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Modeling the Readiness Measurement for Enterprise Resource Planning System Implementation Success

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ABSTRACT — In the digital era, companies are required to optimize technological innovation to increase capacity in achieving work that is more efficient, effective, productive, and has a competitive advantage. Companies must use the enterprise resource planning (ERP) system to improve efficiency, effectiveness, and productivity. Implementing an ERP system provides competitive advantages by means of decision-making proven for fast and precise management. ERP system is an integrated information system for strategic company management decision-making. For this reason, implementing an ERP system is necessary. Unfortunately, the fact shows that many companies fail to implement an ERP system, resulting in costly implementation expenses. Previous research has discussed empirical studies on the critical success factors for implementing an ERP system effectively. Therefore, further research still needs to be done by discussing ERP implementation from the perspective of measuring companies' readiness levels in ERP system implementation. This research methodology criticized and analyzed the comparison of eleven prior research articles as a basis for developing a model to measure companies' readiness levels in implementing ERP systems. This research examined quantitative data gathered through the use of questionnaire method to rank indicators for measuring companies' readiness levels by identifying four dimensions and 27 indicators. This research aims to produce a model for measuring companies' readiness to implement the ERP system on time successfully.

KEYWORDS — ERP, Implementation, Measurement, Modeling, Readiness Level.

I. INTRODUCTION

The impact of the digitalization of technology has caused a transformation in the organizational culture. The purpose of this transformation is to increase competitive advantages and achieve performance. For this reason, implementing enterprise resource planning (ERP) is one of the critical factors that need to be considered by company management so that they can make decisions quickly and accurately based on information obtained from the ERP application they use. Based on the data generated by the ERP application, the managerial level of the company can focus more on deciding and making decisions to manage issues, which in turn allows them to work effectively to achieve competitive advantage and improve company performance. However, companies still need to work on implementing ERP, making ERP procurement's investment value costly [1]. In addition, the process of implementing ERP is highly complex since it is necessary to adjust and follow the working of the ERP used [2]. In addition, the leading cause of complexity in implementing ERP is that the parties involved in the implementation project need to fully understand the company's level of readiness [3].

For this reason, it is wise for company management to assess the company's readiness before deciding to implement ERP. By doing so, the company's management can determine the indicators of the company's weaknesses, which can then be followed up to become the company's strengths. Thus, by understanding the company's readiness level, the company's management can determine which strength indicators are going to be maintained and improved further, so that the ERP implementation runs effectively and on time. This research developed a model for measuring company readiness based on agile parameters that focus on the perspective of processes, people, organization, and technology. The partial least squares structural equation modeling (PLS-SEM) analysis was used in testing the indicators and the entropy method in determining the indicators' ranking that were used as a consideration basis to develop a model for measuring the company's readiness level in implementing the ERP based on agile parameters.

Literature review survey (LRS) method was used to collect the data. This stage was carried out by criticizing, analyzing, and comparing eleven prior research articles related to the readiness to implement ERP in several industries. Based on the background above, this research formulates the research questions that will answer in this research, which are as follows:

1. What are the main factors influencing the readiness measurement of the company's level to implement an ERP System?
2. How can the readiness measurement development model be designed for ERP System implementation based on agile parameters?

Implementing ERP is a complex process to be achieved in an effective and timely manner. The complexity is influenced by the business processes reengineering to suit the business processes of the chosen ERP system [4], [5]. Another reason underlying the complexity of the ERP implementation is it exceeds the expected time and budget. It requires managers to have extensive knowledge to assess the company's readiness and support the ERP implementation process to run effectively and on time [6]. Based on this, the ERP implementation has the complexity of adjusting the business processes of the ERP derived from the current business process. The agile principle focuses on the use of applications as a necessity, good response to the change process, intensive people interaction, people with motivation and effective communication, and organized teamwork. Agile is more flexible and can handle changing business processes, increasing productivity, and aligning the company's business strategy [7]. An agile approach is an

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approach that emphasizes simplification of business processes and dynamic adaptation [8]. The agile method aims to increase customer satisfaction with a dynamic and iterative approach; it designs organizations, processes, and products that promptly respond to changes [9]. The agile method has a work style characterized by flexibility and focuses on customer needs, as well as ensuring that work results meet business needs. This method prioritizes delivery time. Implementing ERP requires a change process to improve business processes, manage investment, and increase feedback actively. The agile approach has advantages in analyzing ERP to detect weaknesses quickly and easily, providing benefits and improving the quality of ERP implementation results optimally [10]. The agile method aims to reduce the complexity of the ERP implementation for industries. The critical factors based on the organization of agile principles are a collaborative work environment, top management support, adaptive view toward change, cooperative horizontal business culture, and people-oriented culture. The principle of agile process is iterative requirements management, early delivery of important features, regular and frequent communication, test-driven environment, and colocation of staff and stakeholders. The people from the agile principle are the adaptive leadership style, self-organizing teams, and close team customer relationships. Meanwhile, the principles of agile project are rapid early delivery of value, emergent requirements, fluid project schedule, customer involvement, and continuous and incremental business value [11].

The measurement model developed to assess the level of company readiness is a strategic decision-support tool to determine an organization's readiness level to improve sustainable performance. The company's readiness to implement ERP is significant as it can provide information to the company management to comprehensively understand by identifying the factors in the form of the company's weaknesses and strengths to determine the increased probability of success in implementing ERP [12]. It shows that the organization's ability to plan, control, and manage related dimensions in implementing the ERP is a critical factor that must be considered carefully. The process of assessing the company's readiness begins with an understanding of the organization's needs, followed by planning an assessment and collecting data, analyzing the results of feedback, and comparing the results to the organization's needs so that company management can determine the company's readiness level. The company's readiness level assessment aims to identify factors from the company's internal and external perspectives in implementing procedures and structures and improving business processes to support project management activities [13], [14]. Top-level management support is an essential driving factor to accelerate overcoming resistance from the parties involved in the ERP implementation; also, top management commitment is one of the critical factors to support the assessment model to be used as a measurement tool for companies in implementing ERP by standardizing changes and integrating business processes, as well as evaluating periodically [15]–[17]. It ensures that the ERP implementation process runs effectively and on time.

In this research, measuring the readiness level of companies in implementing ERP was carried out using the adaptation of the Leavitt's diamond model which focused on four dimensions: process, people, organizational, and technology with the development of indicators on each dimension [18]. This research criticized, analyzed, and compared the results of previous studies on the company's readiness to implement ERP.

Top management, technical requirement, change management, people, and project management are the main components in assessing the company's readiness to implement ERP using analytical hierarchy process (AHP), multi-objective optimization on the basis of ratio analysis (MOORA), and technique for order of preference by similarity to ideal solution (TOPSIS) methods as the research methods [19]. Organizational factors are a critical and a new approach in implementing ERP with agile methods and generic procedure models [20], [21]. Technology readiness levels factor is critical for managing technology development in the ERP implementation, with LRS and interviews as the research with multiple-criteria decision-making (MCDM) and TOPSIS as the research methods used [22], [23]. Process factors are critical in implementing ERP with grounded theory and information technology management framework, business process modeling (BPM) as the research method used [24], [25]. The readiness management factor is critical in implementing ERP with fuzzy cognitive map (FCM), decision-making trial and evaluation laboratory (DEMATEL), cluster, TOPSIS, and fuzzy AHP as the research methods [26]–[28]. Based on the results of indicator mapping from the previous literature, this research makes the definition of each indicator with the following explanation.

Business process reengineering changes and standardizes the current business processes. Currently, the process of integration changes in business processes are to be standardized. Standardization process is the working process to be standardized. Change management manages changes according to ERP standards. Project champion role is required to achieve a successful ERP implementation. IT team must possess technical expertise, skills, and competency. Top-level management's support is essential for a successful ERP implementation. Training is essential for adapting to the new system. Cross-functional support requires user collaboration with relevant cross-departments. Human resource allocation must support the project's execution. The skill project team has teamwork with users. Roles and responsibilities of the team must be clearly defined. Shared values are the impact benefits of using the system to improve the work more effectively. The organizational structure must change. Effective communication creates teamwork synergy. The role of project management must be clearly defined. Organization size determines the functional organization. Goal and vision must be clear. Organization strategy in determining the workload analysis of business processes must be established. Organizational agility is a common implementation of agile approach, without traps and problems focusing on simplicity, moving fast, and delivering the operating functionality of the software. System integration function is used for decision-making. Information must be standardized. Data security determines the quality of information. IT infrastructure is a critical factor to support the ERP implementation. Legacy systems must be analyzed. Technology trends must be synchronized.

The results of the previous research analysis became the basis for building questionnaire statements and testing the respondents as well as a framework for developing a company readiness assessment model to implement an ERP system based on agile parameters. Based on the literature survey, this research mapped the indicators that affect the company's readiness to implement ERP for the industry based on agile

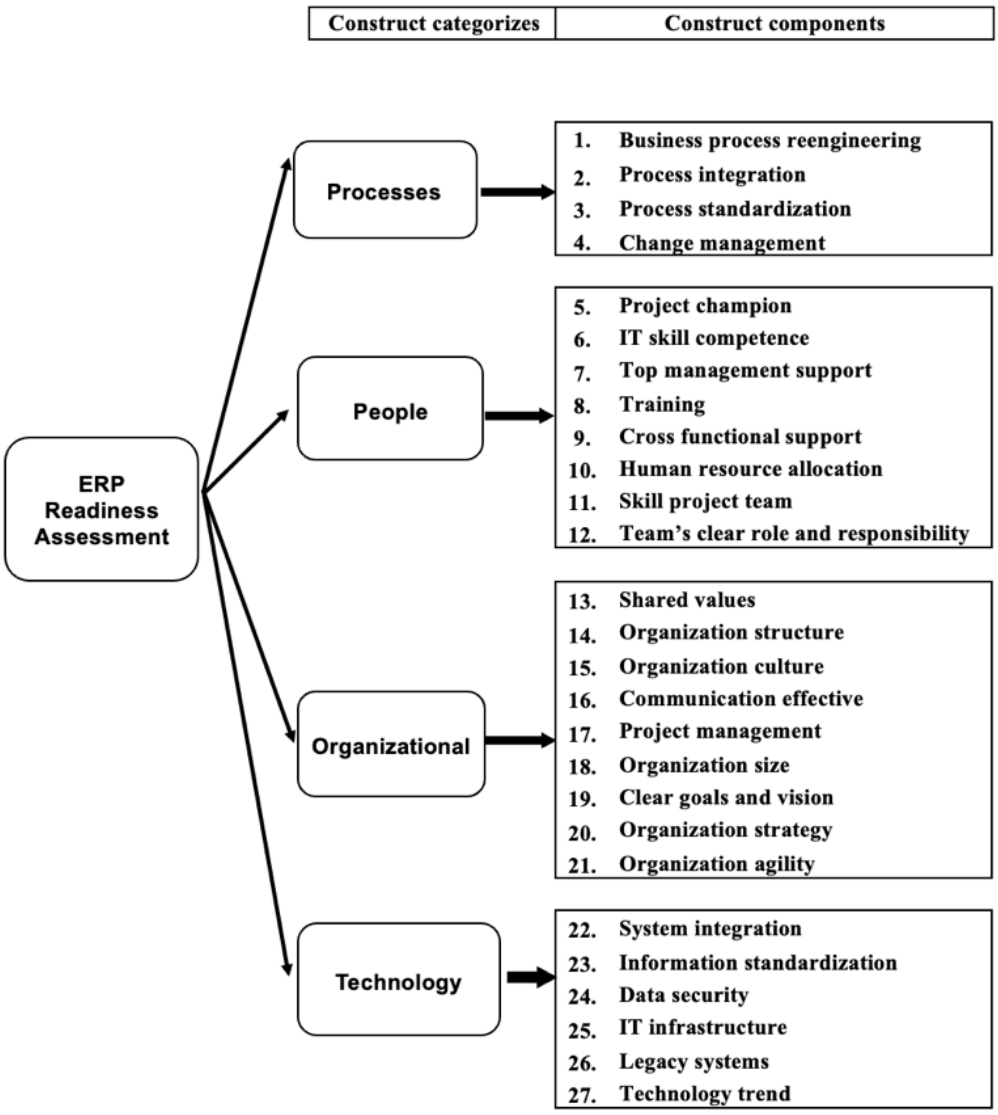

Figure 1. Hierarchy of ERP readiness measurement model.

parameters. The quantitative data collection was carried out using questionnaire to obtain primary data directly from the respondents. Using the Likert scale, respondents rated the level of importance of the questionnaire statements. The scoring group are very unimportant, unimportant, slightly unimportant, fairly important, important, and very important.

II. METHODOLOGY

This research focuses on the literature survey emphasizing on the identification of critical indicators that affect the readiness level of companies in implementing ERP. Based on previous research's critical indicators, indicators were determined as the basis for making questionnaire statements for testing and obtaining feedback from respondents. Besides that, the results of mapping indicators from previous research also formed the basis for developing a research model to adjust company's readiness in implementing ERP. The categories of ERP readiness measurement for processes were business process reengineering, process integration, process standardization, and change management. The categories of ERP readiness measurement for people included the project champion, IT skill and competency, top management support, training, cross-functional support, human resource allocation, skilled project team, and team with clear role and responsibility. The categories of ERP readiness measurement for organizational comprised shared values, organizational structure, organizational culture, effective communication, project management, organizational size, clear goals and vision, organizational strategy, and organizational agility. In addition, the categories of ERP readiness measurement for technology were system integration, information standardization, data security, IT infrastructure, legacy systems, and technology trends. The components and categories of the ERP readiness assessment that implement ERP is shown in the hierarchy in Figure 1.

In collecting respondents' data, the characteristics of respondents in several industrial companies in Indonesia implementing an ERP system were determined. This research designed the respondents' criteria for filling out the questionnaire statements as follows. Gender was intended to consider the behavior level of the respondents in giving opinions. Age was used to consider the age maturity level of the respondents in providing views. Educational level considered the intellectual level of the respondents in giving opinions. Work experience was intended to consider the work experience of the respondents in understanding the use of technology in giving their viewpoint. The experience in using the ERP application to see the respondents' experience in understanding

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TABLE I
DATA TEST RESULTS

Indicator		MSA
PR01	Changes in business processes need user commitment to be standardized understood and documented	0.687
PR02	Integrate business processes and operations to improve the organization's business	0.846
PR03	Standardization of work processes must follow the ERP system	0.697
PR04	ERP implementation becomes more effective by managing changes according to ERP standards	0.906
PE05	The role of the project champion will determine the success of ERP implementation	0.645
PE06	Competency of the IT team must have technical expertise, understanding of ERP business processes	0.836
PE07	Management support will determine the strategic plan in achieving successful ERP implementation	0.734
PE08	Training is an important aspect for users to adapt to the new system	0.872
PE09	Information collaboration becomes effective with user collaboration with relevant cross-departments	0.770
PE10	Human Resource Allocation must be determined at the beginning of the project	0.574
PE11	The project team must cooperate with users in solving ERP problems	0.755
PE12	ERP project team duties & responsibilities must be clearly defined & understood	0.802
OR13	The benefits of using the system will have an impact by improving the way work becomes more effective	0.817
OR14	The organizational structure will determine the competence of the project team	0.888
OR15	Changes in organizational culture must follow the way the selected ERP system works	0.788
OR16	Effective communication will create teamwork synergy	0.885
OR17	ERP project management must be clearly defined	0.849
OR18	The size of the organization will determine the functional organization before implementing ERP	0.705
OR19	Clear goals. vision & objectives must be communicated effectively with management levels	0.796
OR20	ERP implementation decisions are an organizational strategy to adopt technological innovations	0.769
OR21	Organizational intelligence will support a more competitive business change process	0.881
TE22	System integration speeds up the decision-making process for management	0.810
TE23	Standardization of information is important in ERP preparation	0.688
TE24	The availability of accurate data will determine the quality of information generated by ERP	0.839
TE25	IT infrastructure includes software, hardware, and network infrastructure	0.804
TE26	The level of system usage can be analyzed from the actual data input	0.722
TE27	Technology readiness must be synchronized with organizational readiness in project management	0.728

Kaiser-Meyer-Olkin (KMO) and Bartlett's Tests

Measure of Sampling Adequacy (MSA) of KMO	**0.781**
Bartlett's test of Approx Chi Square	**1,107.11**
Sphericity *df*	**0.351**
Sig	**0.000**

project management knowledge, ways of working, and the use of ERP to complete their job and obtain information needed for the decision-making. Educational background was used to consider the suitability of the respondent's educational experience in giving an opinion. Position was intended to consider the operational-related parts of the respondents in providing viewpoints according to the work. Type of industry considered the suitability of the industry or company characteristics of the respondents in delivering opinions.

Based on the consideration that partial least squares structural equation modelling (PLS-SEM) is a model that can overcome multivariate normality, small sample sizes, and reflective measurements, and accommodate both reflective and formative measurement models, thus this research used the PLS-SEM analysis method in testing indicators. The PLS-SEM method is a second-generation multivariate analysis technique that combines factor analysis and path analysis so that it can simultaneously test and estimate the relationship between several indicators by testing the validity of the dimensions and indicators for calculating the determination of Cronbach's alpha (CA), composite reliabilities (CR), and average variance extract (AVE) on dimensions and indicators [29]. This research also used the entropy method as a ranking indicator. The entropy method was used for weighting criteria based on probability distributions scattered in the questionnaire statements which were useful in weighting criteria. The entropy method is one of the methods of MCDM, so it is suitable for determining indicator' ranking [30]. The stages of determining the weight of criteria in the entropy method are as following.

1. All respondents chose a value indicating the importance of a particular criterion determined in the questionnaire statement.
2. Each number was subtracted with the ideal value. *Xij* expresses the result of this subtraction.
3. *Xij* value was obtained from the *Pij* matrix as (1).

$$P_{ij} = \frac{Xij}{\sum_{i=1}^{m} X_{ij}}, \forall i, j. \quad (1)$$

where *m* denotes the number of respondents.

4. Entropy values for each criterion were calculated using (2).

$$Ej = -k \sum_{i=1}^{m} Pij \, ln \, Pij, \forall j, \quad (2)$$

where $K = \frac{1}{lnm}$.

5. Dispersion of each criterion was calculated using (3).

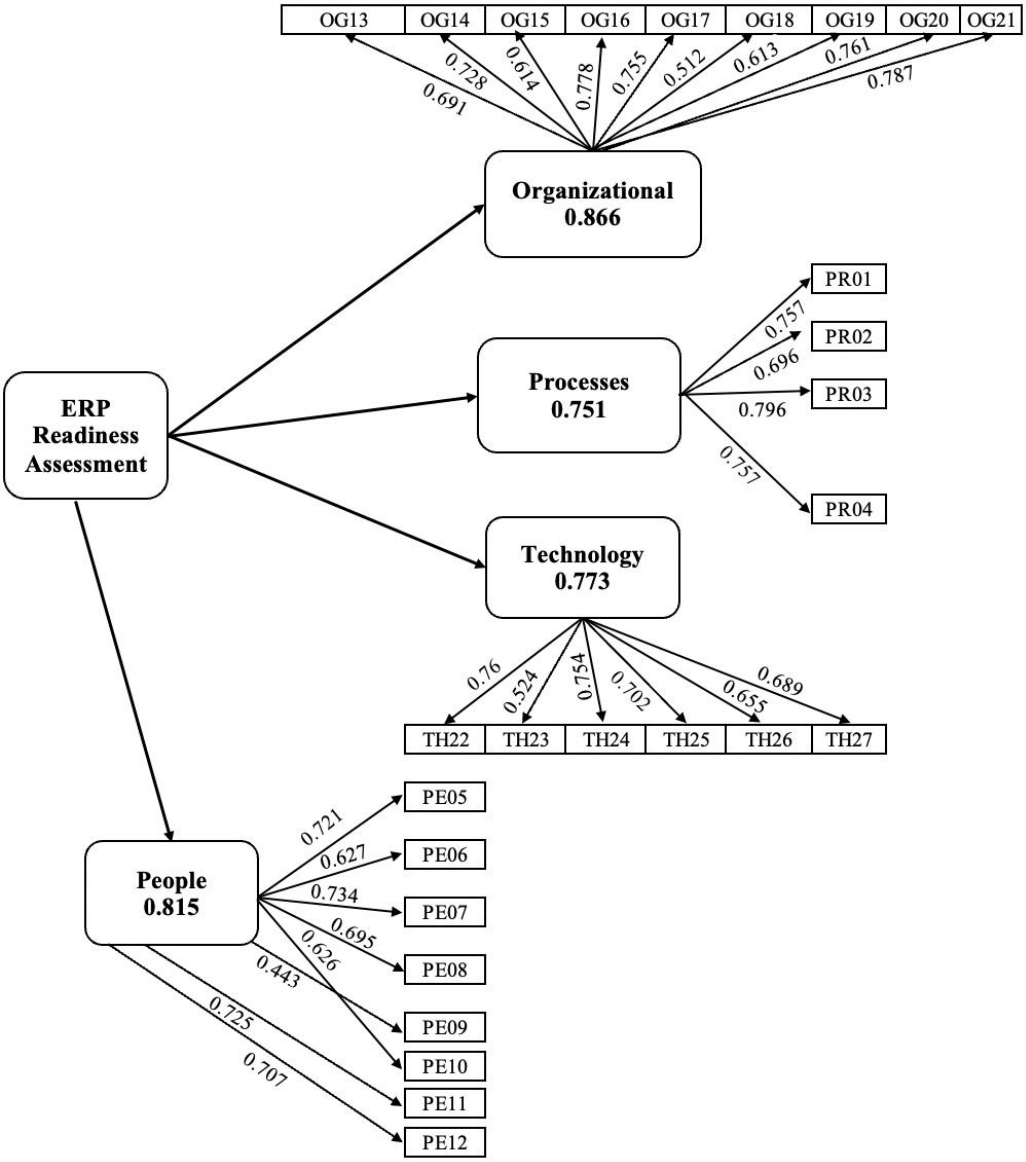

Figure 2. Results of the SmartPLS model.

$$dj = 1 - Ej, \forall j. \quad (3)$$

6. Assume that the total weight = 1, so to get the weight of each criterion, the dispersion value was normalized using (4), where *n* is the number of criteria.

$$Wj = \frac{dj}{\sum_{j=1}^{n} dj, \forall j.} \quad (4)$$

III. RESULT AND ANALYSIS

The results of data processing using PLS-SEM were obtained and the data processing results from the respondents' questionnaire statements were tested using Kaiser-Meyer-Olkin (KMO) and Bartlett's tests. It was then obtained measure of sampling adequacy (MSA) values of 0.781 and sphericity *df* of 0.351. The results of the questionnaire statements from the respondents were declared eligible for further testing. The results of data processing can be seen in Table I.

Based on the data test result in Table I, the measure of sampling adequacy was 0.781, indicating that it was feasible to continue with the test results. The result of the SmartPLS model after the indicators were tested using the PLS-SEM method is shown in Figure 2. The summary of the results of the SmartPLS model to test the validity of the dimensions and indicators showed that the CA values of organization, people, process, and technology were 0.866, 0.815, 0.751, and 0.773, respectively. Then, the CR values of the organization, people, process, and technology were 0.895, 0.862, 0.842, and 0.840, respectively. The AVE values of the organization, people, process, and technology were 0.616, 0.554, 0.637, 0.586, respectively.

Based on the CR and Validity table calculation results, CA and CR had a constructed value of > 0.70 and AVE had a construct value of > 0.50. These results showed that all questionnaire statements from the respondents were reliable. The summary of the analysis results of the measurement model using PLS-SEM can be seen in Table II.

Based on the summary of the analysis results of the measurement model, organization was the first dimension with nine indicators having CA of 0.866, followed by people with eight indicators having CA of 0.815. Processes was the third dimension with four indicators having CA of 0.751. The fourth dimension was technology with six indicators having CA of 0.773. The organization dimension is a significant aspect that affects the measurement of the company's readiness level in

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TABLE II
SUMMARY OF ANALYSIS RESULTS OF THE MEASUREMENT MODEL

Id	FL	CA	CR	AVE	Mean
OG13	0.691	0.866	8.895	0.616	0.689
OG14	0.728				0.730
OG15	0.614				0.608
OG16	0.778				0.771
OG17	0.755				0.735
OG18	0.521				0.529
OG19	0.613				0.608
OG20	0.761				0.757
OG21	0.787				0.795
PE05	0.721	0.815	0.862	0.554	0.712
PE06	0.627				0.629
PE07	0.734				0.725
PE08	0.695				0.692
PE09	0.626				0.626
PE10	0.443				0.447
PE11	0.725				0.723
PE12	0.707				0.704
PR01	0.757	0.751	0.842	0.637	0.766
PR02	0.696				0.691
PR03	0.796				0.665
PR04	0.757				0.777
TH22	0.763	0.773	0.840	0.586	0.747
TH23	0.524				0.514
TH24	0.754				0.737
TH25	0.702				0.713
TH26	0.655				0.645
TH27	0.689				0.684

FL = Factor loading, CA = Cronbach's alpha, CR= composite reliabilities, AVE= average variance extract

implementing ERP. In this research, the ranking of indicators was calculated using the entropy method. The results of indicator ranking data calculation is presented in Table III.

The data processing using the entropy indicator ranking test and comparing the results with the PLS-SEM validity test resulted in ten indicator rankings as seen in Table III. It can be seen from this table that the most significant indicator from the organization dimensions are effective communication, organizational culture, shared values, and agile organization. It shows that communication effectiveness and organizational culture are essential indicators in determining readiness to implement ERP. This result can answer the first research question that the main factor that affects the measurement of the company's readiness level in implementing ERP is communication effectiveness and organizational culture factor from the organization dimension. They are the main strength for organizations in implementing ERP, namely effective communication and organizational culture within the project team and between the involved departments to provide solutions to the constraints faced by users or parties involved in the ERP project. For that, it is necessary to build media for better communication. From the technology dimension, the essential indicators are data integrity management, system integration, and IT infrastructure. It proves that technology strongly influences a company's readiness to implement ERP. With data integrity management, it is vital to ensure data integration in producing information for management decision-

TABLE III
INDICATOR RANKING

Rank	Indicators		Score
1	OR16	Communication effective	0.9598
2	OR16	Organizational culture	0.9387
3	TE24	Data integrity management	0.9248
4	TE22	System integration	0.9221
5	PE08	Training and education	0.8996
6	PE06	Project champion	0.8914
7	TE25	IT infrastructure	0.8906
8	OR13	Shared values	0.8869
9	PE12	Clear roles and responsibilities	0.8499
10	OR21	Agile organizational	0.8427

making. IT infrastructure is also influential in ensuring data traffic communication runs smoothly so that the process of user interaction with the system can create synergy. In addition, the role of system integration is to ensure synchronization in running the ERP system used. It should also be noted from the people dimension that the essential indicators are training and education, project championship, and clear roles and responsibilities. Training and education indicators are essential to ensure that users understand the business processes of the ERP system modules used; it will improve the quality of the information produced by the ERP system for decision-making at the company management level. The project champion indicator also plays a role in achieving successful ERP implementation readiness. The project champion's task is to ensure that each stage of the ERP implementation process proceed according to the specified target. A good project champion is someone who knows and is accepted by the project team and has a comprehensive understanding of the company's business processes. Besides that, in the people dimension, it is essential for each project team to have clearly defined roles and responsibilities. With clear roles and responsibilities, there will be good cooperation and cohesiveness from each project team, which will determine the readiness level of the company in migrating to implement the ERP system.

The research result also designed the measurement model to assess the company's readiness to implement ERP based on agile parameters by focusing on four main variables: processes, people, organization, and technology. By adopting agile parameters, the company has a flexible work style and ensures that work outcomes meet business requirements. It is in line with the aim of implementing an ERP system, which is to improve business processes, so that companies have an advantage in analyzing ERP system requirements and reducing complexity of implementing ERP systems. For this reason, a measurement model is needed to assess the company's readiness to implement an ERP system, which can be used as an assessment instrument to ensure timely ERP implementation success. It answers the second research question in designing a measurement model to measure the readiness level of companies in implementing ERP systems.

IV. CONCLUSION

Based on the results of the analysis and discussion of this research, it can be concluded that effective communication and organization culture within the organization are crucial to achieving successful ERP implementation promptly. This research showed that the level of company readiness in

implementing ERP was carried out by identifying the communication effectiveness and organizational culture indicators, with the organization dimension being an indicator and a dominant measurement in determining the level of company readiness. Focusing on agile parameters such as processes, people, organization, and technology, the results of this research also designed a model to develop a measurement model for determining a company's readiness level in implementing an ERP system. This research identified 27 indicators and indicator ratings as assessment tools. This measurement model can be utilized as a basis for an assessment instrument to achieve ERP implementation by designing a prototype of the company's readiness assessment application features in implementing ERP systems, which can be use d by industry players, practitioners, consultants, and academics to achieve success in implementing ERP systems.

The research results developed a readiness model that could be used as a tool to measure a company's readiness level in implementing ERP. Researchers acknowledge that this research is still limited and has not yet built a readiness application. For this reason, it is an opportunity for future researchers to build a readiness application that can be used by related parties to assess a company's readiness prior to migrating to an ERP system implementation, thereby reducing the failure rate.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest during the writing of this paper.

AUTHOR CONTRIBUTION

Conceptualization, Santo Fernandi Wijaya, Jansen Wiratama, and Angelina Ervina Jeanette Egeten; methodology, Santo Fernandi Wijaya; validation, Jansen Wiratama, and Angelina Ervina Jeanette Egeten; formal analysis, Santo Fernandi Wijaya, Jansen Wiratama, and Angelina Ervina Jeanette Egeten; writing—original draft preparation, Jansen Wiratama, and Angelina Ervina Jeanette Egeten; writing—review and editing, Santo Fernandi Wijaya.

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