MAPPING THE DEGREE OF TECHNOLOGICAL CAPABILITY IN SMALL AND MEDIUM INDUSTRY OF AUTOMOTIVE COMPONENTS

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Abstract

The automotive industry is known to increase exports since 2015 and is predicted to continue to grow. To develop the industry, the government is known to issue several schemes, and one of them is in the form of mandatory rules for partnerships with the small and medium industrial sectors. However, there is no industrial, institutional map seen from various aspects, including technology, human resources, information, and organization. This map is essential and useful for stakeholders to develop the industry because it provides more directed assistance.

In this study, the small and medium industries for processing metal automotive components in Tegal City are used as mapping objects. The technometric method is used to calculate the level of technology contribution they have. The results of this study indicate that the four aspects covering Technoware, Humanware, Infoware, and Orgaware for small and medium-sized automotive component processing industries in Tegal City are in a reasonable range. For improvement or guidance, production facility technology is the priority. Then proceed to employee competencies, information systems, and organizational management. Mapping should be done regularly every five years or less than five years as an evaluation.

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1. Introduction

According to the Coordinating Ministry for Economic Affairs in 2019, the Small and Medium Industry (SMI) sector is the largest sector that contributes 61.07% to Indonesia's GDP (Gross Domestic Product) and provides a proportion of reduced open unemployment through labor employment by 97% (SME & Trade Cooperative Office of the Republic of Indonesia, 2019). Besides this potential, various studies have also proven the SMI sector's resilience in facing economic crises (Sato, 2000). However, SMI productivity is still considered low based on the trade chain in the Southeast Asia region, in which the Indonesian SMI sector only has a proportion of 6.3% of the total value. Ministry of Cooperatives and Small and Medium Enterprises of the Republic of Indonesia, 2019).

The low productivity of the SMI, according to a study of the Directorate of Development of SMEs and Cooperatives in 2019 focused on capital/funding and marketing issues. This is in line with credit data from Bank Indonesia in 2018, which stated that bank credit disbursements for the SMI sector were only 20% of the total bank credit disbursed (Bank Indonesia, 2019b). Based on the various advantages of the SMI sector, the SMI sector is one of the industries that is used as a development priority by the government.

As a legal basis for the SMI, the government has issued Law Number 20 of 2008 as the basis for the classification of the SMI in terms of the owned value of business results and the asset value. Law number 20 of 2008 also functions as the stipulation of regulations regarding the development of the business climate for the SMI, which include aspects of funding, infrastructure, business information, partnerships, business licensing, business opportunities, trade promotion, and institutional support (Law Number 20, 2008).

The automotive industry is one of the industries that has contributed to Indonesia's trade balance surplus since 2015. Based on a report from Bank Indonesia in 2019, the automotive industry has experienced an increase in export value. It is assumed to have the potential for growth in the future. This success is inseparable from the support of the metal component industry, machinery and spare parts, and other supporting electronics that support the automotive industry. As of 2019, it is known that 70% of the total components of the automotive industry (for example cars) had been supplied, and the needs could be met domestically. The rest was still being exported from abroad because the domestic component industry was unable to meet the demand for specifications from the principal party (Bank Indonesia, 2019).

Therefore, in developing the automotive industry, the government has also made regulations regarding investment, one of which is the issuance of regulations regarding the obligation of the automotive industry to create partnerships with small industries as supporting components of the automotive industry (Presidential Regulation of the Republic of Indonesia Number 44, 2016). The government has issued several schemes to encourage the development of the supporting components of the automotive industry, including:

a. Incentives in the form of providing corporate income tax reduction facilities
b. Accelerated processing of permits through the Online Single Submission (OSS)
c. Improved quality of infrastructure that supports smooth logistics mobility

However, this scheme is still considered not optimal in stimulating the development of the automotive industry's supporting components. This is due to the absence of a relevant mapping regarding the immediate needs or obstacles faced by the Small and Medium Industry for the processing of automotive components. It is expected that with a comprehensive and relevant mapping, policy proposals, and steps taken in assisting the development process of SMIs for the processing of automotive components, one of which is metal-based automotive components, it can be more focused and implementable.

This study aims to make a map of the degree of technological capability in SMIs for processing metal-based automotive components using the technometric method from UNESCAP (United Nation Economic and Social Commission for the Asia Pacific), which views technology as the result of interaction in the dynamic transformation process of the four basic components of a builder of technology, including technoware (embodiment in equipment), humanware (embodiment in human resources as users), infoware (embodiment in processes/procedures), orgaware (embodiment in framework/management) (Smith and Sharif, 2007). The Technology Contribution Coefficient (TCC) value is the final result of the technometric method, which is then translated into an assessment scheme to determine the degree classification.

2. Methodology

Technometrics method is a model that can be used as a measurement of technology classification and the aspects that compose the technology degree of a business unit. First released by the United Nation Economic and Social Commission for Asia and the Pacific (UNESCAP) in the Technology Atlas Project, this technology is seen in the context of production as a combination of four basic components that interact dynamically in a transformation process, starting from input to output in the form of final products. The four basic components are engineering facilities *(facilities)*, human abilities *(abilities),* information *(facts),* and organization *(frameworks).*

In a transformation process, the four components of technology are needed simultaneously and interact continuously. No transformation process can be performed without one of these components. The four essential components illustration are shown in Figure 1 and be explained below.

a. Engineering facilities, which are called technoware, are object-embodied technology. These engineering facilities include tools, equipment, machines, vehicles, and physical infrastructure.
b. Human abilities, which are called humanware, are person-embodied technology. These human abilities include knowledge, skills, wisdom, creativity, and experience.
c. Information, called infoware, is document-embodied technology. This information is related to processes, procedures, techniques, methods, observation, and relationships.
d. An organization, which is called orgaware, is institution-embodied technology. This organization includes management practices, linkage, and organizational arrangements.

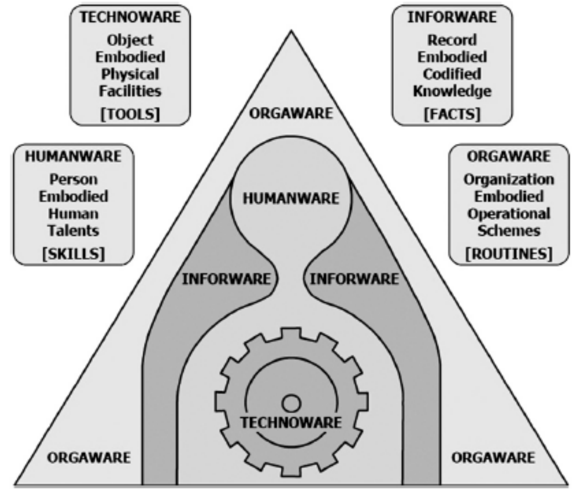

Figure 1. Illustration of Component Interaction of the Four Components (Smith dan Sharif, 2007)

Based on various studies that have been carried out using the technometric model as a method of measuring the degree of technology components, it is known that the technometric method can be applied at various levels of industrial-scale (small industry, medium industry, and large industry) both goods and services, and can be used to see industrial competitiveness. (Warafakih et al., 2015) have used this method to measure the degree of technology content in telecommunication services. The results show that the range of technology possessed by the research object is in a useful classification with the proposed use of new technology to increase technological sophistication. While (Yanthi et al., 2018) analyzed the technical components of the freight train service company.

They found that the technology degree status of the business unit studied reaches a moderate classification. It is also known that the lowest contribution value as a value builder for technology components as a whole belongs to the Technoware component. In fact, as a business unit that operates goods transportation, the use of technology is necessary. The application of technometric in other service industries found that the degree of technology possessed by the research object is in the semi-modern classification with the largest proportion of the value of the technology component degree contributors is from the value of the humanware component (Giyanti, 2015).

In its application, technometric method can also be integrated with other methods, such as AHP (Analytical Hierarchy Process), SMART (Simple Multi-Attribute Rating Technique) for weighting and rating on each component, and SWOT (Strength Weakness Opportunities Trade) to obtain a more comprehensive overview of the research object. (Adiantoro, 2019) used a combination of the technometric method and ANP (Analytical Network Process) in measuring the technological capabilities of a company engaged in the manufacture of transport ships. The results of the study classify the research object in the semi-modern technology classification range. A study using the technometric method focusing on only one component, which is humanware, was carried out by (Lungari, 2017) in the middle-class shipbuilding industry. Lungari found that the degree of technology classification of the research object is at the semi-modern degree. The policy proposal's direction is to provide training and certification for workers for improving human resources.

A combination or integration of the technometric method and other methods is shown in a study conducted by (Sulistiyowati & Jakaria, 2018) using the integration of technometric and AHP (Analytical Hierarchy Process) methods in a small-scale industry engaged in tile manufacturing. In this study, it was found that the degree of technology in the tile industry is classified as low and the Orgaware component owns the lowest component value. Based on this study's results, the researchers suggested that technology's degree should be improved using the Quality Function Development (QFD) method. The same integration method has also been carried out by (Wahyuni et al., 2016) at the SME unit engaged in cracker processing. Based on the study in the SME, it was found that the degree of technology in the business unit studied is classified as semi-modern technology.

Meanwhile, a study by (Pujianto et al., 2017) using the integration of the technometric method with SMART (Simple Multi-Attribute Rating Technique) and SWOT (Strength Weakness Opportunities Trade) was conducted in a large-scale industry engaged in coffee processing. The results of this study found that the degree of industrial technology is modern. Another study that integrates the technometric method with the product lifecycle was conducted by (Smith and Sharif, 2007) to see industries' competitiveness. Based on this study, it is concluded that competitiveness can be increased and strengthened in human resources, followed by enhancing or renewing technology.

Regarding life cycles, innovation analysis based on the technometric model to predict SMEs' technology life cycle while also forecasting sales were carried out by (Rumanti dan Hadisurya, 2017). The research object is a handicraft goods processing industry. The study conducted found that the research object under study has a low degree of technology or is still traditional but has a high humanware component value. Based on the forecast results, the number of items that must be sold can be known to achieve business development.

Based on the previous studies that have used the technometric method and/or the combination with other methods that have been carried out by researchers in various countries and industrial groups, both in goods and services, it is clear that the results of the assessment of the degree of technology are diverse and localistic. The results are very dependent on determining the limits of sophistication, the range of upper and lower limits of sophistication, and the value of state of the art (Purwaningsih et al., 2005). However, the results of technometric overviews in an industry can still be used as a preliminary guideline for improving the industry and other stakeholders, such as the government, which has an interest as industry regulators and facilitators. In this context, this study was carried out in Tegal City, Central Java, to map the degree of technology content possessed by Small and Medium Industries of metal-based automotive components.

The research object was the technology content of the Small and Medium Industries (SMI) for the processing of metal-based automotive components in Tegal City, Central Java. There were two data used, including primary data and secondary data. The preliminary data collected and processed observational data and direct interviews with respondents or SME actors processing metal-based automotive components (upper limit data: UT, UH, UI, UO; and lower limit data: LT, LH, LI, and LO). Observations and interviews were conducted using a questionnaire based on UNESCAP generic criteria.

While the secondary data were in the form of turnover data of business actors whose business units were in the Small Industry Environment of Talang Cempaka Baru (TAKARU), Tegal City, determination of the number of respondents of the questionnaire was carried out using a purposive sampling method based on 2 criteria, including the amount of turnover (highest, moderate, and lowest) and the business unit must be located within the Small Industry Environment. Based on these two criteria, five business units (TMU, KMM, BKT, TBM, and FNF) were obtained as the respondents.

Technology Component Contribution Calculation Stages

The degree of technology content for Small and Medium Industries (SMI) for processing metal-based automotive components is translated into TCC or Technology Contribution Coefficient, which summarizes aspects of technology, human resources, information, and organization, and is formulated by UNESCAP. The stages carried out are as follows:

- **Determination of Degree of Sophistication Limits**

  The questionnaire was made based on UNESCAP generic criteria with a score range of at least 1 for the complexity degree, which is still simple, and a maximum of 9 for the integrated complexity degree. Each component was then assessed based on its physical facilities. The higher the score, the more complex the equipment and systems it has.

- **Assessment of State of the Art (SOTA)**

  The questionnaire was made based on UNESCAP generic criteria to assess each component through its operational activities, evaluated by loading. The range of loads for each answer is a minimum of 0 and a maximum of 10, which then calculated using Equations 1 to 4 (Regina Ambar Ayu, 2018):

  - *Technoware*

  $$ST_i = \frac{1}{10}\left[\frac{\sum_{k=1}^{k_t} t_{ik}}{k_t}\right] \quad (1)$$

  Where, k_t = total number of technoware component criteria, t_{ik} = k value from technoware category

- *Humanware*

$$SH_j = \frac{1}{10}\left[\frac{\sum_{i=1}^{l_h} h_{ji}}{l_h}\right] \quad (2)$$

Where, l_h = total number of humanware component criteria h_{ij}= i value from humanware category j

- *Infoware*

$$SI = \frac{1}{10}\left[\frac{\sum_{m=1}^{m_f} f_{mi}}{m_f}\right] \quad (3)$$

Where, m_f = total number of infoware component criteria f_{mi} = crinterion value of m from infoware

- *Orgaware*

$$SO = \frac{1}{10}\left[\frac{\sum_{n=1}^{n_o} O_n}{n_o}\right] \quad (4)$$

Where, n_o = total number of orgaware component criteria O_n = crinterion value of n from orgaware

- **Determination of Technology Component Contribution Value**

Once the degree of sophistication limits and the rating value of state of the art was obtained, the calculation of the technology contribution coefficient value was carried out using Equations 5 to 8. (Matin & Toloui, 2014):

- **Assessment of Technology Component Contribution Intensity**

The Technology Component Contribution Intensity Values (βt, βh, βi, and βo) were obtained using the Analytic Hierarchy Process (AHP) method with the use of a pairwise comparison matrix between each component of T, H, I, O. Consistency requirements in filling this questionnaire is necessary which is expressed in the form of a consistency ratio value. The consistency ratio value must be ≤ 0.1, and the values of βt, βh, βi, βo are normalized weight values (Utomo & Setiastuti, 2019).

- **Calculation of Technology Contribution Coefficient (TCC)**

Based on the obtained values of T, H, I, O and β, the TCC value can be calculated using Equation 9 (Retnowati & Mayasari, 2016).

$$TCC = T^{\beta t} \times H^{\beta h} \times I^{\beta i} \times O^{\beta o} \quad (9)$$

Where,
TCC : Technology Contribution Coefficient
T : technoware component contribution value
H : humanware component contribution value
I : infoware component contribution value
O : orgaware component contribution value
Bt, βh, βi, βo: values of the calculation of the technoware, humanware, infoware, orgaware component contribution intensity

The technology contribution coefficient value that has been obtained is then translated into a qualitative assessment table (Anggariawan et al., 2019), as shown in Table 1 below:

Table 1. TCC Qualitative Assessment

TCC Value	Classification
0 < TCC ≤ 0.1	Very low
0.1 < TCC ≤ 0.3	Low
0.3 < TCC ≤ 0.5	Moderate
0.5 < TCC ≤ 0.7	Good
0.7 < TCC ≤ 0.9	Very good
0.9 < TCC ≤ 1.0	Advanced Sophistication

3. Result & Discussion

The technometric mapping results for the Small and Medium Industry (SMI) processing metal-based automotive components are described in the form of a radar graphic that includes four aspects (technoware, humanware, infoware, and orgaware). The details of the overall results are (1) the degree of sophistication analysis, (2) the value of state of the art, (3) the technology component contribution, and (4) the technology contribution coefficient.

Analysis of Degree of Sophistication

The value of the degree of sophistication of the Small and Medium Industry (SMI) processing metal-based automotive components is as follows:

a. The degree of sophistication score of technoware is at the lower limit of 1 and the upper limit of 5. On the criteria set by UNESCAP, the coverage on the upper and lower limits owned by the SMI processing metal-based automotive components includes manual facilities for production, the use of machines with powered facilities, and multipurpose machines whose full control is managed by an operator. Facilities, equipment, and processing in manual manner/ handwork can be seen from the process of preparing the primary raw materials to place the tub containing ready-to-pack components on the provided rack, while the use of powered machines, for example, grinder, is generally used during the manual sorting process of components, such as the process of edge smoothing. Select devices with complete control managed by an operator are carried out on the component molding machines.
b. The degree of sophistication score of humanware in the SMI processing metal-based automotive components is at the lower limit of 1 and the upper limit of 5. This shows that this business unit's human resource capabilities are at the level of ability to

perform operations, setup, and ability to improve, to the ability to carry out production.

c. The degree of sophistication score of infoware is at the lower limit of 1 and the upper limit of 5. This shows that the coverage of existing infoware facilities at the SMI includes the introduction facilities to the fact of use as stated in the SOP document, both in the form of a document and a framework placed on each machine.
d. The degree of sophistication score of orgaware is at the lower limit of 1 and the upper limit of 5. This shows that the business unit is at the level of small companies with private ownership status and has low investment/capital to the level of medium companies with several demands that tend to be stable and have built a network through collaborative partnerships.

Analysis of State of the Art Value

The degree of sophistication value at the SMI processing metal-based automotive components is as follows:

a. Technoware
Analysis of the state of the art of technoware components was carried out by analyzing the degree of sophistication and production facilities carried out in the SMI, which covered the entire production process, ranging from handling (standards and quality of raw materials), production processes, standardization to finishing and quality control of the product.
b. Humanware
Analysis of the state of the art of humanware components was carried out by analyzing human resources or manpower, which was carried out in the SMI and included the skills of workers, creativity and innovation, worker orientation, and ability to work together to efficiency in work, appreciation given as well as discipline and responsibilities of the workers.
c. Infoware
Analysis of the state of the art of infoware components was carried out by analyzing activities documentation, procedures, written explanations, and layouts on production carried out in the SMI and covered the spread of information owned by the company, communication networks, information disclosure, and easy access to information.
d. Orgaware
Analysis of the state of the art of orgaware components was carried out by analyzing organizational linkages in management and business arrangements in the SMI, including leadership effectiveness, organizational direction, organizational vision and mission, the innovation climate, and integrity.

Analysis of Technology Component Contribution

The following Table 3 contains the value of industrial technology component contribution for the SMI processing metal-based automotive components along with a graph of the contribution of Technoware Humanware Infoware Orgaware (THIO) in Figure 4.

Table 3. THIO values of the SMI processing metal-based automotive components

No	Name of Business Unit	THIO Value			
		T	H	I	O
1	TMU	0.5545	0.7575	0.8944	0.7619
2	KMM	0.4227	0.4393	0.3463	0.2857
3	BKT	0.8606	0.8030	0.5685	0.2698
4	TBM	0.4469	0.3131	0.1731	0.1428
5	FNF	0.4984	0.8181	0.5777	0.5714

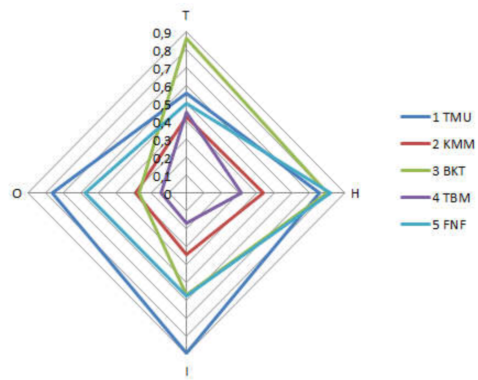

Figure 4. Technoware Humanware Infoware Orgaware (THIO) graph of the SMI processing metal-based automotive components

Analysis of Technology Component Contribution Intensity

The technology component contribution intensity analysis values were obtained from the use of the Analytic Hierarchy Process (AHP) method and the expert choice software for data processing. Based on the TCC formula in Equation 9, the component intensity with the highest value will have a large effect and potential in increasing the technology contribution coefficient (TCC). The results of the assessment of the technology component contribution intensity are presented in Table 4.

Table 4. Technology Component Contribution Intensity

No	Name of Business Unit	Value of Technology Component Contribution Intensity			
		βt	βh	βi	Bo
1	TMU	0.57	0.168	0.187	0.075
2	KMM	0.512	0.295	0.093	0.1
3	BKT	0.635	0.062	0.151	0.151
4	TBM	0.449	0.348	0.101	0.101
5	FNF	0.383	0.432	0.099	0.086

Analysis of Technology Contribution Coefficient (TCC)

Based on the data analysis that has been carried out and based on the degree of TCC value from UNESCAP in Table 1, it can be concluded that the KMM and TBM business units are in a moderate technology classification. Meanwhile, TMU, BKT, and FNF are in a useful technology classification. In the TMU business unit, the largest contributor to the technology classification's total value is the Infoware/ information system aspect. Based on field observations made, the business unit's information system is fully computerized, and each stamp machine is equipped with sensors that function as monitoring.

Meanwhile, in the BKT business unit, the largest contributor to the technology classification's total value is in the Technoware/ technology asset aspect. Based on field observations made, the business unit is equipped with an automatic stamping machine. The owner claimed that it could increase production efficiency by up to 95% and use minimal human resources because one operator only carries out supervision. The following table contains the Technology Contribution Coefficient (TCC) values in the SMI processing metal-based automotive components.

Table 5. Technology Contribution Coefficient (TCC) Values

	TMU	KMM	BKT	TBM	FNF
TCC	0.6544	0.4035	0.6757	0.3200	0.6339

4. Conclusion

The SMI processing metal-based automotive components in Tegal City have a technology range of moderate (TCC = 0.3200) to good (TCC = 0.6757). In business units with a low technology range, the technological aspect of production facilities is considered to have low values (T = 0.442-0.446). The technology used in the SMI with the moderate technology range is generally using a stamping machine operated by an operator and sorting the products and their refinement using a grinding machine. Whereas in business units with useful technology classification, the technological aspect in production facilities is considered to have a range of values up to high (T = 0.498-0.860).

The BKT business unit, as the owner of the Technology Contribution Coefficient (TCC) value of all the SMI respondents, has adopted the form of technology in their production process through the use of automatic feeder machines increase efficiency and productivity up to 95%. Thus, additional suggestions through information systems or monitoring systems and sensors on a computer integrated machine are expected to increase productivity further because they can minimize products that do not pass quality control through an automatic sensor system.

Based on the study that has been carried out, priority suggestions can be provided as SMI training in the order starting from production facility technology, human resource competence, information systems, and organizational management with mapping that should be carried out regularly every five years or less than five years following developments of market adjustment needs. The adoption of technology in the production process aims to improve the quality of the products produced and control product standards that comply with regulations or demands to meet specifications.

The application of technology can assist ease of access to communication with the stakeholders involved and product marketing. Technology also provides convenience in terms of human resources in making innovation and creativity, with the comfort of additional knowledge about target markets and potential products to be developed to realize SMIs that are competitive and ready for technology adaptation, leading to the SMI sector to class improvement with the technology adoption of industry 4.0.

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