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Critical Success Factors for Business Intelligence Implementation in an Enterprise Resource Planning System Environment Using DEMATEL: A Case Study at a Cement Manufacture Company in Indonesia

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Abstract

This paper is aimed at evaluating critical success factors in Business Intelligence (BI) implementation in an Enterprise Resource Planning (ERP) environment. The data analysis method used in this paper is the Decision Making Trial and Evaluation Laboratory Model (DEMATEL). The study has been conducted on a cement manufacturing strategic holding company that has implemented ERP since 2010. This research is done through literature review and interviews with the head of the BI development team as the expert for this research, before distributing questionnaires to Information and Communication Technologies (ICT) Team and BI stakeholders. The questionnaire has been addressed to 18 respondents consisting of the BI development team and stakeholders, which include the Strategic Planning Division, Business Development Division, Transformation Management Division, and Accounting Division. There are 13 factors evaluated, consisting of 4 factors related to the organization, four factors related to the development process, three factors related to the technology, and two factors associated with the external environment. The most critical factor for organizational criteria is Top management support. The most important factor for process criteria is Effective project management. The

most important factor for technology criteria is System reliability, flexibility, and scalability. The most important factor for environment criteria is the selection of a vendor.

Keywords: Business intelligence; Critical success factor; DEMATEL.

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Introduction

During the last decades big data, data analytics, and Business Intelligence (BI) have emerged as important areas of study in the information technology research field (Chen et al., 2012). BI is a system of processes and technologies that businesses use to manage their enormous raw data in the history and current, transform into meaningful data. BI systems are used for finding patterns from a source of data combines both internal and external; data purpose is both operational and strategic that processed with complication techniques. When combined, these data can provide a complete picture that creates a meaningful "intelligence" data that help the business to predict the future (Pham et al., 2016).

Organizations can improve their business practices and thus their performance, by making decisions based on business analytics (Audzeyeva & Hudson, 2015). The ultimate aim of BI is to build shareholder value (Gaardboe & Svarre, 2018). The cost of BI technologies is high because their implementation requires initial setup and support, also training the personnel to handle the new system (Antoniadis et al., 2014).

ERP stands for Enterprise Resource Planning, defined as a software that stores, organizes, and retrieves information from a common database as and when required, providing a solution for enterprise resource planning systems. It is designed to model and automate basic processes across the organization over a centralized database, sheet, or any type of tool that is used by the organization. The organization pays a lot of attention to implementing ERP modules, especially in technically and economically feasible and profitable or non-profitable organizations. SAP, Oracle, Acumatica, Microsoft, Netsuite, Consona are examples of ERP vendors. The world is changing very fast in terms of the enterprise system and industries, which need very specialized solutions (Emam, 2013).

ERP systems have extensive reporting features within each functional module, such as financials and human resources. However, cross-module reporting functionality is limited, and this impacts the system's overall performance (Hawking, 2010). For one of the solutions, ERP vendors extended their product to incorporate BI as a tool for integrating the information contained in ERP systems for reporting and analysis.

Although many companies have already implemented a BI system, the rate of failures is still high (Pham et al., 2016). The reviewed literature suggest that, the success of the BI systems could be ensured by understanding and focusing on the factors that impact the success of the BI system. An understanding of the CSFs enables BI stakeholders to optimize their scarce resources and efforts by focusing on those significant factors that are most likely to aid successful system implementation (Yeoh & Koronios, 2010).

Several studies, such as Olszak and Ziemba (2012), Kfouri (2016), Dawson and Van Belle (2013), and Pham et al. (2016), have investigated the CSFs on implementing BI systems. However, there is a lack of in-depth research on critical success factors associated with the implementation of BI systems as part of an ERP system environment, especially in a developing country like Indonesia. Research to date has investigated the implementation of BI systems in the non-ERP environment- mainly in the realm of the successful implementation of the data warehouse that underpins the BI system's functionality. Therefore, this study intends to identify and evaluate the BI implementation CSFs on the ERP environment using the DEMATEL method. For this purpose, through an in-depth literature review, an interview with the expert on a company that has been implemented ERP since 2010 and implemented BI since 2019, 13 CSFs are identified, and a ranking calculation is proposed using DEMATEL method.

Literature Review

Business Intelligence

The Business Intelligence (BI) system is an integrated set of tools, technologies, and products that are planned to be used to collect, coordinate, analyze, and make data available. The main tasks of the BI system include intelligent exploration, integration, aggregation, and multi-dimensional analysis of data originating from various information sources (Mazreati & Radfar, 2017). In many cases, the data analyzed by the BI system is generated by an Enterprise Resource Planning (ERP) system, and quite often, the BI system is an extension for the ERP system (Hawking, 2010).

BI systems utilize the data collected from the organization and transformed it into information and knowledge that organizations need at the right time to make the right decisions to ensure sustainability and build shareholder value (Dawson & Van Belle, 2013). BI systems can provide improvement in organizational performance, which is productivity and revenue. Outcomes which result through the implementation of BI include an improved operational efficiency of processes, a new or improved product or service, and a strengthened organizational intelligence and dynamic organizational structure (Trieu, 2017).

Enterprise Resource Planning

ERP systems can be defined as an information system that are; integrated, modular, have a broad business functional scope, and are responsible for transaction processing in a real-time environment. An ERP system is responsible for automating and managing business transactions and producing and storing the associated data. However, cross-module reporting functionality and providing decision support activities are limited, such as analyzing historical trends and future planning. To overcome these reporting shortcomings, companies implemented the BI system incorporating data warehouse functionality, which offered by ERP vendor (Hawking, 2013).

ERP application and their BI capabilities have been transforming the way organizations conduct business and operations, by dramatically improving financial transparency, marketing and customer services, supply chain and operations management, human resources management, by integrating all resources and information in a single platform (Antoniadis et al., 2014).

CSF in BI Implementation

The Critical success factor is defined as the term for an element that an organization or project needs to satisfy to achieve its mission (Pham et al., 2016). Several areas of activity are included in the process as CSF must be managed continuously so that a business continuity is maintained (Yeoh & Popovič, 2016).

Olszak and Ziemba (2012) argue that organizations need to realize and learn about CSFs to ensure the occurrence of characteristics and actions affecting the success of BI implementation and put it in the right place, together minimizing negative influences and planning activities and resources as to achieve the desired goals from BI project which would lead to success ultimately.

Based on the literature review, this study has identified a verity of CSFs for BI implementation showed in Table 1 below. The CSF list is divided into four perspectives, namely organization, process, technology, and environment, such as previous studies, which are preferences by Eybers & Giannakopoulos (2015). CSFs perspective, as part of organizational factors, refers to organizational items or actions that should be present in order for BI system implementation to be successful.

CSFs perspective, as part of the process, refers to items that should be present during the execution of a BI system related to the development process in order for the development to be successful. Technical factors for BI system refer to expected system performance or item should be fulfilled for operational management went successful. Thus, the environment perspective refers to external factors of the organization that can influence strategic decision making.

Table 1. Business Intelligence Crittical Success Factors

Perspective	Factor	Literature	Short Description
Organization	Top management support	(Yeoh & Popovič, 2016), (Olszak & Ziemba, 2012), (Mesároš et al., 2015), (Zaied et al., 2018), (Yeoh & Koronios, 2010), (Sianipar et al., 2019), (Hirsimäki, 2017), (Gaardboe & Svarre, 2018), (Eybers & Giannakopoulos, 2015), (Dawson & Van Belle, 2013), (Magaireah et al., 2017), (Mungree et al., 2013), (Naderinejad et al., 2014), (Nguyen et al., 2018), (Sangar, 2013), (Denic et al., 2016), (Pham et al., 2016)	It means commitment, involvement, and support from top management (Magaireah et al., 2017).
	Clear vision & well-established business case	(Yeoh & Popovič, 2016), (Olszak & Ziemba, 2012), (Zaied et al., 2018), (Yeoh & Koronios, 2010), (Sianipar et al., 2019), (Hirsimäki, 2017), (Eybers & Giannakopoulos, 2015), (Dawson & Van Belle, 2013), (Magaireah et al., 2017), (Mungree et al., 2013), (Sangar, 2013), (Emam, 2013), (Pham et al., 2016)	BI initiative is driven by business, so a strategic business vision is needed to direct the implementation. A long term vision is needed to establish a good business case, and the business case must be aligned to the strategic vision (Hirsimäki, 2017).
	BI strategic alignment with business objectives	(Olszak & Ziemba, 2012), (Mesároš et al., 2015), (Zaied et al., 2018), (Dawson & Van Belle, 2013), (Mungree et al., 2013), (Naderinejad et al., 2014), (Nguyen et al., 2018), (Denic et al., 2016)	BI projects must be aligned and driven by business requirements and strategies. BI systems need to be realigned to fulfill changing business needs (Nguyen et al., 2018).
	Understanding organizational culture	(Mesároš et al., 2015), (Zaied et al., 2018), (Hirsimäki, 2017), (Naderinejad et al., 2014), (Sangar, 2013), (Denic et al., 2016)	It means some cultures of working with information within an organization (Olszak & Ziemba, 2012).
	Adequate resources	(Mesároš et al., 2015), (Zaied et al., 2018), (Mungree et al., 2013), (Naderinejad et al., 2014), (Nguyen et al., 2018), (Denic et al., 2016)	There should be adequate funding for hardware, software, and human resources (Mungree et al., 2013).
Process	Change management	(Yeoh & Popovič, 2016), (Olszak & Ziemba, 2012), (Yeoh & Koronios, 2010), (Sianipar et al., 2019), (Hirsimäki, 2017), (Eybers & Giannakopoulos, 2015), (Mungree et al., 2013), (Naderinejad et al., 2014), (Nguyen et al., 2018), (Sangar, 2013), (Pham et al., 2016)	Better user participation in the change process can lead to better communication of their needs, and thus helping to ensure a successful introduction of the new system (Yeoh & Koronios, 2010).
	User involvement & training	(Mesároš et al., 2015), (Hirsimäki, 2017), (Gaardboe & Svarre, 2018), (Dawson & Van Belle, 2013), (Magaireah et al., 2017), (Naderinejad et al., 2014), (Nguyen et al., 2018), (Sangar, 2013), (Denic et al., 2016)	Proper training makes the users more comfortable with the system, and supports the perceived usefulness of the system and makes it easier for the users to accept the use of a new system (Hirsimäki, 2017).

	Business champions	(Yeoh & Popovič, 2016) , (Mesároš et al., 2015), (Yeoh & Koronios, 2010), (Sianipar et al., 2019), (Dawson & Van Belle, 2013), (Magaireah et al., 2017), (Sangar, 2013), (Denic et al., 2016), (Pham et al., 2016)	Business champions are seen as separate from 'top management support' because they consider business champions closer and involved with the project rather than top managers (Dawson & Van Belle, 2013).
	Effective project management	(Olszak & Ziemba, 2012), (Gaardboe & Svarre, 2018), (Nguyen et al., 2018), (Sangar, 2013), (Emam, 2013)	How the team manages to deal with business change and organizational challenges is one of the most influential parts of the success of the BI implementation (Emam, 2013).
	Appropriate team skills	(Olszak & Ziemba, 2012), (Hirsimäki, 2017), (Kfouri, 2016), (Mungree et al., 2013), (Naderinejad et al., 2014), (Nguyen et al., 2018), (Sangar, 2013)	Team skills include both technical and interpersonal abilities, and a team with strong skills is able to perform tasks and interact with users better (Wixom & Watson, 2001).
	Approach method	(Yeoh & Popovič, 2016), (Yeoh & Koronios, 2010), (Sianipar et al., 2019), (Kfouri, 2016), (Nguyen et al., 2018), (Emam, 2013), (Pham et al., 2016)	It is encompassing the existence and use of BI-specific approaches and tools (Kfouri, 2016).
	Well define business processes	(Olszak & Ziemba, 2012), (Mesároš et al., 2015), (Hirsimäki, 2017), (Dawson & Van Belle, 2013), (Naderinejad et al., 2014), (Sangar, 2013), (Emam, 2013), (Denic et al., 2016)	BI projects should have common definitions of what is required from the systems, and these definitions should be agreed by both the business and technical sides (Nguyen et al., 2018).
Technology	Data quality, accuracy and integrity	(Yeoh & Popovič, 2016), (Olszak & Ziemba, 2012), (Mesároš et al., 2015), (Yeoh & Koronios, 2010), (Sianipar et al., 2019), (Hirsimäki, 2017), (Gaardboe & Svarre, 2018), (Eybers & Giannakopoulos, 2015), (Dawson & Van Belle, 2013), (Naderinejad et al., 2014), (Nguyen et al., 2018), (Sangar, 2013), (Denic et al., 2016), (Pham et al., 2016)	Because BI systems' main purpose is to provide insights for decision-makers according to available data, it is extremely important that the data gathering and analyzing processes are planned to the extent that the data is high quality and accurate (Hirsimäki, 2017). Successful BI systems require organizations to have high quality and integrity data (Magaireah et al., 2017).
	System reliability, flexibility and scalability	(Yeoh & Popovič, 2016), (Olszak & Ziemba, 2012), (Yeoh & Koronios, 2010), (Sianipar et al., 2019), (Hirsimäki, 2017), (Eybers & Giannakopoulos, 2015), (Kfouri, 2016), (Magaireah et al., 2017), (Nguyen et al., 2018), (Sangar, 2013), (Pham et al., 2016)	The flexibility and scalability of the system make expansions possible to align it with the changing information needs (Hirsimäki, 2017).

	Integration between BI system and other systems	(Olszak & Ziemba, 2012), (Magaireah et al., 2017), (Nguyen et al., 2018)	The main purpose of the BI system is to unify data originating from various sources that are processed and analyzed for the purpose of making a decision-making process (Magaireah et al., 2017).
	Appropriate technology and tools	(Olszak & Ziemba, 2012), (Naderinejad et al., 2014), (Nguyen et al., 2018)	BI hardware and software should be selected with a high level of organizational fit (Nguyen et al., 2018).
	Adjusting to user expectation	(Olszak & Ziemba, 2012), (Gaardboe & Svarre, 2018), (Nguyen et al., 2018), (Sangar, 2013)	User expectations represent a distinct variable that is narrowly related to users' technology experience. It is difficult to confirm a BI system to user expectations if there is no knowledge of these expectations (Gaardboe & Svarre, 2018).
Environment	Selection of a vendor	(Zaied et al., 2018), (Eybers & Giannakopoulos, 2015), (Denic et al., 2016)	It means external factors such as vendors with whom the organization trade with as well as partners (Eybers & Giannakopoulos, 2015).
	Competitive pressure	(Zaied et al., 2018), (Eybers & Giannakopoulos, 2015)	Trends adopted by competitors refer to factors external for the company to stand on business competition (Eybers & Giannakopoulos, 2015).

BI CSF in an ERP Environment

The close relationship between ERP and BI has seen ERP vendors develop BI functionality as an extension to their system. Hawking (2013) research found that many of the ERP system's critical success factors acknowledged in the research literature were identified as relevant to BI when BI implemented as an extension of an ERP system.

The proposed framework in this paper has been derived from a conceptual framework for investigates the CSF of BI in an ERP system by Hawking (2013), which identifies the relationship between the ERP system and BI. The ERP system is responsible for managing and processing transactions while BI facilitates decision making, especially in regards to business processes and their associated transactions. An ERP system and BI can be broadly classified as Information Systems, and therefore similarities in critical success factors would exist (Hawking, 2013). Thus, the proposed framework in this paper would demonstrate that many success factors to an ERP system are also relevant for a BI system.

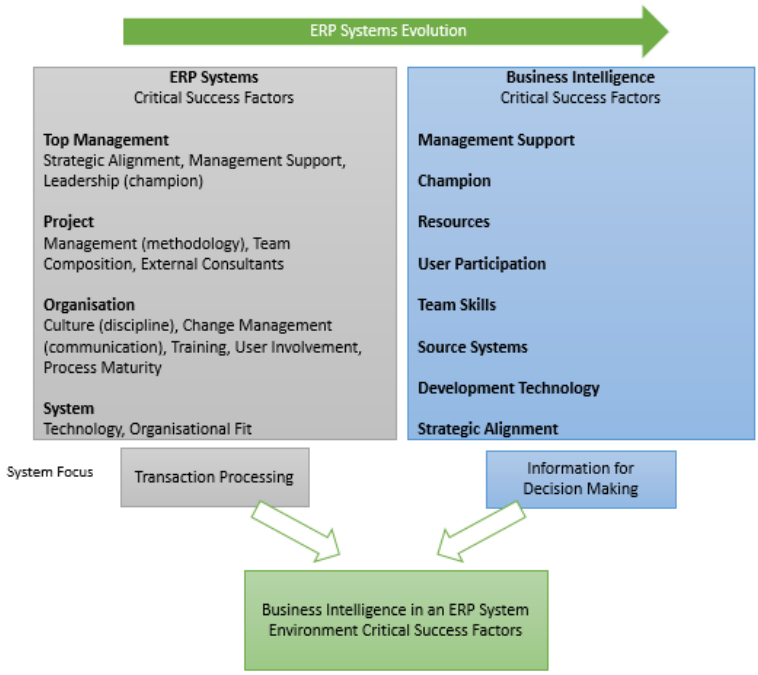

Figure 1. Conceptual framework for the investigation of critical success factors of BI in an ERP system environment (Hawking, 2013)

DEMATEL Method

Every individual or group is often required to be able to make the right decision from a complex problem of the many choices available. In making a decision, there is Multiple-Attribute Decision Making (MDAM), which is a field of operations research and management science, aims to help choose the best candidate from a set of alternatives. One of the MADM methods is Decision Making Trial and Evaluation Laboratory Model (DEMATEL). DEMATEL method has been developed in the Geneva Research Centre of the Battelle Memorial Institute and is one of the methods that can be used to model causal dependencies among criteria. DEMATEL method is able to visualize the complex cause and effect relationships in an understandable manner (Baykasoğlu & Gölcük, 2016).

In the DEMATEL method, similar to the AHP/ANP method, structural relationships occur between the analyzed elements. It is a premise for the use of DEMATEL in the weighting of criteria (Kobryn, 2017). In this paper, CSF ratings for the implementation of BI have utilized DEMATEL as a weighting method in multi-criteria decision analysis. The procedure of weighted DEMATEL method can be divided into the following steps:

Step 1: Construct the respondent matrix.

Every respondent must evaluate the direct influence between any two factors by a score showed table 2 (Kobryn, 2017).

Table 2. DEMATEL Rating Scale

Level of Influence	*Definition*
0	No Influence
1	Very Low Influence
2	Low Influence
3	High Influence
4	Very High Influence

In this paper, the notations of *M*, *N* and x_{ij} represents the number of the respondent, the number of factors, and the degree of factor *i* affects factor *j* which given by the respondent, respectively. For each respondent, a $n \times n$ non-negative matrix $X^k = [x^k{}_{ij}]$ can be established, where *k* is the number of the respondent, and if $i = j$ then $x_{ij} = 0$.

Step 2: Compute the average matrix.

The matrix $A = [a_{ij}]$ represents the average of all the M respondents and a_{ij} can be expressed as eq. (1).

$$a_{ij} = \frac{1}{M}\sum_{k=1}^{M} x_{ij}^{k} \qquad (1)$$

Step 3: Calculate the normalized matrix.

The normalized matrix obtained from the average matrix A which is normalized by Eq (2).

$$s = \max\left(\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}, \max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\right) \qquad (2)$$

$$D = \frac{A}{s} \qquad (3)$$

Step 4: Calculate the total relation matrix.

The total relation matrix $T = [t_{ij}]$ can be calculated by Eq (4).

$$T = D\,(I - D)^{-1} \qquad (4)$$

The notation of *I* is the identity matrix.

Step 5: Calculate the total effects given and received of every factor.

The effects are given by the factor i can be calculated by Eq (5).

$$r_i = \sum_{j=1}^{n} t_{ij} \;\; (i = 1, 2, \ldots, n) \qquad (5)$$

The effects received factor i can be calculated by Eq (6).

$$c_i = \sum_{j=1}^{n} t_{ji} \ (i = 1, 2, \dots, n) \qquad (6)$$

Then the total effects have given of factor i can be calculated by Eq (7).

$$t_i^+ = r_i + c_i \ (i = 1, 2, \dots, n) \qquad (7)$$

The total effects received factor i can be calculated by Eq (8).

$$t_i^- = r_i - c_i \ (i = 1, 2, \dots, n) \qquad (8)$$

That is, t_i^+ indicates the degree of importance that factor i plays in the entire system. On the contrary, t_i^- depicts the net effect that factor i contributes to the system (Jin et al., 2013).

For determining the weight of criteria from the DEMATEL method, these are the steps:

$$t_i^{average} = \frac{1}{2}(t_i^+ + t_i^-) = \sum_{j=1}^{n} t_{ij} \qquad (9)$$

To calculate the normalised weights, the following equation can be used:

$$w_i = \frac{t_i^{average}}{\sum_{i=1}^{n} t_i^{average}} \qquad (10)$$

Criteria whose weights are zeros cannot occur in the set of criteria. Therefore, when comparing criteria and determining their weights using the DEMATEL method, it is necessary to correct the weight values calculated from Eq (10) (Kobryn, 2017).

To increase the weights using the same value δ:

$$w_i^{corrected} = w_i + \delta \qquad (11)$$

Since the main goal to correct the weight whose initial value is zero, the correction value δ should be as small as possible. The value $\delta \leq \Delta$, where Δ is the smallest non-zero weight of the remaining criteria:

$$\Delta = \min_i w_i \text{ if } w_i > 0 \qquad (12)$$

And then to re-normalise them using the following equation:

$$w_i^{normalized} = \frac{w_i^{corrected}}{\sum_{i=1}^{n} w_i^{corrected}} \qquad (13)$$

Materials and Methods

The CSF of BI in an ERP environment evaluation proposed framework has been compiled through interviews with the head of the BI development in the company. Interviews were conducted to identify relevant factors in the implementation of BI carried out by the company. From the results of the literature review and interview, we identified four factors related to the

organization, four factors related to the development process, three factors related to the technology, and two factors related to the environment.

The proposed hierarchy shown in Figure 2 is the DEMATEL hierarchy used in this paper. This hierarchy can also be used by companies to evaluate their implementation of BI.

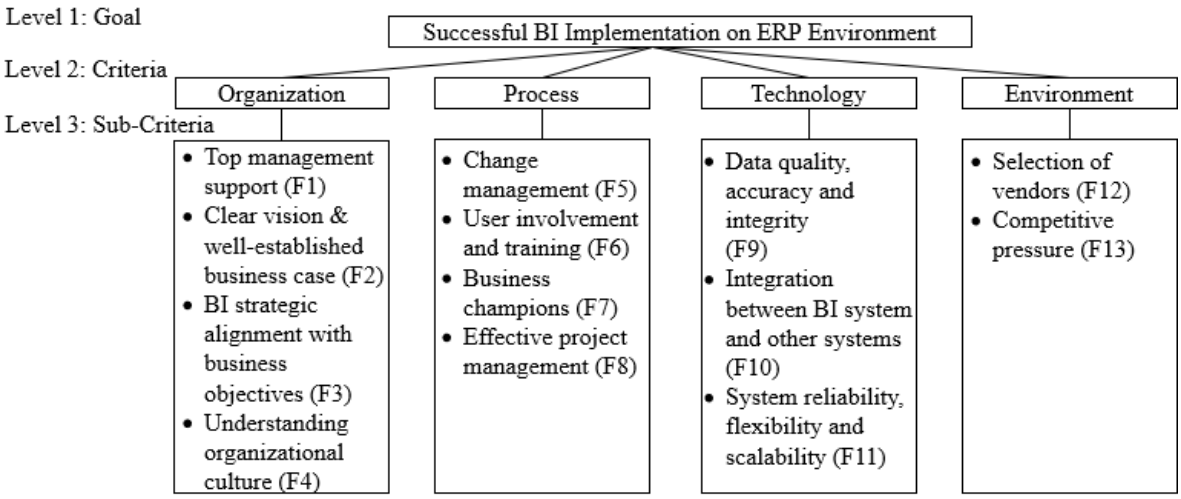

Figure 2. CSF Proposed Hierarchy of BI Implementation

In the proposed hierarchy shown in Figure 2, there are four factors, including organizational criteria, namely clear vision and well-established business case, top management support, organizational culture, and BI strategic alignment with business objectives. The process criteria consist of 4 factors, champions, change management, project management, and user involvement & training. The technology criteria consist of 3 factors, namely data quality, integration between BI system and other systems and system reliability, flexibility, and scalability. The environment criteria consist of 2 factors, namely the Selection of a vendor and competitive pressure.

After identifying the factors that influence the success of BI implementation, we used a questionnaire to evaluate these factors. The questionnaire contains the influencing factors and their level or degree of impact. Respondents were asked to choose the level of influence with a scale of 0 (no influence) up to a scale of 3 (very influential), as shown in Table 2.

Data collection is done in a cement manufacturing strategic holding company that has implemented ERP since January 2010. The company has started implementing BI since January 2019. The system was built by Information and Communication Technologies (ICT) division and external vendor as a development team. The questionnaire was addressed to members of the development team and BI stakeholders, which have some characteristics shown in table 3. The Total of all respondents is 18. These respondents in the company were asked to compare each CSFs and choose the scale of influence.

Table 3. Characteristics of case study respondents

Respondent characteristics		***Sum of respondent N = 18***
Work unit	ICT	10
	Strategic Planning	4
	Business Development	1
	Transformation Management	1
	Accounting	2
ERP experience	< 4 years	7
	> 4 years	11
BI experience	< 4 years	17
	> 4 years	1
Role in BI Implementation	Development Team	8
	Business User	10

The DEMATEL is used to evaluate the priority of the factors that influence the implementation of BI in the company. Priority evaluation refers to the DEMATEL influence matrix that shows which CSF is included as an influence, and which one falls into the category of influence.

Results

The data from the questionnaire was converted into a matrix for each perspective, organization, process, technology, and environment. Using the DEMATEL method will produce a total matrix of influence and then calculate the weights of each CSF based on an approach in the literature (Kobryn, 2017).

Table 4. Total Influence Matrix from Organization Perspective

	F1	***F2***	***F3***	***F4***	***r***
F1	4.8084	5.2269	4.9953	4.7203	19.7509
F2	4.9528	4.8490	4.9089	4.6429	19.3536
F3	4.8508	4.9792	4.5410	4.5077	18.8787
F4	4.5739	4.6906	4.5074	4.0549	17.8268
c	19.1859	19.7457	18.9526	17.9258	

Table 4 shows the result of calculation total influence matrix by equation (7) and (8) from an organization perspective, Top management support (F1), Clear vision & well-established business case (F2), BI strategic alignment with business objectives (F3) and Understanding organizational culture (F4).

Table 5. Weights of CSF from Organization Perspective

CSF	*Prominance* $(r_i + c_i)$	*Relation* $(r_i - c_i)$	*Weight* (w_i)	*Normalized Weight* $(w_i^{normalized})$	*Rank*
F1	38.9368	0.5650	0.260532	0.255427	1
F2	39.0993	-0.3921	0.255291	0.252726	2
F3	37.8313	-0.0739	0.249027	0.249498	3
F4	35.7526	-0.0990	0.235151	0.242348	4

Table 5 shows that the greatest value (r-c) is 0.5650. It means that the Top management support (F1) factor is the most influences than other factors from an organization perspective. On the contrary, CSF F2, namely Clear Vision and Well-established Business Case factor, has the most negative value of (r-c), which is -0.3921, indicating that this factor is more likely to be influenced than influenced in an organization perspective.

Table 6. Total Influence Matrix from Process Perspective

	F5	***F6***	***F7***	***F8***	***r***
F5	3.1409	3.1820	3.2142	3.0320	12.5691
F6	3.1553	2.7397	2.9767	2.8080	11.6797
F7	3.3680	3.1457	2.9337	3.0112	12.4586
F8	3.4434	3.2388	3.2246	2.8414	12.7482
c	13.1076	12.3062	12.3492	11.6926	

Table 6 shows the result of the calculation total influence matrix by equation (7) and (8) from the process perspective, namely Change Management (F5), User involvement and training (F6), Business champions (F7), and Effective project management (F8).

Table 7. Weights of CSF from Process Perspective

CSF	*Prominance* $(r_i + c_i)$	*Relation* $(r_i - c_i)$	*Weight* (w_i)	*Normalized Weight* $(w_i^{normalized})$	*Rank*
F5	25.6767	-0.5385	0.254149	0.252134	2
F6	23.9859	-0.6265	0.236165	0.242886	4
F7	24.8078	0.1094	0.251915	0.250985	3
F8	24.4408	1.0556	0.257771	0.253996	1

Table 7 shows that the greatest value (r-c) is 1.0556. It means that the Effective project management factor (F8) is most influences the other in a process perspective. On the contrary, CSF F6, namely User involvement & training factor, has the most negative value of the (r-c) which is -0.5385, indicating that this factor is more likely to be influenced than influenced in a process perspective.

Table 8. Total Influence Matrix from Technology Perspective

	F9	***F10***	***F11***	***r***
F9	29.0900	29.4162	29.7389	88.2451
F10	29.4162	29.0900	29.7672	88.2734
F11	29.7670	29.7388	29.7524	89.2582
c	88.2732	88.2450	89.2585	

Table 8 shows the result of the calculation total influence matrix by equation (7) and (8) from a technology perspective, namely Data quality, accuracy and integrity (F9), Integration between BI system and other systems (F10), System reliability, flexibility and scalability (F11).

Table 9. Weights of CSF from Technology Perspective

CSF	***Prominance*** $(r_i + c_i)$	***Relation*** $(r_i - c_i)$	***Weight*** (w_i)	***Normalized Weight*** $(w_i^{normalized})$	***Rank***
F9	176.5183	-0.0281	0.332027	0.332679	3
F10	176.5184	0.0284	0.332134	0.332732	2
F11	178.5167	-0.0003	0.335839	0.334589	1

Table 9 shows that the greatest value (r-c) is 0.0284. It means that the Integration between a BI system with other systems is most influences the other from a technology perspective. On the contrary, CSF F9, namely Data quality, accuracy & integrity factor, has the most negative value of (r-c) which is -0.0284, indicating that this factor is more likely to be influenced than influenced in a technology perspective.

Table 10. Total Influence Matrix from Environment Perspective

	F12	***F13***	***r***
F12	41.9658	42.9658	84.9316
F13	41.9647	41.9647	83.9294
c	83.9305	84.9305	

Table 10 shows the result of the calculation total influence matrix by equation (7) and (8) from an environment perspective, namely the Selection of a vendor (F12) and Competitive pressure (F13).

Table 11. Weights of CSF from Environment Perspective

CSF	***Prominance*** $(r_i + c_i)$	***Relation*** $(r_i - c_i)$	***Weight*** (w_i)	***Normalized Weight*** $(w_i^{normalized})$	***Rank***
F12	168.8621	1.0011	0.502968	0.501488	1
F13	168.8599	-1.0011	0.497032	0.498512	2

Table 11 shows that the greatest value (r-c) is 1.0011. It means that the Selection of a vendor is the most influences the other factor from an environmental perspective. On the contrary, CSF F13, namely the Competitive pressure factor, has the most negative value of (r-c), which is -0.0284, indicating that this factor is more likely to be influenced than influenced in an environmental perspective.

Table 12. Summary of CSF priority analysis of successful BI implementation

Rank	*CSF of Successful BI Implementation on ERP Environment*			
	Organization	Process	Technology	Environment
1	Top management support*	Effective project management*	System reliability, flexibility and scalability	Selection of a vendor*
2	Clear vision & well-established business case	Change management*	Integration between BI system and other system	Competitive pressure
3	BI strategic alignment with business objectives*	Business champions*	Data quality, accuracy and integrity	
4	Understanding organizational culture*	User involvement and training*		

*ERP critical success factor based on Hawking (2013)

Conclusion and Recommendations

Understanding the applicability of the CFS is crucial to the successful implementation of BI. This research investigated the critical success factors associated with Business Intelligence when implemented as an extension of an ERP system. Some priorities from different perspectives which valuable conclusion for an insight into CSF of BI implementation in an ERP environment are:

- From the organizational perspective, the implementation of BI should have support from the top management. Top management or executive support enables the smooth provision of required capital, human resources, and availability and coordination of other related internal resources needed for Business Intelligence implementation. A component of top management support is the role of an executive sponsor who is committed to the application and invests time and effort in guiding the project's development. End users are more likely to accept a system if perceived to be supported by top management.
- From the process perspective, it is essential to have effective project management. The implementation of an effective BI system is to ensure the integration of appropriate

and sufficient information and facilitate business operations. The project manager can define the time, budget, and scope clearly.

- From the technology perspective, the BI system should be reliable, flexible, and scalable. For a reliable system, it should produce dependability and accuracy of the data. The technology must be flexible and responsive to the user's requirements. Technical infrastructure must be scalable to facilitate system expansion to align with evolving information needs.
- From the environmental perspective, the IT Division should notice the vendor with whom the organization trades. The vendor was carefully selected as they have to adhere to specific industry standards to adhere to regulations.

The purpose of this study is to provide a better contextual understanding of CFS for BI implementation. Through an analysis of the ongoing BI implementation in the cement manufacturing organization based in Indonesia, the contributions of this paper in contextual CSF for implementing BI in the ERP environment are:

- This research strengthens the argument of Paul (2013) that many of the ERP system's CSFs acknowledged in the study were identified as relevant to BI when BI implemented as an extension of an ERP system. These factors are top management support, BI strategic alignment with business objectives, understanding organizational culture, effective project management, change management, business champions, user involvement and training, and selection of a vendor.
- The research is validating the applicability of many previously identified BI critical success factors, such as top management support, and effective project management as the first rank priority. This result reinforces the research carried out by Celina & Ewa (2012), which argues that effective BI implementation must cover a competent project team and IT specialist so that the implementation project must have a sponsor from top management.
- From the technology perspective, namely system reliability, flexibility & scalability factor is the first rank priority, which reinforces the research carried out by Renne (2017). It claims this factor as the condition to meet the requirements of the dynamic business needs.
- The research has also proposed a new perspective, namely environment, which not identified previously on Paul (2013). It strengthens Sunet (2015) that the organization's vendor list was carefully selected as they have to adhere to certain industry standards to adhere to regulations. They also kept a close eye on the trends adopted by competitors.

The proposed framework in this research provides a summary of CSFs that can be used for further empirical studies. It was developed to assist the researchers and practitioners in

understanding better the relevance of different Business Intelligence critical success factors. The academicians can validate the generalisability of the findings. This evaluation also provides suggested factors for BI stakeholders, who are senior managers, project managers, team members, and vendors, to prioritize in starting and developing the BI system. This framework will assist the organizations to direct their resources towards focusing on the specific CSFs. Thus, the success factors that have been identified can prevent the occurrence of failure factors and the loss of related costs.

This research only consists of the investigation, identification, and ranking of the factors affecting the evaluation of the BI system in a strategic holding company. Suggested future research is the development of a BI evaluation model in their several subsidiaries business companies.

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