Determining priority criteria for industry 4.0 maturity models in small and medium enterprises in Indonesia

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Abstract. For manufacturing companies, especially Small and Medium Enterprises (SMEs), currently measuring the level of the Maturity Model (MM) is not an easy thing to do, because there are still many obstacles, including not knowing what factors are priorities in developing the MM. This research aims to identify the criteria that influence the measurement of maturity model based on survey results in small and medium enterprises. Using the Fuzzy DEMATEL method to find the priority and causality of each criterion attribute. The research results show that the Advanced IT criteria is the first priority to be considered to have the most influence on measuring the industry 4.0 maturity model.

Keywords: industry 4.0, small and medium enterprises (SMEs), criteria, maturity model, Fuzzy DEMATEL.

1. Introduction

Currently, Indonesia is entering the era of the industrial revolution 4.0. The industrial revolution 4.0 refers to the stage of development and management of the entire value chain process in industry. The term of Industry 4.0 (I 4.0) was first used in Germany precisely at the Hannover Fair (Kagermann, Luke & Wahlster, 2011). The purpose of the industrial revolution 4.0 is to increase the competitiveness of a country's industry in the face of a dynamic global market. This is due to the rapid development and utilization of digital technology in various aspects.

The World Economic Forum study classifies world countries into four groups: 1) The Nascent Group, namely countries with weak industrial base conditions and facing major challenges in the future; 2) Legacy Group, namely countries with a weak industrial base, but the challenges that must be faced in the future are relatively lighter; 3) High Potential Group, namely countries that have a strong industrial base but face major challenges in the future; and 4) Leading groups, namely countries that already have a strong industrial base with relatively mild challenges in the future. Based on the assessment, Indonesia is in the Nascent group, which means that Indonesia is a country with a weak industrial base and faces major challenges in the future. Basically, the Indonesian government is committed to building a globally competitive manufacturing industry through the acceleration of I 4.0 implementation (Kearney, 2018).

The Maturity Model (MM) helps companies determine steps or goals to carry out the development process and determine optimization. Maturity assessment is very important because it allows the identification of organizational strengths and weaknesses that can be used to improve corporate governance and corporate risk management. For manufacturing companies, especially small and medium scale, at this time to measure the level of MM is not an easy thing to do, because there are still many obstacles faced including not knowing what factors affect the MM, how to develop an MM. In addition to determining factors and ranking which factors are the most important, then we also need to know the relationship or relationship between factors. It is necessary to see the

relationship between factors, because one factor with another factor that exists in an organization must have a relationship and connection, therefore we want to know which factors have a close and strong relationship.

One way that can be used is with the fuzzy DEMATEL method. The application of the DEMATEL fuzzy method aims to determine the relationship or main criterion in measuring the level of industrial Model Maturity 4.0. The fuzzy DEMATEL method is a merger of the fuzzy theory and the DEMATEL method. The DEMATEL method can show the influence of each factor and fuzzy theory can make calculations more accurate because the value ranges from 0 to 1.

DEMATEL's fuzzy method in this study was conducted to determine the factors that influence developing of the I 4.0 MM for Small and Medium Enterprises (SMEs) in Indonesia. The study was conducted by conducting a survey using questionnaires. The advantage of the DEMATEL method is the ability to uncover relationships between factors that influence other factors in the development of MM (Gabus and Fontela, 1973). In addition, with the DEMATEL method can be obtained direct and indirect influence between criteria, calculating causal relationships and strengths between criteria selection factors. The DEMATEL method does not need large amounts of data. It is hoped that later the results of this research can help select criteria in the development of MM for Small and Medium Enterprises (SMEs) in Indonesia to be able to adopt I 4.0 and also increase understanding and readiness of Small and Medium Enterprises (SMEs) to face I 4.0 in Indonesia. The focus of this study is to identify criteria that affect the measurement of MM based on survey results from small and medium enterprises. And using the Fuzzy DEMATEL method, this study will find the priority and causality of each criterion attribute.

The implementation of this research is certainly motivated by revolutionary science, so it will experience development from day to day. With these developments, modifications of existing science are needed to create more varied research outcomes. The modification and combination of existing science must of course be based on the study of applicable literature and policies. The state of the art of this study is listed in the Table 1.

2. Methods

This research will be conducted by collecting data from the results of questionnaire distribution to several SMEs in Indonesia and also using Forum Group Discussion (FGD). The distribution of questionnaires will be carried out using two stages. The first phase will target 20 SMEs with the aim of obtaining inputs for category weighing domains in MM. The second phase will target 50 companies with the aim of obtaining data for the I 4.0 maturity model. The sample SMEs in this study are "representatives" of SMEs in Indonesia.

The research tools and materials that will be used in this study are by filling out questionnaires by respondents consisting of 2 questionnaires. The first questionnaire contains 44 questions divided into 7 parts, the question type is multiple choice using the Likert scale (4 levels). The first questionnaire is made in the form of google form, while the second questionnaire is made in the form of Microsoft Excel. The collected data will later be processed using the fuzzy DEMATEL method.

In this study, several stages of research were carried out until later the results of the research were obtained. The first stage is taxonomy and the second is ontology, then a survey is carried out to determine what factors I have influenced the development of MM. The sample SMEs in this study are "representatives" of SMEs in Indonesia. After knowing what factors influence, then calculations are carried out using Fuzzy DEMATEL to find out the priority criteria and also to find out the relationship between criteria that affect the development of MM.

Table 1 State of the Art

Research	Institution/ source	Number of level	Name of the attributes	Number of Attributes	Weighting Method	Maturity Definition	Assess-ment method Describe	Strong/ Weak points Identifi-cation
An overview of the Business Process Maturity Model (BPMM)	J. Lee, D. Lee, S. Kang (2007)	5	Elements	4	No	No	No	Yes
Records Management Maturity Model	JISC InfoNet	5	Categories/ Dimensions		No	No	Yes	No
A Capability Maturity Model for Research Data Management	Syracuse University	5	IT-business aligment criteria	6	No	No	Yes	Yes
Gartner Enterprise Information Management Maturity Model	D. Newman, D. Logan (2008)	5	Dimensions / Category	4	No	No	Yes	No
Towards a Risk Maturity Mode	D. A. Hillson (1997)	4	Attributes	4	No	No	Yes	No
COBIT 4.1 – Framework, Control Objectives, Management Guidelines, Maturity Models	IT Governance Institute (2007)	6	Attributes	4	No	No	Yes	Yes
Stanford Data Governance Maturity Model	Stanford University	5	Dimensions	3	No	No	Yes	Yes
The Connected Enterprise MaturityModel	Rockwell Automation (2014)	4	Dimensions	N/A	No	No	Yes	Yes
The Singapore Smart Industry Readiness Index	EDB Singapore (2017)	8	Dimensions	16	No	No	Yes	No
IMPULSE – Industrie 4.0 Readiness, VDMA's IMPULSEtiftung	Lichtblau et al. (2015)	6	Dimensions	18	No	No	No	Yes
Roadmap Industry 4.0— Implementation Guideline for Enterprise	Technische Universitat darmstadt (2017)	2	Dimensions	6	No	Yes	Yes	Yes
This research	Sebelas Maret University (UNS) (2023)	6	Dimensions	16	Yes	Yes	Yes	Yes

Research Steps

Figure 1 shows the research steps. The first step in data processing for this study is to analyse the main criteria that influence the development of the I 4.0 MM based on survey results. The next step is to process survey data using the fuzzy DEMATEL method until finally the best criteria that affect the I 4.0 MM are obtained. Here are the research steps that will be carried out on data processing using fuzzyDEMATEL.

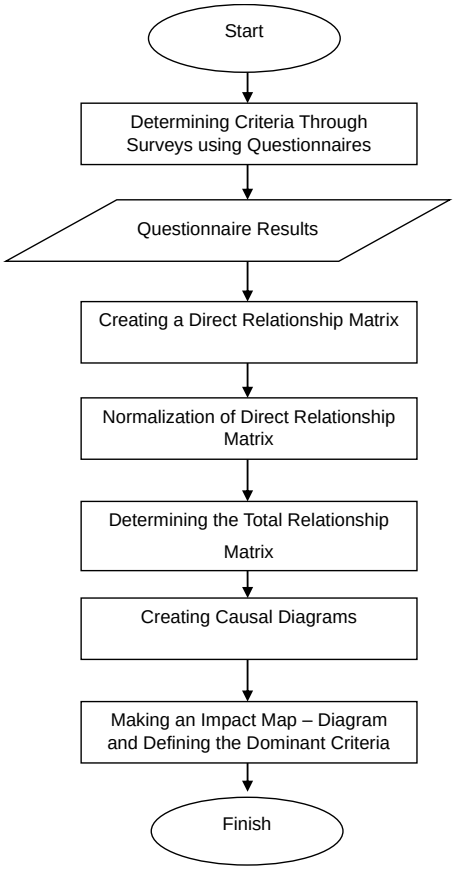

Figure 1 Research steps.

3. Result and Discussion

The DEMATEL method is a well-known and comprehensive method for obtaining structural models that provide casual relationships between complex real-world factors. The DEMATEL method is superior to other techniques such as the Analytic Hierarchy Process (AHP) because it explains the interdependence among system factors through causal diagrams, which are ignored in traditional techniques.

In this study, the Fuzzy DEMATEL method was used to assess the relationship between factors that affect MM. The application of the DEMATEL fuzzy method aims to determine the relationship or main criterion in measuring the level of industrial Model Maturity 4.0. The fuzzy DEMATEL method is a merger of the fuzzy theory and the DEMATEL method. The DEMATEL method can show the influence of each factor and fuzzy theory can make calculations more accurate because the value ranges from 0 to 1. This combination is used for the imprecise and subjective nature of human judgment. Interval sets are used instead of real numbers in fuzzy set theory. Linguistic terms are changed to fuzzy numbers. The proposed method is advantageous for revealing relationships among factors and ranking criteria related to the type of relationship and the impact of severe levels on each criterion.

The procedure of the Fuzzy DEMATEL method is explained as follows:

Step 1. Determine the criteria for evaluation results. The criteria and sub-criteria used to evaluate the I 4.0 MM obtained from the results of the questionnaire distribution are shows in Table 2.

Table 2 Table of criteria and sub criteria

No	Criterion	Sub Criteria
1	Technology	Advance IT Data and Information
2	Product	Data analytics in usage phase ICT add-on functionalities
3	Operation/Process	Integration Inventory and Supply Chain Quality
4	Resources	Asset Utilization Employee
5	Culture	Collaboration Willingness to change Digital Leadership
6	Organization Governance	Innovation Management Agility Investment for Industry 4.0 Strategy for Industry 4.0

Step 2. Select a group of experts who have knowledge and experience on the problem to evaluate the effect between factors using paired comparisons.

Step 3. To deal with the vagueness of human judgment, the linguistic variable "influence" is used with a five-level scale that contains the following scale items in group decision making: No influence, Very low influence, Low influence, High influence, and Very high influence. The fuzzy numbers for these linguistic terms are given in Table 3.

Table 3 Triangular Fuzzy Number Table

Linguistic Relationships	Score	Triangular FuzzyNumber (TFN)
No Influence	0	(1, 1, 3)
Very Low Influence	1	(1, 3, 5)
Low Influence	2	(3, 5, 7)
High Influence	3	(5, 7, 9)
Very High Influence	4	(7, 9, 9)

Step 4. Compile a direct-relation matrix (T) The set of data that has been obtained from respondents is arranged into a direct relationship matrix containing numbers on a scale of 0 to 4. This matrix expresses the influence of the criteria.

Step 5. Transformation of Triangular FuzzyNumber (TFN) into an initial direct-relation matrix (F).

From the results of the TFN transformation, an initial-direct relation matrix F is created.Initial-direct relation matrix F is obtained from the results of TFN transformation into crisp values with the CFCS method. The following is an example of calculating the initial direct relation matrix of the first questionnaire (F1) with the CFCS method. There are five stages in the CFCS method, namely:

a. Normalization

The normalization of the elements in the direct relationship matrix is done using the equation below with n = 1 because of the first person.

$$\bar{z}_{ij1}^{k} = \frac{z_{ij1}^{k} - \min z_{ij1}^{k}}{\max z_{ij3}^{k} - \min z_{ij1}^{k}}; \quad \bar{z}_{ij2}^{k} = \frac{z_{ij2}^{k} - \min z_{ij1}^{k}}{\max z_{ij3}^{k} - \min z_{ij1}^{k}}; \quad \bar{z}_{ij3}^{k} = \frac{z_{ij3}^{k} - \min z_{ij1}^{k}}{\max z_{ij3}^{k} - \min z_{ij1}^{k}}$$

b. Calculates left normal (ls) and right normal (rs) values

$$lz_{ij}^{k} = \frac{\bar{z}_{ij2}^{k}}{1 + \bar{z}_{ij2}^{k} - \bar{z}_{ij1}^{k}}; \quad lz_{ij}^{k} = \frac{\bar{z}_{ij3}^{k}}{1 + \bar{z}_{ij3}^{k} - \bar{z}_{ij2}^{k}}$$

c. Calculate the total value of normal crisp

$$tz_{ij}^{k} = \frac{lz_{ij}^{k}\left(1 - lz_{ij}^{k}\right) + rz_{ij}^{k}\, rz_{ij}^{k}}{1 - lz_{ij}^{k} + rz_{ij}^{k}}$$

d. Calculating crisp values

$$z_{ij}^{k} = \min z_{ij1}^{k} + tz_{ij}^{k}\left(\max z_{ij3}^{k} - \min z_{ij1}^{k}\right)$$

e. Combine crisp values

$$z_{ij} = \frac{1}{l}\sum_{k=1}^{l} z_{ij}^{k}$$

Table 4 shows the initial direction matrix combined and Table 5 is a description table of the symbols in Table 4.

Table 4 Table of Initial direct-relation matrix F combined

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1	1.00	8.17	7.71	7.52	7.61	7.43	7.05	7.24	5.65	5.47	7.43	6.40	7.89	7.71	8.17	8.27
A2	7.89	1.00	7.80	7.43	6.68	7.89	6.49	6.96	5.56	5.46	7.33	6.87	8.08	7.61	7.89	7.89
A3	7.99	8.17	1.00	7.13	6.31	7.15	6.86	6.59	3.70	5.28	7.15	6.77	7.52	7.33	7.89	7.80
A4	8.17	7.61	8.08	1.00	6.31	6.68	6.31	6.77	3.88	4.81	6.49	6.21	7.61	7.52	7.71	7.89
A5	7.80	7.24	6.49	6.31	1.00	6.49	6.02	6.21	6.58	6.02	6.77	5.66	6.77	6.77	7.89	7.89
A6	7.80	6.59	6.49	6.21	6.21	1.00	7.80	5.93	4.90	7.33	7.43	4.62	7.05	6.03	7.71	7.71
A7	7.52	6.49	6.77	6.03	5.84	5.65	1.00	6.77	6.77	6.12	6.68	4.25	8.08	5.56	7.80	8.17
A8	6.96	7.05	6.87	7.89	5.93	5.28	6.77	1.00	5.37	6.03	7.15	6.30	7.33	6.49	7.71	7.61
A9	5.93	6.68	5.65	4.72	6.21	4.63	6.40	4.63	1.00	4.34	6.68	5.18	7.80	6.87	7.71	7.80
A10	6.40	7.15	6.12	5.84	6.59	7.99	7.24	3.60	4.35	1.00	8.08	4.90	7.05	7.33	7.24	7.99
A11	7.15	6.59	6.49	6.03	6.77	5.56	7.52	4.07	7.61	6.59	1.00	6.21	8.08	7.71	7.71	7.71
A12	6.21	6.59	6.96	5.93	6.77	5.19	6.02	5.28	7.61	5.09	6.49	1.00	6.40	7.15	7.61	7.71
A13	7.43	7.15	7.89	7.52	7.89	7.52	7.14	6.31	7.33	8.17	7.99	7.70	1.00	8.08	8.08	8.08
A14	7.24	6.77	6.77	5.84	7.61	6.68	7.24	6.21	6.77	7.61	7.99	7.70	7.89	1.00	8.08	7.99
A15	7.33	6.87	7.33	7.05	6.96	6.31	6.12	6.59	6.21	7.52	7.61	6.96	8.17	7.89	1.00	8.27
A16	7.43	7.15	7.43	7.24	7.05	6.68	6.40	7.15	6.30	7.70	7.71	7.24	8.08	8.08	8.36	1.00

Table 5 Table description symbol criteria

Symbol	Criterion	Symbol	Criterion
A1	Advance IT	A9	Employee
A2	Data and Information	A10	Collaboration
A3	Data analytics in usage phase	A11	Willingness to change
A4	ICT add-on functionalities	A12	Digital Leadership
A5	Integration	A13	Innovation Management
A6	Inventory and Supply Chain	A14	Agility
A7	Quality	A15	Investment for Industry 4.0
A8	Asset Utilization	A16	Strategy for Industry 4.0

Step 6. Compiling the normalization of the matrix of direct relations (S), see Table 6.

Table 6 Generalized direct relation matrix S

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1	0.009	0.071	0.067	0.065	0.066	0.064	0.061	0.063	0.049	0.047	0.064	0.055	0.068	0.067	0.071	0.072
A2	0.068	0.009	0.068	0.064	0.058	0.068	0.056	0.06	0.048	0.047	0.064	0.06	0.07	0.066	0.068	0.068
A3	0.069	0.071	0.009	0.062	0.055	0.062	0.06	0.057	0.032	0.046	0.062	0.059	0.065	0.064	0.068	0.068
A4	0.071	0.066	0.07	0.009	0.055	0.058	0.055	0.059	0.034	0.042	0.056	0.054	0.066	0.065	0.067	0.068
A5	0.068	0.063	0.056	0.055	0.009	0.056	0.052	0.054	0.057	0.052	0.059	0.049	0.059	0.059	0.068	0.068
A6	0.068	0.057	0.056	0.054	0.054	0.009	0.068	0.051	0.043	0.064	0.064	0.04	0.061	0.052	0.067	0.067
A7	0.065	0.056	0.059	0.052	0.051	0.049	0.009	0.059	0.059	0.053	0.058	0.037	0.07	0.048	0.068	0.071
A8	0.06	0.061	0.06	0.068	0.051	0.046	0.059	0.009	0.047	0.052	0.062	0.055	0.064	0.056	0.067	0.066
A9	0.051	0.058	0.049	0.041	0.054	0.04	0.055	0.04	0.009	0.038	0.058	0.045	0.068	0.06	0.067	0.068
A10	0.056	0.062	0.053	0.051	0.057	0.069	0.063	0.031	0.038	0.009	0.07	0.043	0.061	0.064	0.063	0.069
A11	0.062	0.057	0.056	0.052	0.059	0.048	0.065	0.035	0.066	0.057	0.009	0.054	0.07	0.067	0.067	0.067
A12	0.054	0.057	0.06	0.051	0.059	0.045	0.052	0.046	0.066	0.044	0.056	0.009	0.056	0.062	0.066	0.067
A13	0.064	0.062	0.068	0.065	0.068	0.065	0.062	0.055	0.064	0.071	0.069	0.067	0.009	0.07	0.07	0.07
A14	0.063	0.059	0.059	0.051	0.066	0.058	0.063	0.054	0.059	0.066	0.069	0.067	0.068	0.009	0.07	0.069
A15	0.064	0.06	0.064	0.061	0.06	0.055	0.053	0.057	0.054	0.065	0.066	0.06	0.071	0.068	0.009	0.072
A16	0.064	0.062	0.064	0.063	0.061	0.058	0.055	0.062	0.055	0.067	0.067	0.063	0.07	0.07	0.073	0.009

Step 7. Construct a total relation matrix (M). to find the total relationship matrix M, namely by multiplying the normalization matrix S by the identity matrix subtracted by the normalization matrix (S) then inverse the matrix. It is shown in Table 7.

Table 7 Total relation matrix M

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1	**0.629**	**0.671**	0.661	**0.627**	0.639	0.618	**0.635**	**0.581**	0.557	**0.585**	**0.68**	**0.589**	**0.71**	**0.679**	0.731	**0.738**
A2	**0.676**	**0.602**	0.653	**0.617**	0.622	**0.613**	**0.621**	**0.57**	0.548	**0.577**	**0.67**	**0.584**	**0.701**	**0.669**	0.718	**0.724**
A3	**0.655**	**0.64**	0.577	**0.596**	0.599	**0.588**	**0.604**	**0.549**	0.516	**0.557**	**0.647**	**0.565**	**0.675**	**0.645**	0.695	**0.7**
A4	**0.649**	**0.628**	0.627	0.538	0.592	0.577	**0.593**	**0.544**	0.511	**0.546**	**0.634**	**0.554**	**0.667**	**0.639**	0.686	**0.692**
A5	**0.637**	**0.617**	0.606	**0.574**	0.54	**0.568**	**0.583**	**0.532**	0.525	**0.548**	**0.628**	**0.542**	**0.652**	**0.625**	0.678	**0.684**
A6	**0.632**	0.607	0.601	0.568	0.578	0.518	**0.592**	**0.525**	0.507	0.554	**0.627**	0.529	0.648	0.613	0.671	**0.676**
A7	**0.623**	**0.599**	0.596	0.561	0.569	0.55	**0.529**	**0.527**	0.517	0.538	**0.615**	0.52	0.649	0.603	0.664	**0.672**
A8	**0.63**	**0.615**	0.609	0.586	0.581	0.558	**0.588**	0.489	0.515	0.547	**0.63**	0.547	0.656	0.622	0.676	**0.681**
A9	**0.572**	**0.563**	0.55	0.515	0.536	0.507	**0.538**	0.477	0.438	0.491	**0.576**	0.495	0.607	0.575	0.622	**0.628**
A10	**0.611**	**0.601**	0.588	**0.556**	0.572	0.566	**0.578**	**0.498**	0.495	0.494	**0.623**	**0.522**	**0.638**	**0.614**	0.656	**0.667**
A11	**0.636**	0.616	0.61	0.575	0.592	0.564	**0.598**	0.519	0.537	0.556	0.584	0.55	0.667	0.636	0.681	0.687
A12	**0.603**	**0.591**	0.588	**0.551**	0.568	0.538	**0.562**	**0.507**	0.516	**0.522**	**0.604**	0.484	**0.626**	**0.606**	0.652	**0.658**
A13	**0.704**	**0.684**	0.684	**0.647**	0.661	0.638	**0.656**	**0.591**	0.588	0.625	**0.707**	0.618	0.676	0.704	0.754	**0.76**
A14	**0.671**	**0.651**	0.645	**0.605**	0.631	0.604	**0.628**	**0.564**	0.559	**0.594**	**0.676**	**0.591**	**0.701**	0.616	0.721	**0.726**
A15	**0.667**	**0.647**	0.645	**0.61**	0.621	**0.597**	**0.615**	**0.563**	0.55	**0.589**	**0.668**	**0.581**	**0.697**	**0.667**	0.657	**0.722**
A16	**0.682**	**0.663**	0.659	**0.625**	0.635	**0.612**	**0.63**	**0.58**	0.562	**0.603**	**0.683**	**0.596**	**0.712**	**0.683**	0.733	**0.679**

Step 8. Sums row and column values. The next stage in processing data using the fuzzyDEMATEL method is to add the row and column values in the total relation matrix M which is denoted as D and R. The value of D is referred to as the dispatcher vector, while the value of R is referred to as the receiver vector (see Table 8).

The total influence matrix is shown in Table 8, then determine the threshold value to find out the relationship among 16 criteria. According to Shieh (2010) the threshold value is obtained from the average of all T matrix values (total relation matrix) which is 0.608. A value below 0.608 indicates that the two criteria are not related. Table 5 lists the description of the symbols in Table 8.

Step 9. The degree of central role is calculated from the (D+R) and (D-R) values of each criterion. The main criteria based on the degree of central role is the largest value (D + R) and the smallest value (D-R). In the fuzzyDEMATEL method, the degree of central role (Dx + Rx) represents the magnitude of the influence of one criterion on another. In

addition, if (Dx-Rx) > 0 or positive, then criterion x has more influence on other criteria. Meanwhile, if (Dx-Rx) < 0 or negative, then criterion x receives more influence than other criteria.

Table 8 Table of Total R and D values

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	D
A1	**0.629**	**0.671**	0.661	**0.627**	0.639	0.618	**0.635**	**0.581**	0.557	**0.585**	**0.68**	**0.589**	**0.71**	**0.679**	0.731	**0.738**	10.33
A2	**0.676**	**0.602**	0.653	**0.617**	0.622	**0.613**	**0.621**	**0.57**	0.548	**0.577**	**0.67**	**0.584**	**0.701**	**0.669**	0.718	**0.724**	10.16
A3	**0.655**	**0.64**	0.577	**0.596**	0.599	**0.588**	**0.604**	**0.549**	0.516	**0.557**	**0.647**	**0.565**	**0.675**	**0.645**	0.695	**0.7**	9.809
A4	**0.649**	**0.628**	0.627	0.538	0.592	0.577	**0.593**	**0.544**	0.511	**0.546**	**0.634**	**0.554**	**0.667**	**0.639**	0.686	**0.692**	9.677
A5	**0.637**	**0.617**	0.606	**0.574**	0.54	**0.568**	**0.583**	**0.532**	0.525	**0.548**	**0.628**	**0.542**	**0.652**	**0.625**	0.678	**0.684**	9.541
A6	**0.632**	0.607	0.601	0.568	0.578	0.518	**0.592**	**0.525**	0.507	0.554	**0.627**	0.529	0.648	0.613	0.671	**0.676**	9.446
A7	**0.623**	**0.599**	0.596	0.561	0.569	0.55	**0.529**	**0.527**	0.517	0.538	**0.615**	0.52	0.649	0.603	0.664	**0.672**	9.334
A8	**0.63**	**0.615**	0.609	0.586	0.581	0.558	**0.588**	0.489	0.515	0.547	**0.63**	0.547	0.656	0.622	0.676	**0.681**	9.528
A9	**0.572**	**0.563**	0.55	0.515	0.536	0.507	**0.538**	0.477	0.438	0.491	**0.576**	0.495	0.607	0.575	0.622	**0.628**	8.691
A10	**0.611**	**0.601**	0.588	**0.556**	0.572	0.566	**0.578**	**0.498**	0.495	0.494	**0.623**	**0.522**	**0.638**	**0.614**	0.656	**0.667**	9.28
A11	**0.636**	0.616	0.61	0.575	0.592	0.564	**0.598**	0.519	0.537	0.556	0.584	0.55	0.667	0.636	0.681	0.687	9.61
A12	**0.603**	**0.591**	0.588	**0.551**	0.568	0.538	**0.562**	**0.507**	0.516	**0.522**	**0.604**	0.484	**0.626**	**0.606**	0.652	**0.658**	9.175
A13	**0.704**	**0.684**	0.684	**0.647**	0.661	0.638	**0.656**	**0.591**	0.588	0.625	**0.707**	0.618	0.676	0.704	0.754	**0.76**	10.7
A14	**0.671**	**0.651**	0.645	**0.605**	0.631	0.604	**0.628**	**0.564**	0.559	**0.594**	**0.676**	**0.591**	**0.701**	0.616	0.721	**0.726**	10.18
A15	**0.667**	**0.647**	0.645	**0.61**	0.621	**0.597**	**0.615**	**0.563**	0.55	**0.589**	**0.668**	**0.581**	**0.697**	**0.667**	0.657	**0.722**	10.1
A16	**0.682**	**0.663**	0.659	**0.625**	0.635	**0.612**	**0.63**	**0.58**	0.562	**0.603**	**0.683**	**0.596**	**0.712**	**0.683**	0.733	**0.679**	10.34
R	10.28	9.995	9.899	9.353	9.537	9.216	9.551	8.616	8.441	8.926	10.25	8.869	10.68	10.2	11	11.09	0.609

Table 9 Table of degrees of central role

	D	R	D+R	D-R
A1	10.329691	10.277389	20.60708	0.0523019
A2	10.164963	9.9952238	20.160187	0.1697391
A3	9.8092101	9.8993441	19.708554	-0.090134
A4	9.6770206	9.3531411	19.030162	0.3238795
A5	9.5411477	9.5366224	19.07777	0.0045253
A6	9.4460112	9.2162519	18.662263	0.2297593
A7	9.3340239	9.5509361	18.88496	-0.216912
A8	9.5283281	8.6158469	18.144175	0.9124812
A9	8.6905186	8.4410518	17.13157	0.2494668
A10	9.2800946	8.9258793	18.205974	0.3542153
A11	9.6099963	10.251744	19.861741	-0.641748
A12	9.1754081	8.8687053	18.044113	0.3067028
A13	10.695546	10.681876	21.377422	0.0136707
A14	10.184514	10.19539	20.379904	-0.010877
A15	10.095377	10.995331	21.090708	-0.899954
A16	10.336542	11.093659	21.4302	-0.757117

Analysis of linkage relationships between criteria can be determined from the results (D - R). When (D – R) is positive, the criterion is part of a causal group, meaning it affects another criterion. Meanwhile, if (D - R t) is negative, the criterion is part of the affected group, meaning it is influenced by other criteria.

Criteria A1 (Advance IT), A2 (Data and Information), A4 (ICT add-on functionalities), A5 (Integration), A6 (Inventory and Supply Chain), A8 (Asset Utilization), A9 (Employee), A10 (Collaboration), A12 (Digital Leadership), A13 (Innovation Management) affect other criteria. Meanwhile, the criteria that are influenced or influenced by other criteria are A3

(Data analytics in usage phase), A7 (Quality), A11 (Willingnes to change), A14 (Agility), A15 (investment for I 4.0), A16 (Strategy for I 4.0).

Step 10. Build casual diagrams and strategy maps. A clearer visualization of the structure and relationships between existing criteria will be visible at this stage. In a causal diagram, the horizontal axis is formed from the value (D+R) which is the level of the central role. Meanwhile, the vertical axis is formed from the value (D-R) which is the level of relationship. In a causal diagram, the main criteria can be determined by looking at the x and y values on the diagram. The main criterion has the largest x value and the smallest y value. The strategy map is built from the importance and total-relation matrix M.

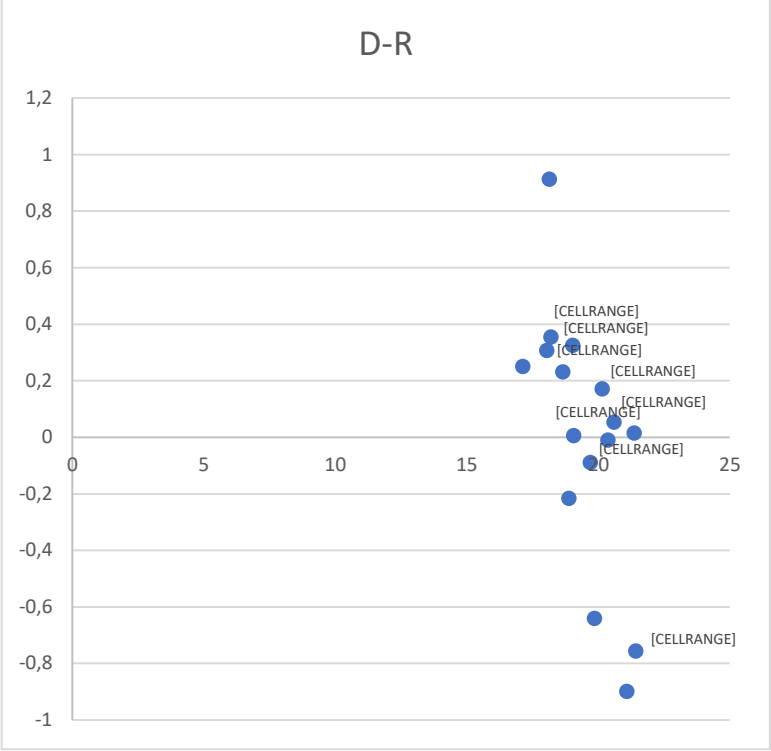

Figure 2 Causal diagram.

In Figure 2, the casual diagram shows that the greater the value of x, the greater the influence of the criterion on other criteria. Criteria below the y=0 line receive less influence from other criteria than criteria above the y=0 line. The main criteria based on the casual diagram are determined from the largest x value and the smallest y value. From the diagram above, there are 10 criteria that have a considerable influence on the other 6 criteria. Criteria A1 (Advance IT) with value x = 20.607, A2 (Data and Information) with value x = 20.160, A4 (ICT add-on functionalities) with value x = 19.030, A5 (Integration) with value x = 19.077, A6 (Inventory and Supply Chain) with value x = 18.622, A8 (Asset Utilization) with value x = 18.144, A9 (Employee) with value x = 17.131, A10 (Collaboration) with value x = 18.205, A12 (Digital Leadership) with a value of x = 18,044, A13 (Innovation Management) with a value of x = 21,377. From the ten criteria, there are 6 criteria under the line y = 0, namely A3 (Data analytics in usage phase) with a value of y = -0.090, A7 (Quality) with a value of y = -0.216, A11 (Willingnes to change) with a value of y = -0.641, A14 (Agility) with a value of y = -0.010, A15 (investment for I 4.0) with a value of y = -0.899, A16 (Strategy for I 4.0) with a value of y = -0.757.

Based on these results, the 10 highest priorities can be determined from 16 criteria that have been tested for importance. From the calculation results obtained, it can be

concluded that the criteria that are the top priority are the Advance IT criteria. Advanced IT criteria are considered to greatly affect the development of MM because. In addition to having an important role, information and communication technology is also a company asset that needs careful attention. Today, business infrastructure cannot be separated from information and communication technology. Information and communication technology infrastructure allows business people to communicate and conduct transactions with stakeholders so easily.

4. Conclusion

This research using questionnaires to identify 6 main criteria with 16 sub-criteria that influenced the development of The Industry 4.0 Maturity Model. We used the Fuzzy DEMATEL method to identify causal relationships between criteria. Therefore, using the Fuzzy DEMATEL method, the importance of the six criteria can be determined and causal relationships between criteria can also be seen. The results of this study show that Advance IT is a very important and prioritized criterion. Advanced IT criteria are considered to greatly affect the development of the Maturity Model because. In addition to having an important role, information and communication technology is also a company asset that needs careful attention. Information and communication technology infrastructure allows business people to communicate and conduct transactions with stakeholders so easily. The presence of IT technology can provide various important benefits in order to develop the company's business. Some of the roles of IT technology in business development include presenting opportunities for the emergence of new business potential, simplifying the process of monitoring company employees, potentially reducing company operational costs, helping to speed up the communication process within the company and making business data more organized. Further research in supplier selection can be conducted using other fuzzy methods such as fuzzyAHP, fuzzyTOPSIS, and fuzzyANP.

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