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Assessment of technology content level with integrated technometrics and Analytical Hierarchy Process (AHP) methods in small and medium enterprises

Assessment of technology content level with integrated technometrics and Analytical Hierarchy Process (AHP) methods in small and medium enterprises

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Abstract. This article aims to determine the level of technological content through the components of technology in Small and Medium Enterprises (SME). The method used is qualitative with approach method of Technometrics and Analytical Hierarchy Process (AHP). Technometrics methods are used to assess the contribution of technological components, i.e. technoware, humanware, infoware, and orgaware. While the AHP method is used to assess the normalization of the weighting of each criterion. The result of this research is got a value of the coefficient of technology contribution or Technology Contribution Coefficient (TCC) equal to 0.223. Based on the calculations, it shows that the technoware value is 0.188; humanware of 0.260; infoware of 0.20 and orgaware of 0.11. With the value of TCC 0.223 or 0 <0.233 <0.3 so that it can be interpreted that the level of technology content of SMEs arjuna is traditional. Based on the measurement results seen that the lowest technological value found in orgaware, namely the attributes of competitiveness is still low. This is because there is no innovation and creativity model tile production Arjuna SMEs. Thus, for more improvement is emphasized to innovation and creativity in the process of making tile in SME Arjuna.

1. Introduction

Technology becomes one of the essential things in the development of small and medium enterprises (SMEs). By using technology, the SMEs can improve the competitiveness and quality of its products. Technology not only does it facilitates transformation operation, but also provides the infrastructure for survival and development of business in today's global, integrated economy [1]. SMEs in Indonesia has an important role for its great contribution to the Indonesian economy [2]. The development of the technology, of course, take a contribution to push the company to always update with new technology or the most powerful technology to become one of value added for the company itself [3]. SME's rated to be given suitable role and contribution that can be used in almost developing countries because SMEs could motivate local entrepreneurial with national resources saving, could absorb a quite large amount of employee, and this development of small business [4]. SMEs contribution greatly to the development of any nation and account for a large share of new jobs in countries which have demonstrated a strong employment record and are known as a primary driver for GDP [5]. Efforts to improve the quality of roof tiles are continuously pursued in line with various materials for roofing, such as zinc, printing tile. Clay tile is one of the excellent roof covering medium,

and the price is affordable by the community. With the development of technology, make clay tile business conducted by SMEs. Arjuna as a producer of clay tile should be able to adopt technique per the ability of the company and improving the product quality. Quality has become one of the most important drivers of the global competition today [6]. This research aims to determine the level of technological content through the components of technology in Small and Medium Enterprises (SME).

2. Experimental method

The method of this research is a qualitative method. The study was a purpose to determine the level of technological content through the components of technology in Small and Medium Enterprises (SME). Data collected using a questionnaire that had close-ended and open-ended. The questionnaire has 4 (four) variables, these are technoware, infoware, orgaware and humanware. The object SME is Arjuna. The research using Technometrics and Analytical Hierarchy Process (AHP) methods approach. Technometric method used for assessment technology component contribution through technoware, infoware, orgaware and humanware. Technometric method is a systematic international comparison between specification covering new products and processes [7]. Furthermore, the technometric method seems feasible to measure product and process innovations directly [7]. The proposed AHP methodology adopted a multi-criteria approach to information system project selection which is dissimilar to the single criteria approach [8]. While the AHP method is used to assess the normalization of the weighting of each criterion. Analytical Hierarchy Process (AHP) is utilized to evaluate the importance of nodes and identify influential nodes by regarding the centrality measures as the multi-attribute of a complex network [9]. The hierarchical structure of AHP methodology is able to measure and synthetize a variety of factors of a complex decision making process in a hierarchical manner, making it simple to combine the parts in a whole [10]. AHP method involves in structuring multiple criteria into a hierarchy and assessing the relative importance of these criteria, while comparing alternatives for each criterion and obtaining an overall ranking of the alternatives [11], furthermore this process has been conceptualized as a hierarchical composition of Goal, Criteria and Alternative. AHP method of Multi Criteria Decision Making techniques was applied for determination of criteria weight [12]. AHP is a method which structures a decision situation into a goal, decision criteria, and alternatives assuming all of them are independent[13]. There are several steps, namely: (1). The estimated level of Sophistication; (2). Assessment of Advanced Sophistication; (3). Determination of Contribution of Components; (4). Assessment of Intensity of Component Contributions; and (5). Calculation of Technology Contribution Coefficient.

2.1. Estimation of sophistication level

The determination of the estimated value of the Sophistication rate was done through the questionnaire distribution. Calculation of Sophistication rate is differentiated according to the type of its variable contained in table 1. In table 1 there is lower limit value and an upper limit of each component, upper limit value and lower limit are used to calculate contribution value of each technology component.

Table 1. Assessment of boundaries and limits on technology components.

Component	Limit	
	Lower	Upper
Technoware	LT:	UT:
Humanware	LH:	UH:
Infoware	LI:	UL:
Orgaware	LO:	UO:

There are:
LT = Lower Technoware
UT = Upper Technoware
LH = Lower Humanware
UH = Upper Humanware

LI = Lower Infoware
UI = Upper Infoware
LO = Lower Orgaware
UO = Upper Orgaware

2.2. Assessment of advanced sophistication

The latest sophistication assessment is the percentage of technological state of the facility under the study of the best facilities in the world. The formula for measuring state of the art ratings [14] is as follows:

2.2.1. Rating state of the art technoware components, namely:

$$ST_i = \frac{1}{10}\left[\frac{\sum_k t_k}{k_t}\right] \quad \text{.....(1)}$$

Where:
ST_i = State of the art technoware
k = 1,2, ... k_t
t_k = k-criteria score for technoware at company level.

2.2.2. Rating state of the art humanware components, namely:

$$SH_i = \frac{1}{10}\left[\frac{\sum_j h_j}{i_h}\right] \quad \text{.....(2)}$$

Where:
SH_i = State of the art humanware
i = 1,2, …i_h
h_j = j-criteria score for humanware at company level.

2.2.3. Rating state of the art infoware components, namely:

$$SI_i = \frac{1}{10}\left[\frac{\sum_m f_m}{m_f}\right] \quad \text{.....(3)}$$

Where:
SI_i = State of the art infoware
m= 1,2, …m_f
f_m = m-criteria score for infoware at company level.

2.2.4. Rating state of the art orgaware components, namely:

$$SO_i = \frac{1}{10}\left[\frac{\sum_n O_n}{n_o}\right] \quad \text{.....(4)}$$

Where:
SO_i = State of the art infoware
n= 1,2, …n_o
O_n = m-criteria score for infoware at company level.

2.3. Determination of component contributions

Based on the value of the degree of sophistication on the state of the art rating, the next process is to calculate the value of the contribution of the technology component. The formula used to calculate the contribution of technological components [14] is as follows:

$$T = \frac{1}{9}\left[LT + ST(UT - LT)\right] \quad \text{.....(5)}$$

$$H = \frac{1}{9}\ [LH + SH(UH - LH)] \quad \ldots\ldots\ldots\ldots (6)$$

$$I = \frac{1}{9}\ [LI + SI(UI - LI)] \quad \ldots\ldots\ldots\ldots (7)$$

$$O = \frac{1}{9}\ [LO + SO(UO - LO)] \quad \ldots\ldots\ldots\ldots (8)$$

2.4. Assessment of intensity of component contributions

Purpose of the assessment of the intensity of component contributions. Measurements were performed with the AHP concept approach.

2.5. Calculation of technology contribution coefficient

The calculation of the coefficient of technology contribution aims to show the technological contribution of total transformation of inputs to output [14]. The formula of calculation[14], namely:

$$TCC = T^{\beta_t} x\, H^{\beta_h} x\, I^{\beta_i} x O^{\beta_o} \quad \ldots\ldots\ldots\ldots (9)$$

Where:
TCC = Technology Contribution Coefficient
T = Value of contribution of technoware component
H = Value contribution of humanware components
I = Contribution value of infoware component
O = Contribution value of orgaware component
βt = Value of Technoware Contribution Intensity
βh = Value of Humanware Contribution Intensity
βi = Infoware Contribution Intensity Value
βo = Value of Orgaware Contribution Intensity

The classification of technological sophistication [15] is found in tables 2 and 3, as follows:

Table 2. Qualitative assessment based on TCC value hose.

TCC Value	Classification
0 < TCC < 0.1	Very Low
0.1 < TCC < 0.3	Low
0.3 < TCC < 0.5	Enough
0.5 < TCC < 0.7	Good
0.7 < TCC < 0.9	Very Good
0.9 < TCC < 1.0	Modern Sophistification

Table 3. Classification of technology levels based on TCC value.

TCC Value	Classification
0 < TCC < 0.3	Traditional
0.3 < TCC < 0.7	Semi Modern
0.7 < TCC < 1.0	Modern

3. Result and discussion

The factory that makes this tile is SME Arjuna. The raw material for making tile is clay with good quality. Clay is obtained from the local village for a purchase price of IDR. 30.000 / m3. Some of the facilities contained in SME Arjuna are four tile molding tools, one roller, one burner and several racks and trays used to maintain continuity of tile manufacturing process. Stages of the process of making the roof tile there are four stages. Namely, the first stage is to water the clay as raw materials until the dough; then the dough is milled with a rolling machine. The second stage is the clay of the grind cut

into pieces, then in print press and be a tile according to the mold. Before the soil is formed in the mold, first the mold is lubricated with a special oil so that in the separation of the printout with the print tool is not difficult. The third stage is the drying process. The drying process takes approximately one day, depending on the weather. If the weather is rainy or overcast, it takes more than one day. The purpose of drying the tile is so that the bonding strength of the clay is strong and not easily broken. Then, the fourth stage is the combustion process. In the combustion process required 2 (two) workers, because to keep the stability of the heat to make the roof more qualified. The fuel used is wood and husk. The combustion time is 24 hours and then aired for one day. The capacity of the furnace is 10,000 - 15,000 tiles.

3.1. Identification of component indicator criteria

In the measurement of the component level technology firstly compile and identify and compile the criteria used in the research contained in table 4.

Table 4. Assessment criteria components of technology criteria.

Component of Technology	Criteria
Technoware	Department of Milling Printing Department Department of Drying Department of Combustion
Humanware	Owner Employees
Infoware	Communication Device Product Design Product Price
Orgaware	Leadership Ability to Cooperate Competitive ability

3.2. Estimation of sophistication level

Based on these criteria, then used to compile and measure the estimated value of Sophistication rate. The result of measurement estimate of Sophistication rate is in table 5, table 6, table 7 and table 8.

Table 5. Calculation of lower and upper technoware component

Technology	SME of Arjuna	
	Lower Limit	Upper Limit
Department of Milling	1	3
Printing Department	1	3
Department of Drying	1	3
Department of Combustion	2	3
Degree of Sophistication Technoware	1.25	3.5

Table 6. Lower and upper computation of humanware component.

Technology	SME of Arjuna	
	Lower Limit	Upper Limit
Owner	3	5
Employees	1	3
Degree of Sophistication Humanware	2	4

Table 7. Calculation of lower and upper infoware components.

Component of Technology	SME of Arjuna	
	Lower Limit	Upper Limit
Communication Device	2	4
Product Design	2	5
Product Price	2	4
Degree of Sophistication Infoware	2	4.3

Table 8. Calculation of lower and upper orgaware components.

Component of Technology	SME of Arjuna	
	Lower Limit	Upper Limit
Leadership	1	3
Ability to Cooperate	1	3
Competitive ability	1	3
Degree of Sophistication Orgaware	1	3

3.3. Recent compassion rating calculations

Based on the calculation of estimated values contained in table 5, table 6, table 7 and table 8, then the calculation results will be used in performing the calculation of sophisticated sophistication or state of the art (SOA). The following is the calculation result of SOA technoware, humanware, infoware and orgaware contained in table 9.

Table 9. Calculation result of state of the art.

Component Technology	Criteria	Sub Criteria	Score
Technoware	Department of Milling	Mill / Molen	4
		Hoe	3
	Printing Department	Bucket	3
		Print Tools	3
	Department of Drying	Tray	3
		Crowbar	2
		Tray	2
	Department of Combustion	Drying Rack	2
	Total Number	Kapi	2
		Burning Place	4
	State of The Art Technoware	Firewood	2
		Blower	4
			34
			= 1/10 x [34/12]
			= 0.28
Humanware	Owner	Creativity	4
		Orientation	3
		Efficiency	3
		Discipline	3
		Bravery	3
	Employee	Creativity	3
		Discipline	4
		Efficiency	3
	Total Number		26
	State of The Art Humanware		= 1/10 x [26/8]
			= 0.3
Infoware	Communication Device	Access to Information	4
	Product Design	Innovative Design	
	Product Price	Compete	4
		Appropriate Market	4
	Total Number		3
			15
	State of The Art Infoware		
			=1/10 x [15/4]
			= 0.37
Orgaware	Leadership	Lead capability	4
	Ability to Cooperate	Access open cooperation	
	Competitive ability	Competitive	4
	Total Number	Quality product	
			3
	State of The Art Orgaware		3
			14
			=1/10 x [14/4]
			= 0.35

3.4. Components contribution rating
Component Contribution Calculation, namely:

3.4.1. Contribution of technoware components

$$T = \frac{1}{9}\,[LT + ST(UT - LT)]$$

= 1/9 [1.25 + 0.28 (3.5 -1.25)] = 0.188

3.4.2. Contribution of humanware components

$$H = \frac{1}{9}\ [LH + SH(UH - LH)]$$

= 1/9 [2+0.3 (4-2)] = 0.260

3.4.3. Contribution of infoware components

$$I = \frac{1}{9}\ [LI + SI(UI - LI)]$$

= 1/9 [2+0.37 (4.3 – 2)] = 0.285

3.4.4. Contribution of orgaware components

$$O = \frac{1}{9}\ [LO + SO(UO - LO)]$$

= 1/9 [1+0.35 (3-1)] = 0.189

3.5. Intensity assessment of component contributions

Based on the weighting calculation using analytical hierarchy process (AHP) method for each technology component is shown in table 10.

Table 10. Weights of the technology components.

Component	Weight
Technoware	0.46
Humanware	0.22
Infoware	0.20
Orgaware	0.11

3.6. Calculation Technology Contribution Coefficient (TCC)

Based on result calculation from component contribution rating and weights of the technology component using AHP method, and then count on TCC value. AHP has been used in many research areas including selection of the best alternative, planning, resources selection, conflict resolution, optimization etc. [15]. Furthermore, AHP is used to solve real-world problem [16].

$$TCC = T^{\beta_t} x\ H^{\beta_h} x\ I^{\beta_i} x O^{\beta_o}$$

$= 0.188^{0.46}$ x $0.260^{0.22}$ x $0.285^{0.20}$ x $0.189^{0.11}$
$= 0.223$

Based on TCC calculation value of 0.223 indicates that SME Arjuna is in low classification and level of preparedness of traditional technology.

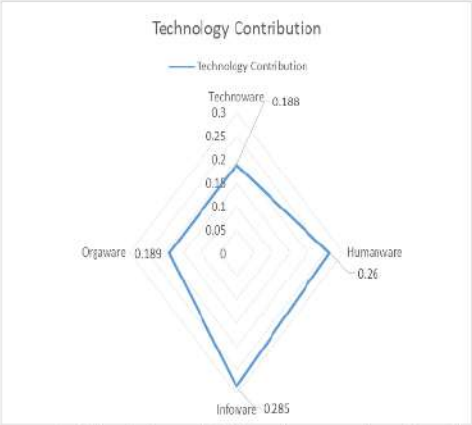

Figure 1. The Arjuna SME technometric radar chart.

Based on Figure 1 shows that the level of sophistication on each component of technology has not reached the value of 1 (maximum value). At present, the achievement of technology contribution in SME Arjuna for each technoware component is 0.188, humanware is 0.260, infoware is 0.20 and orgaware component is 0.11. So that can be depicted technometric radar graphics in SME Arjuna. So, the highest value of technology contribution is found in the humanware component, while the lowest component technology in orgaware components. The result of this research has supported the result of research conducted by Rumanti & Wirawan shown that total contribution coefficient (TCC) is 0.0566, indicated that the technology classified as a traditional [4].

The suggestions for further research are compared with another method for developing these SME Arjuna. For example, Quality Function Deployment (QFD) method. Because in WFD method will be compared Arjuna SME and the other SME with commodities is same. And then, in QFD can measure customer satisfaction for this product from SME Arjuna.

4. Conclusion

Based on the results of research can be concluded that the level of sophistication of technology components in SMEs Arjuna for technoware of 0.188, humanware of 0.260, infoware of 0.20 and orgaware component of 0.11. So that can be depicted technometric radar graphics in SME Arjuna. So, the highest value of technology contribution is found in the humanware component, while the lowest component technology in orgaware components.

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