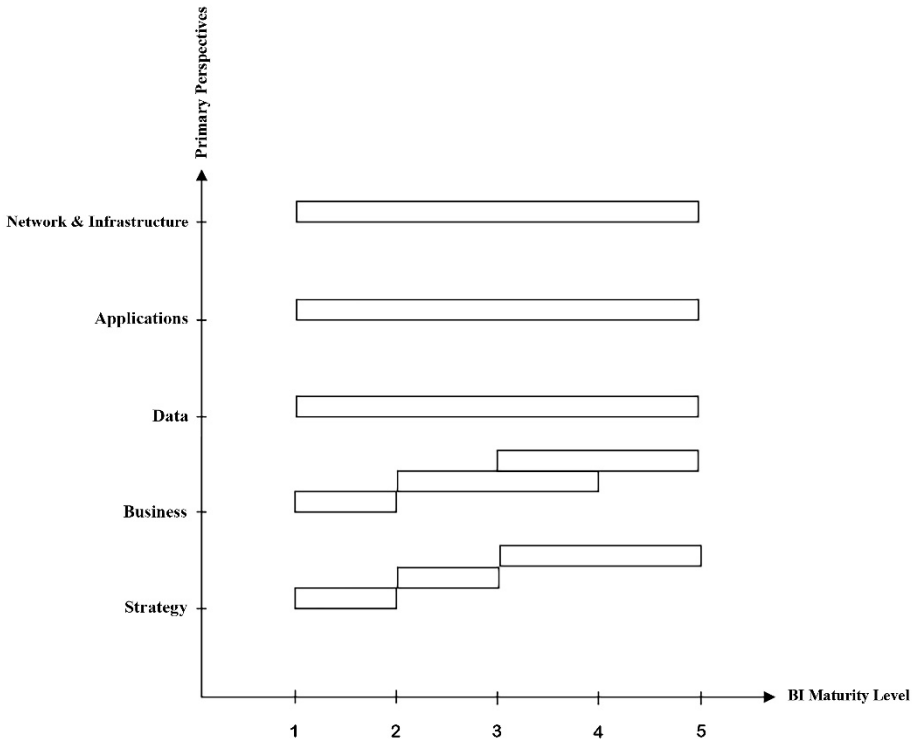

Figure 4. Comparison of the importance of primary perspective at BI maturity levels

As shown in Figure 5, the importance of the project management perspective at all maturity levels one to five is equal. Environment perspective and Human Capital Management were categorized into only two subcategories, and the difference in their importance is only at level 5 maturity and level 1 maturity. The importance of the security perspective includes four different subsets of significance at maturity levels and increases exponentially from maturity one to maturity five. This shows the great importance of security at high levels of BI maturity. From the point of view of configuration management and standards, the importance of maturities one, four, and five are different.

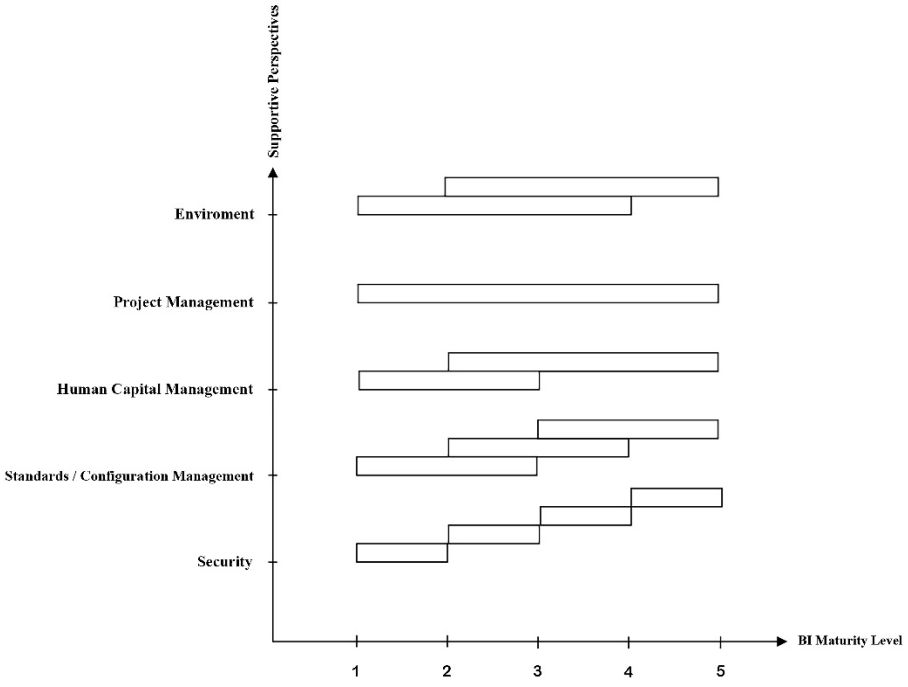

Figure 5. Comparison of the importance of supportive perspective at BI maturity levels

DISCUSSION

Identifying the CSF of the BI project plays a significant role in the success of the BI project (Ain et al., 2019; DeLone & McLean, 2003; El-Adaileh & Foster, 2019; Halim et al., 2020; Olszak & Ziemba, 2012; Pham et al., 2016; Yeoh & Koronios, 2010; Yeoh & Popovič, 2016). There are many classifications of CSF in previous studies. For example, Yeoh and Koronios (2010) classified CSF into three categories: organizational, process, and technology. Subagja et al. (2020) classified CSF into two categories: technical and organizational. Halim et al. (2020) categorized CSF into three categories: people, process, and technology. Adjie Eryadi and Nizar Hidayanto (2020) classified BI project CSF into four different dimensions: organization, process, technology, and environment. Some authors only reviewed a list of CSF, while others discussed the importance of CSF in their categories in general without regard to the maturity level of the organization.

A review of the literature on CSF of BI reveals that many scattered factors require proper coherence and structure. An enterprise architecture framework was used for categorizing the CSF. The experts who implemented enterprise architecture and BI projects were interviewed to rank CSF. Their experience and expertise were used in categorizing and ranking these factors. The most important identified CSF are consistent with earlier studies such as "management support and team skills" (El-Adaileh & Foster, 2019), and "management support and data quality" (Eder & Koch, 2018). Besides, some factors like project management, change management, and information technology infrastructure were described generally as critical success factors which decompose into layers in this study, and 'scope management, documentation, and hardware quality' get the most weight in their layers respectively. In addition, 'identify processes, analysis quality, security standards, and transformation of customer needs, are also identified as the most CSF in this study.

Despite some prior studies suggesting the technology category has a higher or lower priority than the organizational category in the success of BI projects, this study shows that, as the organization moves to higher levels of maturity, the average importance of strategy, business, and security perspectives increases. But the average importance of data, applications, infrastructure and network, and

project management perspectives is equal regardless of the level of BI maturity. Therefore, the actions needed for each organization are strongly related to the maturity level of the organization and are not equal for every organization.

CONCLUSION

Despite the great benefits of BI, BI projects bring many challenges that can cause failure. BI projects are implemented on a large scale now and there is a need for a holistic approach to implementing them. Besides, different classifications have been made for critical success factors but they were limited and not described in detail. To address this gap, a comprehensive list of BI success factors was reviewed and a framework was provided based on enterprise architecture to categorize all identified CSF in different layers of the framework and then rank them. Enterprise architecture, with its holistic approach, covers all dimensions of the organization and contributes to reducing complexities through its instructions and guidance.

This study shows 42 distinct critical success factors for BI projects and provides a holistic multi-layered framework to classify and rank CSF based on the enterprise architecture approach. The most important CSF in the ten layers of the framework include: from a strategy perspective "senior management support," from a business perspective "process identification," from a data perspective "data quality," from an application perspective "analytics quality," from an infrastructure and network perspective "hardware quality," from a security perspective "security standards," from a project management perspective "scope management," from a configuration management perspective "documentation," from a human resource management perspective "project team skills," and from an environment perspective "customer needs transformation" received the highest scores in framework layers or perspectives.

Although both understanding CSF and their importance contribute to BI project success, the actions needed are strongly related to the maturity level of the organization and are not equal for every organization. The result of this study shows that the higher the level of maturity of the organization, the greater the importance of layers such as strategy, business, and security. Support of senior managers, well-defined processes, and security standards are identified as the most important CSF in these layers which should be considered more in more mature organizations. But the average importance of data, applications, infrastructure and network, and the project management perspective is equal regardless of the level of BI maturity.

A comprehensive list of CSF and their ranking in separate layers of the framework can help to better implement BI projects and also decrease the failure rate of BI project implementation. For future research, the interaction of critical success factors of BI can be examined with different methods.

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APPENDIX A

First Survey Questionnaire

Personal information

Age	Educational level	Work experience and knowledge	Field of study

Pairwise comparison scale for AHP preferences, numerical rating, verbal judgments of preferences. If an element in a row has greater or equal importance than the element in the column, use the following table:

Equal preference	Slightly more important	More important	Very important	Absolutely more important
1	3	5	7	9

But if the element in the column is more important than the element in the row, use the inverse of the mentioned procedure, which means employing the following table:

Slightly more important	More important	Very important	Absolutely more important
1/3	1/5	1/7	1/9

Strategy	Business needs identification	User expectations identification	Goals and strategies definitions clear	Senior management support	Alignment of business and information technology
Business needs identification					
User expectations identification					
Goals and strategies definitions clear					
Senior management support					
Alignment of business and information technology					

Business	Clear definition of the goals of each business unit	Business performance management	Well-defined business process	Business process reengineering
Clear definition of the goals of each business unit				
Business performance management				
Well-defined business process				
Business process reengineering				

Data	Data quality	Quality of data access	Data architecture compatibility with the needs of the organization
Data quality			
Quality of data access			
Data architecture compatibility with the needs of the organization			

Application	Analysis quality	Scalability	Flexibility	Evolutionary development	Ease of use of the system	Integration of business intelligence with knowledge management	Integration of business intelligence with other information systems
Analysis quality							
Scalability							
Flexibility							
Evolutionary development							
Ease of use of the system							
Integration of business intelligence with knowledge management							
Integration of business intelligence with other information systems							

Network and infrastructure	Network infrastructure and communications	Hardware quality
Network infrastructure and communications		
Hardware quality		

Security	Privacy	Security standards
Privacy		
Security standards		

Standards and configuration management	Change management	Data standards, metadata, platform	Documentation
Change management			
Data standards, metadata, platform			
Documentation			

Human resource management	User involvement	Team leadership	BICC team	Project team skills	User training and motivation
User involvement					
Team leadership					
BICC team					
Project team skills					
User training and motivation					

Project management	Scope management	Time management	Communication management	Risk management	Procedure management	Cost management
Scope management						
Time management						
Communication management						
Risk management						
Procedure management						
Cost management						

Environment	Power and politics	Organizational culture	Competitive pressure	Transformation of customer needs	Emergence of new technologies
Power and politics					
Organizational culture					
Competitive pressure					
Transformation of customer needs					
Emergence of new technologies					

APPENDIX B

Second survey questionnaire

Please rate the effectiveness of each of the categories at different levels of maturity (Davenport BI maturity model) in integers for the range of 1 to 5.

1 – Very Low 2 – Low 3 – Moderate 4 – High 5 – Very Much

Layers	Analytical disability	Local analysis	Analytical passion	Analytical companies	Analytical competitors
Strategy					
Business					
Data					
Application					
Network and infrastructure					
Security					
Standards and configuration management					
Project management					
Human resource management					
Environment					

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