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Modeling SMEs' Trust in the Implementation of Industry 4.0 using Kansei Engineering and Artificial Neural Network: Food and Beverage SMEs Context

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Highlights:

- The questionnaire was developed using semantic analysis.
- The best ANN model were selected based on 4 main architectures.
- The output of ANN model was classification of distrust, trust and overtrust.
- SMEs trust was influenced by education, knowledge, familiarity, benefit, preference ranking and verbal components
- The model could be used to assist policy makers in recommending appropriate technology

Abstract. Trust is an important aspect for policy makers in recommending the implementation of Industry 4.0 in food and beverage small and medium-sized enterprises (SMEs). SMEs' trust in the implementation of Industry 4.0 is defined as the level of belief in applying appropriate technology for Industry 4.0 based on their knowledge, familiarity, agreement and preference. Trust is a complex construct involving several Kansei words, or human mentality parameters. Artificial neural network modeling was utilized to model SMEs' trust in implementation of Industry 4.0. The research objectives were: 1) to analyze the trust of SMEs in the implementation of Industry 4.0 using Kansei Engineering; 2) to model the trust of SMEs in the implementation of Industry 4.0 using an artificial neural network (ANN). A questionnaire was developed using Kansei words that were generated from adjectives to represent human mentality parameters, which were stimulated by visual samples of Industry 4.0 technology. The questionnaires were distributed among 190 respondents from the three large islands of Indonesia. The data were recapitulated for training, validating and testing the ANN model based on the backpropagation supervised learning method. The best model architecture was eight input neurons, eight hidden neurons, and one output neuron (8-8-1) The output was classification of trust as 'distrust', 'trust' or 'overtrust'. The research results indicated that the SMEs' trust was influenced by education, knowledge, familiarity, benefit, preference ranking and verbal components.

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1 Introduction

Food and beverage SMEs (small and medium-sized enterprises) have significant potential growth, resources and domestic demand in Indonesia. More than 80% of human resources in the food and beverage industry are employed by SMEs [1]. The Ministry of Industry of Indonesia has launched the program Making Indonesia 4.0 as a strategy to develop national Industry 4.0 sovereignty through integrated information and communication technology [1]. Industry 4.0 in food and beverage SMEs was selected as a priority for Making Indonesia 4.0 [1].

The implementation of Industry 4.0 is expected to have several positive impacts on SME development. The 'smart learning factory' is referred to as an essential example of Industry 4.0 for SMEs [2]. The utilization of information and communication technology is expected to have a positive impact on the competitiveness of SMEs [3]. Despite these benefits, food and beverage SMEs are vulnerable and not yet fully ready to accept Industry 4.0 [4]. Industry 4.0 has not yet gained sufficient trust of SME management due to the gap between financial constraints and creativity amenities [4]. The trust of SME management is defined as the level of belief among the owners or managers of SMEs to decide to implement the appropriate technology for Industry 4.0. Trust can be categorized as 'trust', 'overtrust' or 'distrust' [4]. 'Trust' occurs when there is risk management prior to the decision; 'overtrust' occurs when there is no risk management prior to the decision; 'distrust' occurs when there is doubt about the decision.

Trust has been proposed as a Kansei parameter in the scope of innovation. Kansei is a Japanese word that refers to human mentality parameters. Trust can be influenced by several other Kansei parameters, such as knowledge, familiarity, agreement and preference [4,5]. Some Kansei parameters have been evaluated for food and beverage SMEs, such as workload [6], environmental ergonomics [7] and work incentives [8]. However, these parameters were utilized in the context of ergonomic workplace design. The function of the Kansei Engineering method is to quantify Kansei words as measurable parameters. Kansei Engineering has been used in industry due to its capability to analyze human mentality parameters in product areas [9,10], service areas [11,12], information technology [13], and system development [6-8]. Kansei Engineering is required to analyze trust in the implementation of Industry 4.0 due to the complexity of human mentality parameters.

Artificial intelligence has been used to model Kansei parameters based on taxonomist knowledge [14], worker behavior and motion [15], and postures [16]. Artificial neural network (ANN) is an artificial intelligence method that can be used to define complex systems of abstract parameters due to its capability of handling large feature sets and nonlinearity [17]. This is supported by various example applications of ANN for Kansei Engineering related to Kansei words [18], semantic labeling [17], technology adoption by SMEs [19] and the food industry [20]. Therefore, in this study ANN modeling was an appropriate method to model trust in the implementation of Industry 4.0. Research on trust modeling related to Industry 4.0 has been conducted in different fields, such as the maritime industry [21]; agricultural systems (farmer training) [22]; food systems [23]; electronic commerce [24]; recommendations in social networks [25]; wireless sensor networks [26]; Internet of Things [27], and a rural support program [28]. However, none of these modelings concerned trust of food and beverage SMEs in the implementation of Industry 4.0.

This paper proposes the modeling of trust in the implementation of Industry 4.0 in food and beverage SMEs using Kansei Engineering and ANN. The research objectives were: 1) to analyze the trust of SMEs in the implementation of Industry 4.0 using Kansei Engineering; 2) to model the trust of SMEs in the implementation of Industry 4.0 using an ANN. The resulting model can be used to assist policy makers in recommending the appropriate technology, start-up capital and financial incentives based on SME creativity.

2 Theoretical Foundation: Conceptual Model

Figure 1 depicts the conceptual model of SMEs' trust in the implementation of Industry 4.0 using Kansei Engineering. The methodology of Kansei Engineering-type II as Kansei Engineering system was selected due to its capability to model SMEs [6-8]. The conceptual model was adapted from Lee and See [5] and Ushada, *et al*. [4]. The model covers four scopes: 1) SME management; 2) Industry 4.0 technology; 3) Industry 4.0 implementation; and 4) local governments.

The SME management scope concerns human mentality parameters, technology benefit, education level, and technology preference. These factors consider trust as a complex modeling problem that can be solved by using an ANN. The basic hypothesis of this model is that trust can be influenced by the mentality parameters knowledge, familiarity, and agreement level [10]. These mentality parameters stimulate the innovation capability based on technology benefits. The technology benefits, i.e. machinery and tools, e-commerce and promotion, and ergonomic work methods, can assist SMEs in creatively upgrading to Industry 4.0. The Industry 4.0 technology scope concerns the decision whether to use existing technology or an improved version. The Industry 4.0 implementation scope concerns technology application and evaluation to provide feedback to the management of SMEs. The local governments scope concerns the commitment of policy makers for financial support and capacity building. Higher trust of SMEs stimulates higher responsiveness to the recommendation of the government to upgrade to Industry 4.0 technology.

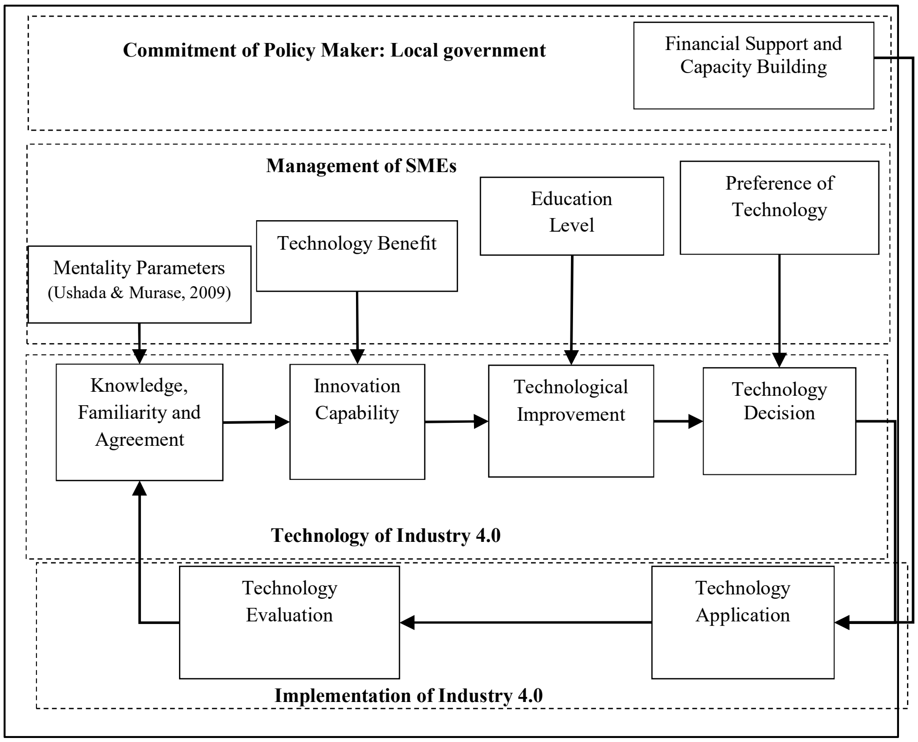


Figure 1 A conceptual model of trust in implementation of Industry 4.0 in food and beverage SMEs (adapted from Lee & See [5] and Ushada, *et al.* [4]).

3 Material and methods

Figure 2 indicates the research method used for modeling SMEs' trust. It consists of the following steps.

3.1 Preliminary Interviews

Preliminary interview were conducted with 21 managers of SMEs in the Special Region of Yogyakarta. The respondents were selected with convenience sampling based on their willingness to respond to the questionnaire. The interview was structured to stimulate responding to the questionnaire. The twelve questions were generated by a focus group discussion as guidance for the interviews (See Table 1). Structured interviews were conducted, where the respondents were prompted with a list of questions and they could answer anything to the given questions.

Table 1 List of interview questions.

No	Questions
1	SME company profile
2	Please explain the production process
3	Please explain the technology/machinery in the production system
4	Please explain if you apply hybrid manual and automatic technology
5	Please explain your feelings about the existing technology fulfilling ergonomic requirements
6	Please explain your plan to increase SME productivity by using technology
7	Please explain your method for promotion and marketing
8	Please explain your opinion on industrial revolutions
9	Please explain your opinion on Industry 4.0
10	Please explain your opinion on ICT application in SME production systems
11	Please explain your opinion on automatization technologies and computerized production systems
12	Please provide five keywords to represent your opinion on Industry 4.0

3.2 Extraction of Kansei Words

The interviews generated the list of Kansei words shown in Table 2, stimulated by visual samples of Industry 4.0 technology. The Kansei Engineering method was used to extract Kansei words from the interviews. The method uses a semantic analysis based on: 1) total repetition of words; 2) number of respondents who respond to similar words based on the twelve interview questions in Table 1 related to implementation of Industry 4.0 in food and beverage SMEs.

3.3 Development of Questionnaire

The developed questionnaire consisted of attribute-based Kansei words and the preference for Industry 4.0. Kansei words were developed in the form of adjective as well as nouns; this is appropriate in the context of the development of a new product/technology [10].

3.3.1 Attribute-based Kansei words

The list of Kansei words in Table 2 was extracted to get the list of user attributes in the questionnaire shown in Table 3. This is effective to extract the user response to a new technology [10]. The questionnaire was developed in Bahasa Indonesia and required five to ten minutes to answer. It was conducted in two versions: paper-based (offline) and Google form-based (online).

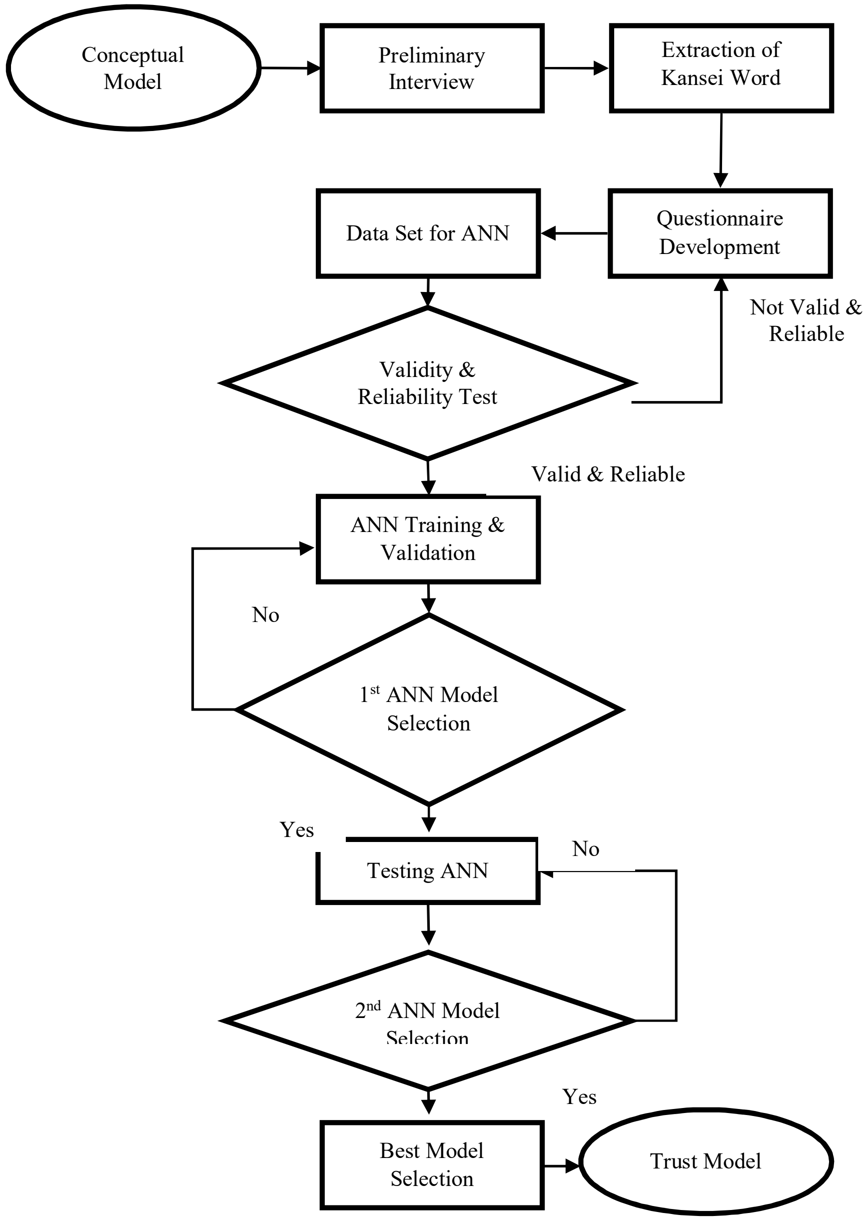


Figure 2 Research methods for modeling SMEs' trust in the implementation of Industry 4.0.

Table 2 Repetition of words in interviews.

Kansei Words	Total Repetition	Number of Respondents
No	19	3
Enough	4	2
Benefit	3	1
Not yet	8	4
Abandoned	2	1
Human	8	2
Productions	56	13
Not	35	8
Market	2	1
Marketing	6	2
Entrepreneurship	5	1
Technology	51	12
Nice	12	4
Nothing	2	1
Difficult	2	1
Easy	2	1
Not interested	3	1
Interested	4	1
Industry	3	1
Automation	4	2
Work	9	3
Dream	2	1
Already	8	2
Tools	4	1
Effective	2	1
Efficient	2	1
Labor	13	4
Computer	2	1
Have been	2	1
Good	3	1
Expensive	4	1
Advantage	2	1
Industrial revolution	6	1
Comfort	2	1
SMEs	3	1
Demand	2	1
Data	2	1
Modern	2	1
Work	9	3

3.3.2 Technology Preference for Industry 4.0

Technology preference refers to the types of Industry 4.0 technology that are recommended [29]. Technology ranking is the best possible way to identify the preferences of respondents related to new products and technologies [10]. Three categories of technology preferences were generated from the interviews. These were ranked by the respondents from 1st to 3rd choice.

1. *Ergonomic work methods*
   Ergonomic work methods refers to ergonomic sensor technology. The latest development related to ergonomic sensors in SME production systems is the Kansei Engineering-based sensor for agroindustry [30].

Table 3 List of questions for questionnaire.

Code	Questions
A	**Informed consent and pre-knowledge explanation**
B	**Demographic Data**
1	Business scope
2	SME's location
3	Educational background of SME's manager
C	**Knowledge and Background Information**
1	Do you know about ergonomic work methods, machinery and tools, e-commerce and promotion?
2	Are you familiar with the use of handphones/laptops/computers in workstations?
3	Do you agree that Industry 4.0 could support better performance of SMEs?
D	**Ranking of Recommendations for Industry 4.0**
1	Ergonomic work methods
2	Machinery and tools
3	E-commerce and promotion
E	**Benefit of Industry 4.0**
1	Ergonomic work methods
2	Modern machinery and tools
3	E-commerce and promotion
F	**Preference for Industry 4.0**
1	**Work method**
A	Efficient
B	Effective
C	Simple
D	Realistic
E	Adaptive
F	Tutorial
G	Readiness
2	**Machinery & Tools**
A	Efficient
B	Effective
C	Modern
D	Economical
E	Automatic
F	Quality
G	Realistic
H	Adaptive
I	Tutorial
J	Readiness
K	Appropriate version
3	**E-commerce and promotion**
A	Modern
B	Simple
C	Economical
D	Quality
E	Adaptive
F	Tutorial
G	Readiness
H	Attractive
I	Appropriate version
G	**Trust**
1	Do you have trust in Industry 4.0 compared to existing technology?

2. *Machinery and tools*
   Technology in the form of machinery and tools provides advantages for food and beverage SMEs. This includes modern mechanization as the basic technology for agricultural industry in Indonesia [31].
3. *E-commerce and promotion*
   E-commerce is online technology that assists SMEs in trading their products, while promotion is used for marketing their products regionally, nationally and internationally. It also provides feedback for product design and development [13].

3.4 Calibration of Questionnaire

The questionnaire was calibrated prior to data acquisition in order to minimize the bias of the respondents when responding to the questionnaire. The questionnaire was calibrated internally with 11 researchers from the project team. The researchers were two technicians and nine students who supported the research activities. The calibration process stimulated the researchers to find biases towards questionnaire attributes when they acted as SME respondents.

3.5 Validity and Reliability Test for Questionnaire

The questionnaire attributes were validated to confirm whether they could achieve the research objective. Data were confirmed as valid if the counted correlation coefficient $R_{count} > R_{table}$, the correlation coefficient of Pearson's table. Subsequently, the questionnaire attributes were tested for reliability to confirm sustainable application. Cronbach's alpha was utilized to test the reliability. Data were confirmed as reliable based on the minimum value of correlation coefficient R_{count}. Validity and reliability tests were applied to the questionnaire attributes using SPSS.

3.6 Descriptive Statistical Analysis

Descriptive statistical analysis was conducted to process the questionnaire results. The statistical analysis was conducted in terms of mean, mode and standard deviation.

3.7 Data Set for ANN

An artificial neural network was used to model the trust of SMEs in implementation of Industry 4.0. An ANN was used for its capability to model multiple Kansei parameters such as trust. As can be seen from Table 3, trust is influenced by several of the factors described in the list of questions in the questionnaire. The questionnaire could contain derivative bias in the interview questions (Table 1) and the Kansei words (Table 2). The ANN used a feedforward architecture and supervised backpropagation learning. The ANN software was developed using Macro-based Microsoft Visual Basic Application for Microsoft Excel [32]. The training, validation and verification data were acquired from 190 respondents representing the three large islands of Indonesia. The data set of the questionnaire was recapitulated for use as the input and output of the ANN model.

3.7.1 Input of ANN Model

The input data of the ANN model consisted of education level, knowledge, familiarity, benefit of ergonomic work methods, and benefit of machinery and tools, benefit of e-commerce and promotion, preference ranking, and stated verbal trust. The input data were acquired from the questionnaire using a 1 to 5 Likert scale.

3.7.2 Output of ANN Model

The output of the ANN model was classification as 'distrust', 'trust' or 'overtrust'. The attribute of trust in the questionnaire was converted using the formula of the trust index. The formula indicates that the stated trust responses influenced the predicted trust in the questionnaire and the mentality constraint factors as follows:

$$Tp = (Ts \times MCf) \tag{1}$$

T_p = Predicted trust
T_s = Stated trust in the questionnaire
MC_f = Mentality constraint factors

The mentality parameters were defined as follows:

$$MC_f = \frac{\sum_{n=3}^{n}(\frac{B_e+B_m+B_c}{n})}{\sum_{m=3}^{m}(\frac{K+F+A)}{m}} \tag{2}$$

MC_f = Mentality parameters
B_e = Benefit of ergonomic technology (1 to 5 Likert scale)
B_m = Benefit of machinery technology (1 to 5 Likert scale)
B_c = Benefit of e-commerce technology (1 to 5 Likert scale)
K = Knowledge level of respondent (1 to 5 Likert scale)
F = Familiarity level of respondent (1 to 5 Likert scale)
A = Agreement level of respondent (1 to 5 Likert scale)
n = Number of benefits
m = Number of levesl

Finally, the error of trust (E_t) was defined as the deviation between the stated trust and the predicted trust as follows:

$$E_t = (T_s\text{-}T_p) \tag{3}$$

Individual trust was categorized as 'distrust' when $E_t < 0$
Individual trust was categorized as 'trust' when $0 < E_t < 1$
Individual trust was categorized as 'overtrust' when $E_t > 0$

3.8 Respondents for ANN Data Training and Validation

One hundred and sixty managers of food and beverage SMEs participated in the research. Eighty respondents came from the Special Region of Yogyakarta, while the remaining 80 respondents came from Medan and surrounding areas, Northern Sumatra and surrounding provinces. The data acquisition was conducted offline in Yogyakarta, where the experimenters visited each SME. It was conducted by online in Medan and surrounding areas.

3.9 Respondents for ANN Data Testing

Thirty respondents were selected from Timor Tengah Utara district, Eastern Nusa Tenggara province for ANN data testing. The questionnaire acquisition was conducted in a focus group discussion (FGD). The same questionnaire was used in Yogyakarta and Medan for the purpose of data testing. The FGD was a local art workshop. The area of Timor Tengah Utara was selected because it is a frontier area and outermost region, unlike Yogyakarta and Medan. Also, the respondents were categorized as SMEs fostered by the local government. This circumstantial differentiation made the respondent sample suitable for ANN's data testing. Having different segments was appropriate for testing the performance of the ANN [20].

4 Results

Table 4 shows the results of the validity and reliability tests of the questionnaire attributes. The statistical test indicated that 34 attributes were valid and reliable. These attributes were validated using Pearson's correlation. Subsequently, the reliability was tested using Cronbach's alpha. Data were valid if the counted correlation coefficient $R_{count} > R_{table}$, the correlation coefficient from Pearson's table. $R_{table} = 0.2199$ and a correlation was significant at the 0.05 level (two-tailed). An attribute was categorized as reliable if the counted correlation coefficient $R_{count} > R_{table}$. The R_{count} values for knowledge and background information, the benefit of Industry 4.0, preference for ergonomic work methods, machinery and tools, e-commerce and promotion, and trust were 0.520, 0.707, 0.786, 0.796, 0.820 and 0.908, respectively. The questionnaire attributes were analyzed using a descriptive statistical analysis of which the results are shown in Table 5.

Table 4 Validity and reliability test.

Num	Questions	Validity R_{count}	Reliability R_{count}	Status
A	**Knowledge and Background Information**			
A1	Do you know about ergonomic work methods, machinery and tools, e-commerce and promotion?	0.578	0.520	Valid & Reliable
A2	Are you familiar with handphones/laptops/computers in workstations?	0.828	0.520	Valid & Reliable
A3	Do you agree that Industry 4.0 could support better performance of SMEs?	0.734	0.520	Valid & Reliable
B	**Benefit of Industry 4.0**			
B1	Ergonomic work methods	0.759	0.707	Valid & Reliable
B2	Modern machinery and tools	0.772	0.707	Valid & Reliable
B3	E-commerce and promotion	0.848	0.707	Valid & Reliable
C	**Preference for Industry 4.0**			
C1	**Ergonomic work method**			
C11	Efficient	0.637	0.786	Valid & Reliable
C12	Effective	0.638	0.786	Valid & Reliable
C13	Simple	0.614	0.786	Valid & Reliable
C14	Realistic	0.682	0.786	Valid & Reliable
C15	Adaptive	0.637	0.786	Valid & Reliable
C16	Tutorial	0.700	0.786	Valid & Reliable
C17	Readiness	0.738	0.786	Valid & Reliable
C2	**Machinery & Tools**			
C21	Efficient	0.630	0.796	Valid & Reliable
C22	Effective	0.630	0.796	Valid & Reliable
C23	Modern	0.526	0.796	Valid & Reliable
C24	Economical	0.465	0.796	Valid & Reliable
C25	Automatic	0.544	0.796	Valid & Reliable
C26	Quality	0.580	0.796	Valid & Reliable
C27	Realistic	0.491	0.796	Valid & Reliable
C28	Adaptive	0.580	0.796	Valid & Reliable
C29	Tutorial	0.588	0.796	Valid & Reliable
C210	Readiness	0.681	0.796	Valid & Reliable
C211	Appropriate version	0.656	0.796	Valid & Reliable
C3	**E-commerce and promotion**			
C31	Modern	0.599	0.820	Valid & Reliable
C32	Simple	0.555	0.820	Valid & Reliable
C33	Economical	0.561	0.820	Valid & Reliable
C34	Quality	0.749	0.820	Valid & Reliable
C35	Adaptive	0.520	0.820	Valid & Reliable
C36	Tutorial	0.601	0.820	Valid & Reliable
C37	Readiness	0.713	0.820	Valid & Reliable
C38	Attractive	0.696	0.820	Valid & Reliable
C39	Appropriate version	0.784	0.820	Valid & Reliable
D	**Trust***			
D1	Do you have trust in Industry 4.0 compared to existing technology?	0.437	0.908	Valid & Reliable

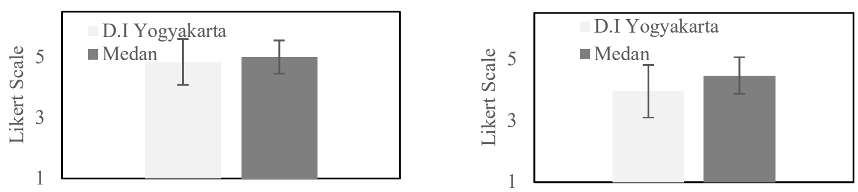
Table 5 Descriptive statistical analytic.

Questions	Mode		Percentage		Average	
	Yogyakarta	Medan	Yogyakarta	Medan	Yogyakarta	Medan
A1	4	4	61.25	32.93	3.83 ± 0.85	3.27 ± 1.02
A2	2	4	38.75	36.59	3.08 ± 1.31	3.78 ± 1.05
A3	3	5	56.25	48.78	3.95 ± 0.86	4.46 ± 0.60
B1	4	4	58.75	56.10	4.09 ± 0.77	4.36 ± 0.56
B2	5	5	50	69.51	4.35 ± 0.76	4.65 ± 0.60
B3	5	5	57.5	75.61	4.40 ± 0.88	4.73 ± 0.53
C11	5	5	45	62.20	4.34 ± 0.67	4.56 ± 0.66
C12	4	5	47.5	51.22	4.25 ± 0.68	4.40 ± 0.74
C13	4	5	48.75	35.37	4.15 ± 0.84	4.18 ± 0.80
C14	4	3	46.25	42.68	3.91 ± 0.92	3.68 ± 0.80
C15	4	3	47.5	40.24	3.69 ± 0.84	3.64 ± 0.82
C16	4	4	53.75	43.90	3.80 ± 0.92	3.88 ± 0.91
C17	4	5	50	28.05	4.04 ± 0.85	4.45 ± 0.71
C21	5	5	51.25	70.73	4.39 ± 0.74	4.64 ± 0.64
C22	5	5	51.25	62.20	4.43 ± 0.65	4.53 ± 0.72
C23	5	5	41.25	45.12	4.10 ± 0.94	4.26 ± 0.87
C24	5	5	68.75	62.20	4.60 ± 0.65	4.53 ± 0.72
C25	4	4	46.25	41.46	3.96 ± 0.88	4.10 ± 0.89
C26	5	5	71.25	70.73	4.66 ± 0.57	4.67 ± 0.60
C27	4	4	41.25	45.12	3.61 ± 0.77	3.82 ± 0.79
C28	3	4	41.25	43.90	3.70 ± 0.82	3.76 ± 0.84
C29	3	5	36.25	41.46	3.51 ± 0.95	4.17 ± 0.86
C210	4	5	40	45.12	3.84 ± 0.89	4.24 ± 0.84
C211	5	5	53.75	78.05	4.38 ± 0.80	4.74 ± 0.57
C31	5	5	53.75	80.49	4.30 ± 0.89	4.77 ± 0.58
C32	4	5	43.75	60.98	3.91 ± 0.93	4.42 ± 0.92
C33	5	5	58.75	65.85	4.53 ± 0.64	4.62 ± 0.65
C34	5	5	61.25	71.95	4.49 ± 0.76	4.68 ± 0.61
C35	4	4	42.5	50.00	3.65 ± 0.78	3.86 ± 0.73
C36	4	5	47.5	40.24	3.93 ± 0.88	4.19 ± 0.85
C37	4	5	47.5	53.66	3.95 ± 0.90	4.47 ± 0.66
C38	5	5	72.5	81.71	4.56 ± 0.82	4.79 ± 0.54
C39	5	5	43.75	52.44	4.21 ± 0.88	4.31 ± 0.87
D1	4	4	53.75	68.29	4.84 ± 0.75	5.00 ± 0.55

The selected attributes for three forms of recommendation technology are given in Table 6. Figure 3(a) and (b) summarize the comparison of the trust and agreement levels in Yogyakarta and Medan based on mode, percentage, and average values.

Table 6 Selected attributes for recommendation of industry 4.0.

Priority	Industry 4.0	Attribute
1	**Machinery and Tools**	
		Efficient Effective Modern Economical Automatic Quality Realistic Appropriate version
2	**E-commerce and promotion**	
		Modern Economical Quality Adaptive Attractive Appropriate version
3	**Ergonomic work methods**	
		Efficient Tutorial



(a) (b)

Figure 3 Comparison between Yogyakarta and Medan: (a) trust; (b) agreement.

4. **Discussion**

4.1 Recommendations for Industry 4.0

Based on the comparison of the statistical descriptive analytics (Table 4), both the respondents from the Special Region of Yogyakarta and Medan and surrounding areas selected machinery and tools as the first priority and ergonomic work methods as the last priority as recommendations for implementation of Industry 4.0. Besides, the research results confirmed Ushada, *et al.* [4] who stated that the government should initiate the dissemination of a sustainable ergonomic program for the production systems of food and beverage SMEs. Improvement of work methods is no full concern yet in food and beverage SMEs due to the gap between ergonomics and welfare benefits such as wages, incentives and other financial support [4]. Table 6 shows the attributes selected for Industry 4.0. When an attribute was preferred by respondents from both Yogyakarta and Medan we call it a collective preference. For machinery and tools, eight out of eleven attributes were collective preferences. For e-commerce and promotion, six out of nine attributes were collective preferences. For ergonomic work methods, only two out of seven attributes were collective preferences.

4.2 SMEs' Trust

Figure 3(a) shows that there was no significant trust difference between Yogyakarta, representing the island of Java, and Medan, representing the island of Sumatra. Both segments had high collective trust in Industry 4.0. The trust result was supported by the comparison of agreement in Figure 3(b). Both respondent groups had high agreement with the statement that implementation of Industry 4.0 can increase the added value in the scopes of machinery and tools, e-commerce and promotion, and ergonomic work methods. However Figure 3(a) and 3(b) show that the respondents from Medan had a higher level of trust and agreement than those from Yogyakarta. This was affected by the higher values of A1 (knowledge) and A2 (familiarity). Table 5 shows a higher level of knowledge and familiarity in Medan and surrounding areas compared to the Special Region of Yogyakarta.

4.3 Building the ANN Model

The data of sub-system measurement were recapitulated into a set containing 190 data. The 190 data were collected from three respondent segments: 1) 80 respondents from SMEs in Medan and surrounding areas, Sumatra island; 2) 80 respondents from the Special Region of Yogyakarta, Java island; 3) 30 respondents from the Timor Tengah Utara district, Nusa Tenggara island. The segments of Medan and Yogyakarta were used for training and validation, while the segment of Timor Tengah Utara was used for testing. The training process was conducted in two steps. Table 1 shows the sensitivity analysis results of the ANN model based on the output error determined on a trial-and-error basis. Based on the minimum root mean square error (RMSE) of training and validation, the optimum neurons in the hidden layer were selected.

4.4 First Training

In the first step, we used the respondent data from Yogyakarta and Medan. The numbers of training and validation data were 145 and 15 respectively. The individual trust was modeled using the ANN model. Four architectures of the ANN were evaluated to test the sensitivity of the trust model, as shown in Table 7. The four best architectures were selected based on trial and error with the parameters in terms of RMSE and coefficient of determination R^2 between the measured and the predicted value.

Table 7 The four best ANN based on training and validation.

Model	Architecture (Input-Hidden-Output)	Iteration	Training RMSE	Validation RMSE	R^2
1	5-3-1	20000	0.13	0.11	0.83
2	6-4-1	10000	0.1	0.076	0.85
3	7-3-1	20000	0.1	0.078	0.88
4	8-4-1	10000	0.058	0.049	0.95

4.5 Testing the ANN Model

The four best models were validated using the data of the respondent segment from Timor Tengah Utara. The purpose was to test the capability of the model in responding to different data [7]. In the second step, the thirty data of the respondents from Timor Tengah Utara were added accordingly. The numbers of training and validation data were 170 and 20 respectively. Based on Table 2, the best ANN architecture was selected. The behavior of the ANN was evaluated using a comparison of the structure of the ANN. The comparison indicated that the data from Nusa Tenggara were appropriate to test the structure of the ANN for different SME segments compared to respondents from Yogyakarta and Medan. For example, in the same structure of eight inputs, the 8-4-1 structure changed to 8-8-1 when R^2 was reduced from 0.95 to 0.85, increasing the error from 0.049 to 0.088. This indicated that by adding thirty data from a different segment, the number of hidden layers increased from four to eight, which means more capability of ANN was required.

Table 8 Selected four best models using ANN .

Models	Architecture (Input-Hidden-Output)	Iteration	Training RMSE	Validation RMSE	R^2
1	5-2-1	20000	0.16	0.14	0.78
2	6-3-1	20000	0.15	0.13	0.76
3	7-3-1	20000	0.096	0.16	0.63
4	8-8-1	10000	0.067	0.088	0.85

4.6 Best Model Selection

The research results indicated that the best ANN structure was 8-8-1. The selected inputs of ANN were education level, knowledge, familiarity, benefit of ergonomic work methods, benefit of machinery and tools, benefit of e-commerce and promotion, preference ranking, and stated verbal trust. The output was classification of trust in the implementation of Industry 4.0 as distrust, trust or overtrust. The tested ANN model successfully classified SMEs trust in Industry 4.0 using the backpropagation supervised learning method.

4.7 Possible Application of Trust Model

The trust model was used as an additional feature for the Kansei Engineering-based Sensor for Agro-industry (KESAN) as parameterization system for collective trust [33]. The trust model can be used by local governments to formulate the precise recommendations for implementation of Industry 4.0 among SME clusters. The government assistance could be focused on clusters instead of single SMEs. For instance, if a local government grants a machinery upgrade then the SME cluster could share the utilization of the machinery by appropriate scheduling among single SMEs. This kind of assistance could be effective for the implementation of Industry 4.0 in food and beverage SMEs [34].

5 Conclusion

The research results indicated that SMEs’ trust in Industry 4.0 was successfully modeled by using Kansei Engineering and an artificial neural network (ANN). Kansei Engineering was used to extract Kansei words using the semantic methods of word repetition and number of respondents who responded with similar words. Trust could be modeled using ANN based on the backpropagation supervised learning method. The best model architecture was eight input neurons, eight hidden neurons and one output neuron (8-8-1). The output was classification of trust in the implementation of Industry 4.0 as distrust, trust or overtrust. The training, validation and testing data showed satisfying performance of the ANN with minimum error rate. The ANN model had similar R^2 values between the training and validation data. The modeling indicated that the classification of trust in the implementation of Industry 4.0 in food and beverage SMEs is influenced by education level, knowledge, familiarity, benefit of ergonomic work methods, machinery and tools, e-commerce and promotion, preference ranking, and stated verbal trust. The model can be used to assist policy makers in recommending appropriate technology for food and beverage SMEs.

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References

[1] Anonymous, *Making Indonesia 4.0: Indonesia's Fourth Industrial Revolution,* National Ministry of Industry, 2018.

[2] Grube, D., Malik, A.A. & Bilberg, A., *SMEs Can Touch Industry 4.0 in the Smart Learning Factory,* Procedia Manuf., **31**, pp. 219-224, 2019. DOI: 10.1016/j.promfg.2019.03.035.

[3] Qosasi, A., Permana, E., Muftiadi, A., Purnomo, M. & Maulina, E., *Building SMEs'competitive Advantage and the Organizational Agility of Apparel Retailers In Indonesia: The Role of ICT as an Initial Trigger*, Gadjah Mada Int. J. Business **21**(1), pp. 69-90, 2019. DOI: 10.22146/ gamaijb. 39001.

[4] Ushada, M., Wijayanto, T. & Trapsilawati, F., *Trust as a Human Factor for Sustainable Ergonomics Application in Agro-industry*, Proceeding International Conference on Agro-industry 2018.

[5] Lee, J.D. & See K.A., *Trust in Automation: Designing for Appropriate Reliance*, Hum. Factors, **46**(1), pp. 50-80, 2004. DOI: 10.1518/hfes.46.1. 50_30392.

[6] Ushada, M., Okayama, T. & Murase, H., *Development of Kansei Engineering-Based Watchdog Model to Assess Worker Capacity in Indonesian Small-Medium Food Industry*, Engineering in Agriculture, Environment, and Food, **8**(4), pp. 241-250, 2015. DOI: 10.1016/ j.eaef.2015.03.004.

[7] Ushada, M., Okayama, T., Khuriyati, N. & Suyantohadi, A., *Affective Temperature Control in Food Smes Using Artificial Neural Network*, Applied Artificial Intelligence, **31**(7-8), pp. 555-567, 2017. DOI: 10.1080/ 08839514.2017.1390327.

[8] Ushada, M., Putro, N.A.S. & Khuriyati, N., *An Intelligent Incentive Model Based on Environmental Ergonomics for Food SMEs*, Journal of Engineering and Technological Sciences, **51**(6), pp. 839-864, 2019. DOI: 10.5614/j.eng.technol.sci.2019.51.6.7.

[9] Guo, F., Qu, Q., Nagamachi, M. & Duffy, V.G., *A Proposal of the Event-Related Potential Method to Effectively Identify Kansei Words for Assessing Product Design Features in Kansei Engineering Research*, International Journal of Industrial Ergonomics, **76**, 102940, 2020. DOI: 10.1016/j.ergon.2020.102940.

[10] Ushada, M. & Murase, H., *Design of Customisable Greening Material Using Swarm Modelling*, Biosys. Eng. **104**(2), pp. 169-183, 2009. DOI: 10.1016/j.biosystemseng.2009.06.019.

[11] Zabotto, C.N., Luis da, S.S., Amaral, D.C., Hornos, J.C.M. & Benze, B.G., *Automatic Digital Mood Boards to Connect Users and Designers with Kansei Engineering*, International Journal of Industrial Ergonomics, **74**, 102829, 2019. DOI: 10.1016/j.ergon.2019.102829.

[12] Yeh, C. & Chen, M., Applying Kansei Engineering and Data Mining to Design Door-to-door Delivery Service, Comput. Indust. Eng., **120**, 2018. DOI: 10.1016/j.cie.2018.05.011.
[13] Jiao, Y. & Qu, Q., *A Proposal For Kansei Knowledge Extraction Method Based on Natural Language Processing Technology and Online Product Reviews*, Comp. Indust., **108**, pp. 1-11, 2019. DOI: 10.1016/j.compind. 2019.02.011.
[14] Chaw, J.K. & Mokji, M., *Agricultural Products Recognition System Using Taxonomist's Knowledge as Semantic Attributes*, Food Agric. Environ, **9**(3), pp. 224-234, 2016. DOI: 10.1016/j.eaef.2016.01.004.
[15] Morio, Y.M., Shoji, T. & Murakami, K., *Working Motion Templates for Detecting Agricultural Worker Behaviors*, Food Agric. Environ., **9**(4), pp. 297-304, 2016. DOI: 10.1016/j.eaef.2016.03.002.
[16] Morio, Y., Inoue, T., Takaaki, T., Katsusuke, M., *Worker Posture Recognition for Understanding Agricultural Worker Behaviors*, Food Agric. Environ., **10**(3), pp. 208-222, 2017. DOI: 10.1016/j.eaef. 2017.03.002.
[17] Ayala, D., Borrego, A., Hernandez, I. & Ruiz, D. *A Neural Network for Semantic Labelling of Structured Information*, Expert Systems with Applications. **143**, 113053, 2019. DOI: 10.1016/j.eswa.2019.113053.
[18] He, T., Cao, L., Balas, V.E., McCauley, P. & Shi, F. *Curvature manipulation of the spectrum of Valence-Arousal-related fMRI Dataset Using Gaussian-shaped Fast Fourier Transform and Its application to Fuzzy KANSEI Adjectives Modeling*, Neurocomputing, **174**(Part B), pp. 1049-1059, 2016. DOI: 10.1016/j.neucom.2015.10.025.
[19] Habahbeh, A., Fadiya, S.O. & Akkaya, M., *Factors Influencing Smes Clouderp Adoption: A Test with Generalized Linear Model and Artificial Neural Network*, Data Brief., **20**, pp. 969-977, 2018. DOI: 10.1016/j.dib. 2018.07.012.
[20] Delgado, A., Rauh, C., Park, J., Kim, J. Groβ, F. & Diez, L., *Artificial Neural Networks: Applications in Food Processing*, Reference Module in Food Science, 2016. DOI: 10.1016/B978-0-08-100596-5.03125-5.
[21] Ellingsen, O. & Aasland, K.E, *Digitalizing the Maritime Industry: A Case Study of Technology Acquisition and Enabling Advanced Manufacturing Technology*, J. Eng. Technol. Manage, **54**, October-December 2019, 12-27, 2019. DOI: 10.1016/j.jengtecman.2019.06.001
[22] Valizadeh, R., Kawarizadeh, F. & Shokri, T., *Investigating the Effective Factors of Farmers' Trust in Trainers (Case Study: Agricultural Center of Ilam Province)*, Procedia – Social and Behavioral Sciences, **205**, 584-590, 2015. DOI: 10.1016/j.sbspro.2015.09.084.
[23] Tonkin, E.,Wilson, A.M., Coveney, J.,Meyer, S.B., Henderson, J.,McCullum, D., Webb, T. & Ward, P.R., *Consumers Respond to a Model*

For (Re)Building Consumer Trust in the Food System, Food Control, **101**, pp. 112-120, 2019. DOI: 10.1016/j.foodcont.2019.02.012.

[24] Fang, H., Zang, J., Sensoy, M., *A Generalized Stereotype Learning Approach and its Instantiation in Trust Modelling*, Electron. Commer. R.A. **30**, pp. 149-158, 2018. DOI: 10.1016/j.elerap.2018.06.004

[25] Lingam, G. & Rout, R.R., *Learning Automata-Based Trust Model for User Recommendations in Online Social Networks*, Comput. Electric. Eng., **66**, pp. 174-188, 2018. DOI: 10.1016/j.compeleceng.2017.10.017

[26] Rathore, H., Badarla, V. & George, K.J., *Sociopsychological Trust Model for Wireless Sensor Networks*, J. Netw. Comput. Appl., **62**, pp. 75-87, 2006. DOI: 10.1016/j.jnca.2015.09.009

[27] Fernandez-Gago, C., Moyano, F. & Lopez, J., *Modelling Trust Dynamics in the Internet of Things*, Inform. Sci., **396**, pp. 72-82, 2017. DOI: 10.1016/j.ins.2017.02.039

[28] McKitterick, L., Quinn, B. & Tregear, A., *Trust Formation in Agri-Food Institutional Support Networks*, J. Rural Stud., **65**, pp. 53-64, 2019. DOI: 10.1016/j.jrurstud.2018.11.008.

[29] Patel, M.K., *Technological Improvements in Electrostatic Spraying and its Impact to Agriculture During the Last Decade and Future Research Perspectives – A Review*, Food Agric. Environ., **9**(1), pp. 92-100, 2016. DOI: 10.1016/j.eaef.2015.09.006.

[30] Ushada, M, Suyantohadi, A., Khuriyati, N. & Putro, N.A.S., *Ergonomic Assessment System for Food Production*, Patent Pending P0201804325, 2018. (Text in Indonesian)

[31] Paman, U., Inaba, S. & Uchida, S., *The Mechanization of Small-scale Rice Farming: Labor Requirements and Costs*, Food Agric. Environ. Volume **7**(3), pp. 122-126, 2014. DOI: 10.1016/j.eaef.2014.03.001.

[32] Okayama, T., *Neural Network Macro*, Microsoft Visual Basic Application for Microsoft Excel. Microsoft Inc. Japan, 2002.

[33] Ushada, M., Wijayanto, T. & Trapsilawati, F., *Parameterization System for Collective Trust*, Patent Pending P00201809654, 2018. (Text in Indonesian)

[34] Xu, J., Le G. K., Deitermann A. & Montague E., *How Different Types of Users Develop Trust in Technology: A Qualitative Analysis of the Antecendents of Active and Passive User Trust in a Shared Technology*, Appl. Ergon., **45**(4), pp. 1495-1503, 2014. DOI: 10.1016/j.apergo. 2014.04.012.