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Evaluation of Critical Success Factors in The Indonesian Automotive Industry using DEMATEL-Based ANP to Implement Green Supply Chain Management

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Abstract – **Analysis of Indonesian car production data in 2022 shows significant trend for increase in production and sales from year to year. The automotive industry in Indonesia is currently an important non-oil and gas sector which has a major contribution to the national economy. Currently, Indonesia has 22 four-wheeled motor vehicle industry companies. The higher the level of car production, the higher the CO2 emissions produced, and the higher the worldwide pressure to the countries to reduce the CO2 emission damage. Therefore car companies must implement Green Supply Chain Management (GSCM). However, the many criteria in GSGM implementation make it difficult for industry players to decide on the appropriate strategic decisions. The aim of this study is to find out the critical success factors in implementing GSCM in the Indonesian automotive industry and their interrelationship. The method used in this study is the Decision Making Trial and Evaluation Laboratory (DEMATEL) based on the Analytic Network Process (ANP). The results of this study show that the top five of 25 critical success factor in global weight are: top management perspective 4.86%, company competitiveness 4.57%, economic interest 4.55%, Using energy-efficient machinery and equipment 4.49% and Carbon footprint identification 4.48%.**

Keywords *- Automotive Industry, Critical Success Factors, DEMATEL Based ANP, Green Supply Chain Management.*

INTRODUCTION

The automotive industry can be regarded the largest and most dominant manufacturing sector throughout the world [1]. The automotive industry is not always the cleanest, it has a major impact on the environment as the major source of emissions and fossil energy consumption. Apart from emissions from vehicle use, other problems also arise from industrial growth at the production and consumption levels. This industry only has two choices, accepting its impact on the earth or accelerating environmentally friendly initiatives through innovation [2]. In Indonesia, as much as 38.5% of CO2 in 2021 is produced by the industrial sector with a proportion of 22.9% direct emissions and 15.6% indirect emissions. Indonesia currently has the challenge of increasing energy efficiency or reducing emissions by decarbonizing [3]. In 2021, CO2 emissions produced by Indonesia based on the agricultural sector, industrial sector, development sector, transportation sector, electric power sector and energy sector can be seen in figure 1.

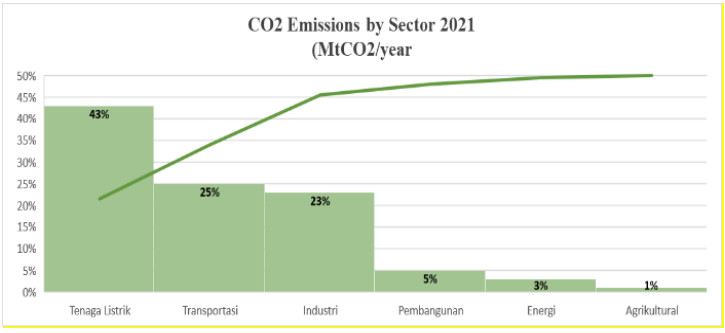

Figure 1. CO2 Emissions by Sector 2021

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The transportation sector and industrial sector are the 2nd and 3rd largest contributors respectively with 25% and 23% of the total CO2 emissions produced by several sectors in Indonesia [3]. The growth of automotive industry production has had a significant impact on the environment. To mitigate this impact, many car manufacturers are implementing environmentally friendly practices [4]. Automotive industry faces various environmental challenges, such as ineffective management of end-of-life vehicles, increasing air pollution, the adverse impacts of climate change, and strict government rules and regulations [5].

Global warming is a phenomenon that increases the temperature of the earth's atmosphere, sea and land. The leading cause of the greenhouse effect is water vapor, while the second biggest cause is carbon dioxide (charcoal acid), which is caused by human activities; among others, it is produced by vehicles, factories and power plants that use fossil fuels [6]. Organizations (automotive industry) have more responsibility to prevent environmental accidents and waste generation in their supply chains, which is primarily motivated by regulatory fines and customer demands [2]. Currently, the Indonesian automotive industry is one of the mainstay sectors that make a large contribution to the national economy. There are 22 four-wheeled or more motorized vehicle industrial companies in Indonesia. This sector has contributed an investment value of IDR 99.16 trillion with a total production capacity of 2.35 million units per year and absorbs a direct workforce of 38.39 thousand people [7]. In 2022, Indonesia will be in second place after Thailand with production of 1.47 million units, an increase from the previous year of 39.5% [8]. Lenort said that automotive industry is a good subject to be analyzed because foundation of the global economic, main driver of economic macro, stability and advanced technology [9].

Green Supply Chain Management (GSCM) is an effective way to reduce environmental risks, reduce waste, and increase flexibility in meeting new environmental requirements and customer demands [4]. GSCM integrates environmentally friendly aspects into every business operation, such as product design, procurement, production, logistics, marketing, final product delivery and end-of-life product management in the supply chain [2]. The application of (GSCM) brings several benefits to industry, GSCM maximizes environmental performance and minimizes waste production, GSCM also helps companies improve their environmental proficiency [10].

Industries in developing countries face difficulties in incorporating environmentally friendly initiatives into their traditional systems due to lack of expertise or knowledge regarding them [11]. Therefore, for successful implementation of GSCM, appropriate specialized knowledge is required, requiring extensive research. Understanding GSCM also involves knowledge of norms and regulations, globalization, suppliers, competition and other areas [12]. Companies need to know the important factors for successful GSCM implementation [10].

Measuring Critical Success Factors (CSFs) is an essential prerequisite for controlling the implementation process and increasing the chances of success. Finding and selecting adequate measurement instruments is a major challenge for companies because there is no consensus on specific factors or a holistic framework [13].

Studies conducted in Malaysia show that the Malaysian automotive supply chain is still in its infancy and has significant negative impacts on the environment. This study concludes that there is a potential positive impact of green innovation initiatives on the company's economy, social and environment simultaneously [1]. In addition, in implementing environmentally friendly technology practices, found the driving factors and inhibiting factors in the implementation of GSCM in Brazil, namely cost reduction as a supporting factor, while implementation costs are rejected by suppliers as the main inhibiting factor [4].

The approach used is Multi-Criteria Decision Making (MCDM) using the Decision Making Trial and Evaluation Laboratory (DEMATEL) method combined with the Analytical Network Process (ANP) method. The DEMATEL approach helps decision makers to identify interdependencies between factors [14], and this results in the categorization of factors by dividing them into cause and effect groups [12]. The purpose of the study is designed based on the formulation of the problems that had been identified previously, evaluating and identifying CSF by looking at the strength of the relationship and the level of importance between factors in the implementation of GSCM in the Indonesian automotive industry. The relationship between CSF and the level of importance obtained can be used as evaluation material in determining strategic steps for automotive industry players.

METHODS

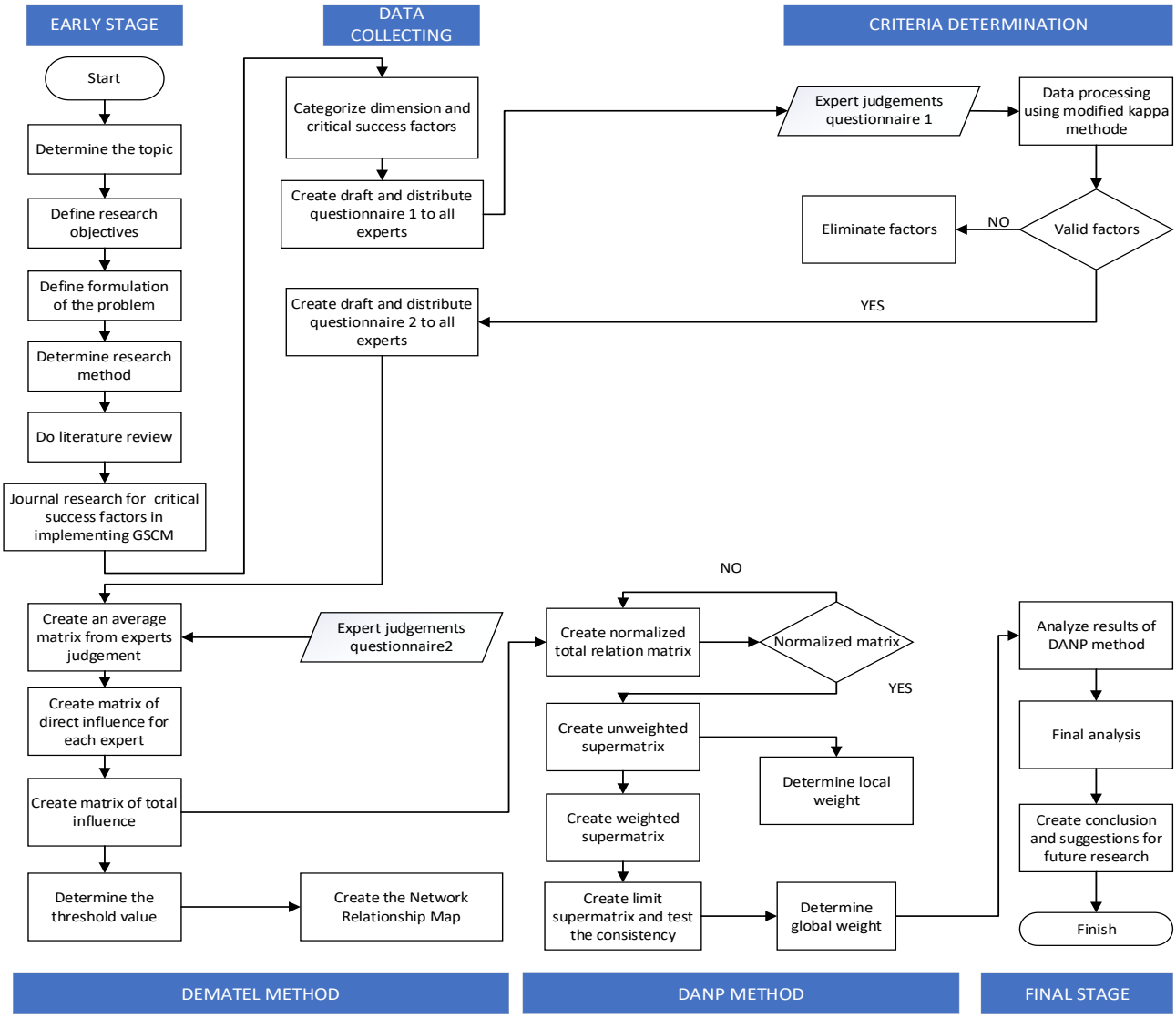

Figure 2. Research Flowchart

Research Framework

The research objective was designed based on the background problem. Evaluating and identifying Critical Success Factors (CSF) by looking at the strength of the relationship and level of importance between factors in the implementation of GSCM in the Indonesian automotive industry with the MCDM approach using the method DEMATEL (Decision Making and Evaluation Laboratory) based on Analytical Network Process (ANP). So, the output can be used as evaluation material in determining strategic steps for automotive industry players in their activities to implement GSCM

Research Flowchart

To improve reader comprehension and provide a clear guide for the following sections, we included a research flowchart, as shown in Figure 2. This visual aid details the primary techniques used in this study, helping to clarify the overall data acquisition, processing, and evaluation processes.

Determination of CSF Initial List

Based on studies from other research, Sunil identified the initial list of rankings strategies to implement GSCM in Indian manufacturing industry [15]. The study categorizes the GSCM implementation strategies into four dimensions – green operations, green design, green manufacturing, reverse logistics and waste management.

Based on literature review, our study gathered 7 dimensions in determining critical success factors, namely (green design, green purchasing and procurement, green production and manufacturing,

green transportation and distribution, green warehousing, green packaging, organizational perspective), and a total of 30 initial lists of critical success factors in implementing green supply chain management in the Indonesian automotive industry. The indicators created will be validated by several Indonesian experts, with experts criteria as follows [16], Expertise due to knowledge at the academic or research level, Expertise due to specialty, for example: practitioner, Expertise due to the position as a decision maker.

Experts Information

The expert will provide an assessment of the factors that have been designed through literature studies with interviews and filling out offline questionnaires. This stage is carried out to determine the suitability of the designed factors with conditions in Indonesia. The expert's information as shown in table 1. The experts will fill out the questionnaire provided by assessing how relevant the initial list of factors is to conditions in Indonesia. The more relevant the factor, the greater the chance of the factor being valid, and vice versa.

Validation of CSF Initial List with CVI Combined Modified Kappa

After distributing Questionnaire 1 to all experts, the CVI method is used because it is the most appropriate formula for testing the validity of interactive learning media content oriented to the Creative Problem-Solving model, as more than one validator is involved in this validation testing [17].

The minimum acceptable expert number to validate a factor is two experts, and it states that the requirement for an I-CVI score for three to five experts is 1.00, and for at least six experts, it is 0.83 [16]. Currently, this study uses five experts for validating factors (questionnaire 1) and a pairwise comparison questionnaire (questionnaire 2). Experts were asked to rate the relevance of each factor on an instrument using a 4-point Likert scale: 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, and 4 = very relevant. The benefits of a 4-point scale include avoiding neutral midpoint values [18].

The kappa statistic is an important complement to CVI because the kappa formula produces an index of the level of agreement, the CVI method does not indicate the level of agreement (Polit & Beck, 2006). Another concern is that CVI discards information by grouping experts' multipoint ordinal ratings into two categories (i.e., into relevant/irrelevant categories) [19]. The following is a way to calculate the Kappa value, the first step is calculating the probability chance using equation and calculating the Modified Kappa value using equation (1) [20]:

1. Calculate the probability of change agreement

$$Pc = \left[\frac{N!}{A!(N-A)!}\right] . 5^N \quad (1)$$

Where:
Pc = Probability of chance agreement
N = Number of experts
A = Number of assessments with good relevance (quite relevant and very relevant)

2. Calculate modified kappa score K^* with equation (2)

$$K^* = \frac{I - CVI - p^c}{1 - p^c} \quad (2)$$

Table 1. Expert's Information

Code	Expert's Background	Position	Experience	Category
E1	Kaizen, Quality Control Circle Leader Implementation	Production Strategy & Continuous Improvement Manager	> 15 years	*Industry*
E2	Facility & layout design	Logistics Engineer	> 13 years	*Industry*
E3	Logistics improvement specialist	Executive Director	> 15 years	*Association*
E4	Supply Chain Engineering	Associate Professor	10 years	*Academia*
E5	Supply chain risk management & logistics engineering	Academia	> 15 years	*Academia*

Kappa score use for evaluation whether the factors can be used for questionnaires 2. The factors that will be used for the next stage are factors with k* > 0.6 or factors with good – excellent kappa evaluation score. Detail of the evaluation score are shown in table 2.

Table 2. Kappa Evaluation Score

Kappa	Interpretation
< 0,40	Unacceptable
0,40 - 0,59	Fair
0,60 - 0,74	Good
0,74 - 1,00	Excellent

After calculating CVI and modified kappa, 5 factors of 30 factors were obtained with a k* value < 0.6 or factors with kappa evaluation unacceptable – fair and considered irrelevant for implementation GSCM critical success factors in Indonesian automotive industry, namely the factors designing robust products (GD02), supplier localization (GPP04), workforce optimization (GPM03), use of one-way packaging (GPG03), and use of returnable packaging (GPG04). The details of the calculation are shown in table 3.

Table 3. Kappa Score Critical Success Factors

Dimension	Code	Factors	Description	k*	Kappa Evaluation
Green Design	GD01	Components that can be recycled	Recycling program for reusable components	1,00	Excellent
	GD02	Design robust products	Increase product durability in product design	0,42	Fair
	GD03	The design uses recycled raw materials	Product development with sustainable raw materials	1,00	Excellent
	GD04	Information on disposal steps / disposal of goods	Provide information about how to dispose of components in the user guide	1,00	Excellent
Green Purchasing and Green Procurement	GPP01	The role of Supplier / suppliers	Supplier cooperation to integrate environmental goals with collaboration with suppliers and vendors for environmental improvement.	1,00	Excellent
	GPP02	Supplier development	Embed “sustainability” into supplier relationships	1,00	Excellent
	GPP03	Supplier Audits	Supplier audits for GSCM compliance testing	1,00	Excellent
	GPP04	Supplier Localization	Supplier localization for Just in time	0,42	Fair
	GPP05	Government support and regulation	Government incentive assistance for the procurement of environmentally friendly goods and services	0,76	Excellent
Green Production and Manufacturing	GPM01	CO2 reduction in the production process	Reducing CO2 in manufacturing and production processes	0,76	Excellent
	GPM02	Using energy-efficient machinery and equipment	Utilization of energy and fuel efficient tools & machines	1,00	Excellent
	GPM03	Workforce optimization	Improved management of labor usage	-0,03	Unacceptable
	GPM04	Carbon footprint identification	Calculate the carbon footprint produced by the company	1,00	Excellent
Green Transportation and Distribution	GTD01	Selection of warehouse location	Optimize distribution hub locations	0,76	Excellent
	GTD02	Use of the Milk-run delivery scheme	Using Milk Run to optimize transportation processes and reduce consumption of natural resources	1,00	Excellent
	GTD03	Use of cross-dock delivery scheme	Consolidate cargo from suppliers in the same region at distribution centers to optimize vehicle utilization	0,76	Excellent
	GTD04	Optimization of Transportation and distribution routes	Optimize delivery routes from origin to destination	0,76	Excellent
	GTD05	Truck load optimization	Improves cubication and optimizes use of space on the truck	1,00	Excellent
Green Warehousing	GW01	Selection of warehouse roof	Reduce energy consumption through the use of solar panels and environmentally friendly roofing options	0,76	Excellent
	GW02	Inventory management and movement of goods	Reduce the amount of inventory and movement of goods (material handling)	1,00	Excellent

Dimension	Code	Factors	Description	k*	Kappa Evaluation
	GW03	Use of forklifts by type	Carry out actions to replace LPG-fueled forklifts with electric forklifts	0,76	Excellent
	GW04	Establish waste pre-treatment requirements	Prohibit companies from sending waste to landfill before processing	1,00	Excellent
Green Packaging	GPG01	Selection of Packaging Materials	Selection of packaging materials that can be recycled	1,00	Excellent
	GPG02	Material Reduction	Reducing the use of packaging materials	0,76	Excellent
	GPG03	Use of One Way Packaging	Using one-way packaging to receive products originating from international suppliers and returnable packaging with local suppliers	0,42	Fair
	GPG04	Use of Returnable Packaging	Returnable packaging comprises vacuum forming materials, corrugated plastic packaging, and foam.	0,42	Fair
Organizational Perspective	OP01	Top management perspective	Top management initiation and commitment, company regulations, and technological advances and information technology empowerment	1,00	Excellent
	OP02	Employee perspective	Organizations can recruit professional employees who have the awareness, training and skills that can further assist in implementing GSCM	1,00	Excellent
Organizational Perspective	OP03	Economic interest	Companies implement GSCM to reduce costs by increasing efficiency, reducing waste	0,76	Excellent
	OP04	Company competitiveness	The initial implementation of GSCM makes it possible to develop new market	0,76	Excellent

DEMATEL-BASED ANP Method

DEMATEL-based ANP is a hybrid or combined method that combines two methods, DEMATEL and ANP methods. DEMATEL method is used to visualize the structure of complex causal relationships between the criteria of a system by obtaining the level of influence of these criteria obtained from the network relationship map (NRM), then adopting the level of influence value as the basis for a normalization supermatrix to calculate the ANP weight to determine the level of importance of a factor [21]. This map depicts the relationship between the elements involved in a system making it easier to solve the problem.

By the calculation of modified kappa, five irrelevant factors are eliminated. Next, a questionnaire was formed from 25 relevant critical success factors to determine the relationship between the factors and other factors. The assessment weight scale used is the same as the assessment weight scale used in the AHP method as shown in table 4 according to [22].

Table 4. Analytic Hierarchy Process Assessment Weight Scale

Scale	Definition	Interpretation
1	Equal Importance	Two activities contribute equally to the goal.
3	Moderate Importance	Experience and judgment slightly favor one activity over another.
5	Strong Importance	Experience and judgment strongly favor one activity over another.
7	Very strong importance	The activity is very popular and its dominance is visible in practice.
9	Absolute importance	The evidence that supports one activity over another is the highest order of assertion possible
2, 4, 6, 8	Intermediate values	When compromise is needed

The following are the calculation steps using the DEMATEL-based ANP method according to Khan [23]:

The first step is to build a matrix of direct influence from experts judgement that show the influence of factor *i* to factor *j*, equation (3).

$$x_h = x_{ij}^h \tag{3}$$

The second step is to build a direct relation matrix or matrix (Z) which is calculated using the following equation (4):

$$z = \begin{bmatrix} Z_{11} & \cdots & Z_{1m} \\ Z_{21} & \cdots & Z_{2m} \\ \vdots & \ddots & \ddots \\ Z_{n1} & \cdots & Z_{nm} \end{bmatrix} \tag{4}$$

The third step is to build a direct relation matrix (D) obtained from the normalized direct relation matrix that can be calculated using equation (5-7).

$$Z = \frac{\sum_{h=1}^{H} Z^h}{H},\ h = 1,2,\ldots,H \quad (5)$$

And $$D = \lambda * Z \quad (6)$$

$$\lambda = min\left[\frac{1}{max1 \le i \le n \sum_j^n z_{ij}}, \frac{1}{max1 \le i \le n \sum_i^n z_{ij}}\right] \quad (7)$$

Calculate total relation matrix (T)

$$T = D(I - D)^{-1} \quad (8)$$

The fourth step is to calculate the Threshold value and build a Network Relationship Map using the equation (9-11).

$$T = \left[t_{ij}\right]_{nxn}\ i,j = 1,2,\ldots,\mathrm{n} \quad (9)$$

$$Di = \left[\sum_{i=1}^{n} t_{ij}\right]_{nx1} = \left[t_{ij}\right]_{nx1}; \quad (10)$$

$$Ri = \left[\sum_{j=1}^{n} t_{ij}\right]_{nx1} = \left[t_{ij}\right]_{nx1} \quad (11)$$

The Di value is obtained by adding up all the factor elements in the T matrix row, where the Di value indicates the magnitude of the influence of factor i on other factors. Meanwhile, the Ri value is obtained by adding up all the factor elements in the T matrix column which shows the amount of influence received from other factors, then the Di + Ri value, the Di – Ri value can be calculated and a Network relationship map (NRM) can be formed. The threshold value is obtained from the average value of the total relation matrix (T). The threshold value shows whether a factor influences or is influenced by other factors, if the value of a factor or dimension is greater than the threshold value, then an arrow will be mapped on the NRM indicating an influence. The total relation matrix (T) includes TD for dimensions and TC for factors.

The seventh step is to build the unweighted supermatrix (W). Unweighted supermatrix (W) is obtained by transposing the normalization matrix (Tc). Afterward, build the weighted supermatrix that obtained by multiplying unweighted supermatrix (W*) with a normalized Td matrix.

The final step is to calculate the ANP weight by creating limits from the weighted supermatrix (W*) until a relatively stable value is obtained. The weight value for each factor is the weighted supermatrix value which is stable or called the supermatrix limit.

RESULT AND DISCUSSION

Result

The results of the DEMATEL-based ANP method produce weight priority and level of interest for each dimension and factors, details as shown in table 5.

Table 5. Dimensional and Critical Success Factors Weight Priority Results

Dimension	Dimension Weight	Code	Factors	Local Weight	Local Rank	Global Weight	Global Rank
Green Design	0,098	GD01	Components that can be recycled	**0,381**	**1**	0,0375	**21**
		GD03	The design uses recycled raw materials	**0,312**	**2**	0,0307	**24**
		GD04	Information on disposal steps / disposal of goods	**0,306**	**3**	0,0301	**25**
Green Purchasing and Green Procurement	0,162	GPP01	The role of Supplier / suppliers	**0,248**	**4**	0,0402	**14**
		GPP02	Supplier development	**0,250**	**2**	0,0405	**11**
		GPP03	Supplier Audits	**0,249**	**3**	0,0403	**13**
		GPP05	Government support and regulation	**0,252**	**1**	0,0408	**9**
Green Production and Manufacturing	0,134	GPM01	CO2 reduction in the production process	**0,329**	**3**	0,0439	**6**

Dimension	Dimension Weight	Code	Factors	Local Weight	Local Rank	Global Weight	Global Rank
		GPM02	Using energy-efficient machinery and equipment	**0,336**	**1**	0,0449	**4**
		GPM04	Carbon footprint Identification	**0,335**	**2**	0,0448	**5**
Green Transportation and Distribution Green Transportation and Distribution	0,205	GTD01	Selection of warehouse location	**0,198**	**4**	0,0405	**12**
		GTD02	Use of the Milk-run delivery scheme	**0,210**	**1**	0,0429	**7**
		GTD03	Use of cross-dock delivery scheme	**0,195**	**5**	0,0398	**15**
		GTD04	Optimization of transportation and distribution routes	**0,198**	**3**	0,0406	**10**
		GTD05	Truck load optimization	**0,200**	**2**	0,0409	**8**
Green Warehousing	0,154	GW01	Selection of warehouse roof	**0,255**	**1**	0,0393	**17**
		GW02	Inventory management and movement of goods	**0,245**	**3**	0,0377	**19**
		GW03	Use of forklifts by type	**0,255**	**2**	0,0392	**18**
		GW04	Establish waste pre-treatment requirements	**0,245**	**4**	0,0377	**20**
Green Packaging	0,068	GPG01	Selection of Packaging Materials	**0,500**	**1**	0,0341	**22**
		GPG02	Material Reduction	**0,500**	**2**	0,0341	**23**
Organizational Perspective	0,179	OP01	Top management perspective	**0,271**	**1**	0,0486	**1**
		OP02	Employee perspective	**0,221**	**4**	0,0396	**16**
		OP03	Economic interest	**0,254**	**3**	0,0455	**3**
		OP04	Company competitiveness	**0,255**	**2**	0,0457	**2**

Table 5 shows the weight priority of critical success factors, global weight shows the priority level of each factor outside of dimensions, local weight shows the priority level of each factor in the dimensions, while the dimension weight shows the priority level between dimensions. The greater the global weight of the dimensions, the greater the influence as a success factor to implement GSCM in Indonesia automotive Industry.

The top three for dimension weight are green transportation and distribution, organizational perspective and green purchasing and procurement. Moreover, the top five critical success factors are top management perspective, company competitiveness, economic interest, use of machines and equipment and identify carbon footprint.

Figure 3 shows that the higher the position of dimension, the higher that dimension influences other dimensions. The dimension with most influences is green production and manufacturing, and green transportation and distribution is the dimension that tends to be influenced by other dimensions. Factors that affect visually are divided into two groups, namely positive and negative.

Positive (D - R) values will be included in the "Cause" group or affect the negative value (D - R) will be entered into the "Effect" group or influenced.

The "Cause" group means the factors that influence, have an impact or influence the whole system whose performance can affect the overall goal. The "effect" group means that it tends to be easily influenced.

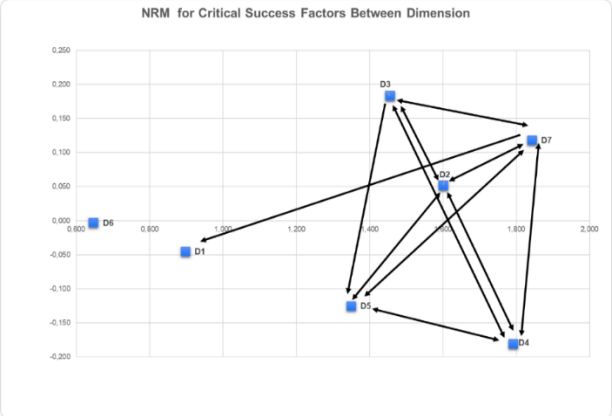

Figure 3. NRM for Critical Success Factors between Dimension

Below is the explanation of the relationship between critical success factors in each dimension. In the green design dimension, figure 4. Information on disposal steps / disposal of goods (GD04) is dominant over the other factors. This shows that the GD04 factor has a greater influence on other factors. This happens because the D -R score for GD04 is the highest score compared to other factors. D - R score for GD04 is 0.019. Meanwhile, the factors most influenced by other factor are components that can be recycled (GD01). This is because D – R score for GD01 is the lowest between all factors in the green design dimension at -0.033.

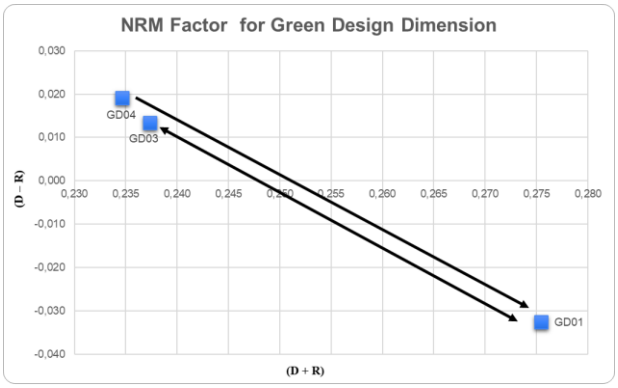

Figure 4. NRM Critical Success Factors in Green Design Dimension

In the green purchasing and procurement dimension, figure 5. Supplier development (GPP02) factor has a greater influence on other factors. This happens because the D - R score for GPP02 is the highest score compared to other factors. D - R score for GPP02 is 0.004. Meanwhile, the factors most influenced by other factor is supplier audits (GPP03). This is because D – R score for GPP03 is the lowest between all factors in green purchasing and procurement dimension at -0.002.

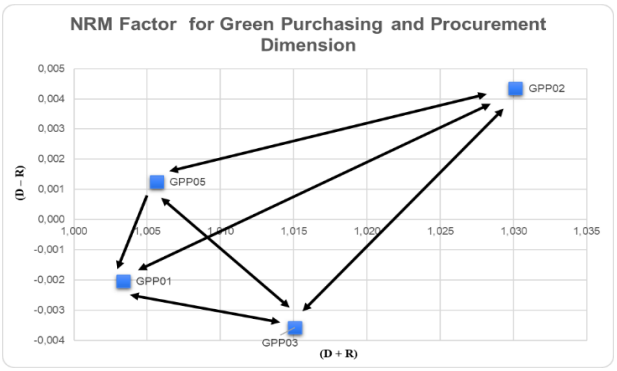

Figure 5. NRM Critical Success Factors in Green Purchasing and Procurement Dimension

In the green production and manufacturing dimension, figure 6. Carbon footprint identification (GPM04) factor has a greater influence on other factors. This happens because the D - R score for GPM04 is the highest score compared to other factors with D - R score for 0.002. Meanwhile, the factors most influenced by other factor is use of machines and equipment (GPM02). This is because D – R score for GPM02 is the lowest between all factors in the dimension at -0.003.

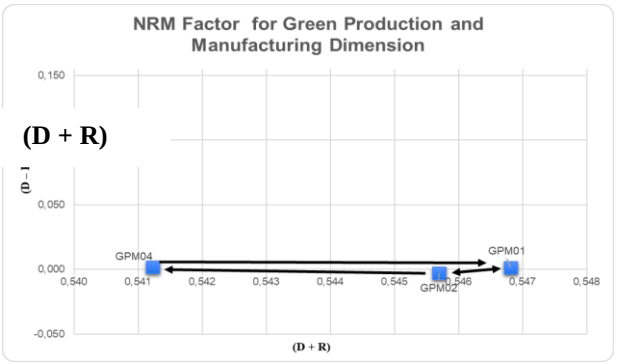

Figure 6. NRM Critical Success Factors in Green Production and Manufacturing Dimension

In the green transportation and distribution dimension, figure 7. Truck load optimization (GTD05) factor has a greater influence on other factors. This happens because the D - R score for GTD05 is the highest score compared to other factors with score 0.034. Meanwhile, the factors most influenced by other factor is use of the milk-run delivery scheme (GTD02). This is because D – R score for GTD02 is the lowest between all factors in the dimension at -0.047.

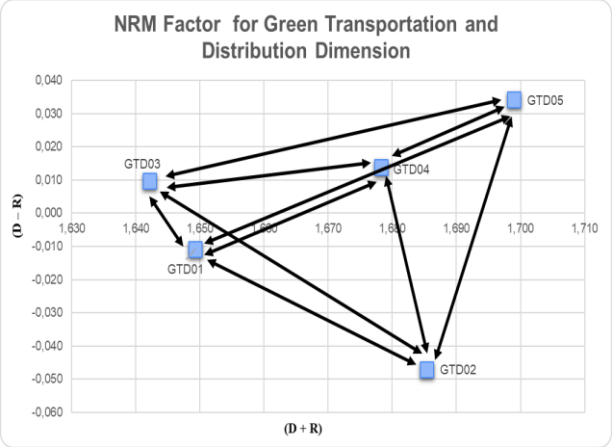

Figure 7. NRM Critical Success Factors in Green Transportation and Distribution

In the green warehousing dimension, figure 8. Inventory management and movement of goods (GW02) factor has a greater influence on other factors. This happens because the D - R score for GW02 is the highest score compared to other factors with score 0.029. Meanwhile, the factors most influenced by other factor is use of forklifts by type (GW03). This is because D – R score for GW03 is the lowest between all factors in the dimension at -0.027.

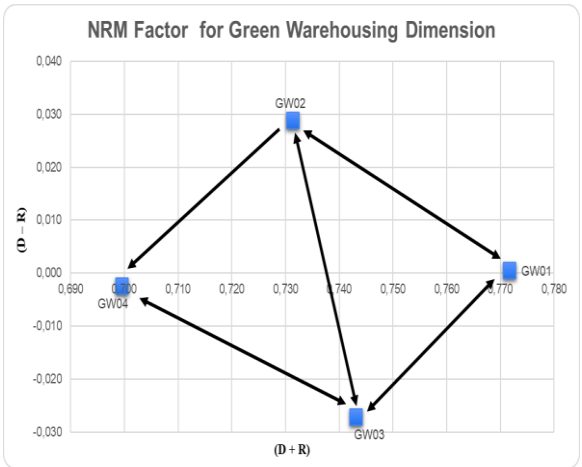

Figure 8. NRM Critical Success Factors in Green Warehousing Dimension

In the green packaging dimension, figure 9. Selection of packaging materials (GPG01) factor has a greater influence on other factors. This happens because the D - R score for GPG01 is the highest score compared to other factors with score 0.00014. Meanwhile, the factors most influenced by other factor is material reduction (GPG02). This is because D – R score for GPG02 is the lowest between all factors in the dimension at -0.00014.

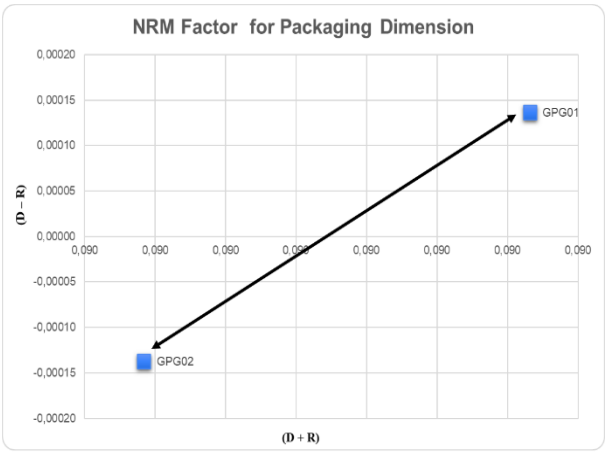

Figure 9. NRM Critical Success Factors in Green Packaging Dimension

In the organizational dimension, figure 10. Employee perspective (OP02) factor has a greater influence on other factors. This happens because the D - R score for OP02 is the highest score compared to other factors with score 0.097. Meanwhile, the factors most influenced by other factor is top management perspective (OP01). This is because D – R score for OP01 is the lowest between all factors in the dimension at -0.072.

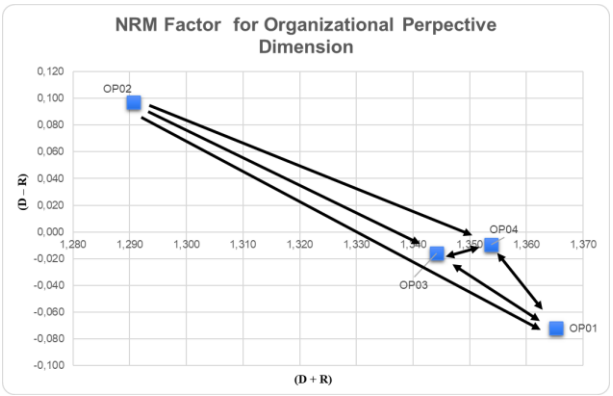

Figure 10. NRM Critical Success Factors in Organizational Perspective Dimension

Discussion

Top Five Critical Success Factors Analysis

Top management perspective is the most important factor that supports success in implementing GSCM, top management commitment and support is the main thing because they have the authority and power to make strategic decisions that affect all company operations, including changing company culture by providing demonstrations of practices and motivate employees at all levels or by creating new policies that are in line with GSCM implementation. This factor also ranks first in the organizational perspective dimension.

The company's competitiveness is in second place, along with increasing consumer awareness of environmental issues, consumers tend to choose products that care about the environment and sustainability. By implementing GSCM the company will have a new unique selling point that will improve the company's image in the market. In addition, currently the Indonesian government is increasingly establishing strict regulations regarding sustainability issues, so that by implementing GSCM early, companies can avoid the risk of violations and maintain the company's competitiveness in the market. This factor is also ranked second in the organizational perspective dimension.

The weight of the economic importance factor is ranked third, the thing that supports a company to implement GSCM is the opportunity to reduce operational costs by increasing efficiency and reducing waste. For example, optimizing the use of energy and raw materials so as to reduce production costs.

Using energy-efficient machinery and equipment is ranked fourth, because it reduces greenhouse gas emissions, saves company operational costs, encourages product innovation, and fulfills corporate social responsibility.

Carbon footprint identification is in fifth place, carbon footprint identification is the first step for a company to understand and determine the environmental impact of operational activities carried out by the company, identify emission reduction opportunities such as the use of environmentally friendly transportation, supplier selection and supplier development. in line with sustainability practices.

Relationship between Critical Success Factors in Dimensions

Analysis will be carried out on the network relationship map between factors in 4 dimensions with the highest dimension weights based on ANP calculation which consists of the dimensions of green transportation and distribution, organizational perspective, green purchasing and procurement, and green production and manufacturing

Green transportation and distribution

The truck load optimization factor (GTD05) has the highest influence compared to other factors. In this dimension, all factors influence and receive influence from all other factors, this can be seen from all the arrow directions in the NRM which have arrows, meaning that the load on the truck and the optimal transportation route (GTD04) can be achieved using the milk-run scheme delivery (GTD02), the use of a cross-dock delivery scheme (GTD03) can optimize the load on the truck and design optimal routes. The optimal route (GTD04) can be achieved by selecting the right warehouse location and vice versa.

Organizational perspective

Employee perspective (OP02) has a high influence because this factor is the only factor that does not receive influence from other factors in the dimensions and has an influence on management perspective (OP1), economic interests (OP3) and company competitiveness (OP4), meaning that employees who have competence, awareness, training and skills in implementing GSCM can help companies increase competitiveness, provide a new perspective for top management to take strategic steps and provide efficiency in company costs. Meanwhile, the factors of company competitiveness (OP4), economic interests (OP3) and top management perspective (OP1) influence and are influenced by each other, meaning that the strategy formulated by top management will take into account the company's economic interests and company competitiveness, and vice versa.

Green purchasing and procurement

The role of suppliers (GPP01) mutually influences supplier development factors (GPP02) and supplier audits (GPP03), but is influenced by government support and regulation factors (GPP05), this shows that with government support and regulations, companies and suppliers will collaborate To integrate environmental goals with environmental improvement initiatives, this must of course be supported by embedding sustainability initiatives through the company's supplier development program. To ensure that initiatives continue to run in the procurement and purchasing process, supplier audits are carried out to ensure supplier compliance with sustainability initiative programs, and vice versa. Government support and regulations (GPP05) influence each other with supplier development factors (GPP02) and supplier audits (GPP03), this indicates that the positive impact received by the government from the supplier development process through instilling sustainability initiatives and supplier compliance testing through company audits can create The government designs regulations with the help of incentives or compensation so that industry players are interested in implementing

sustainability initiatives in the process of purchasing and procuring goods in their supply chains.

Green production and manufacturing

Carbon footprint identification (GMP04) has an influence on CO2 reduction factors in the production process (GPM01), and is influenced by machine and equipment usage factors (GPM02), this shows that to reduce CO2 produced by the production process, carbon footprint identification must be done first in order to see opportunities for improvement and sustainability in supporting the implementation of GSCM, while the use of energy-efficient and fuel-efficient machines and equipment (GPM02) can influence the calculated results of the carbon footprint identification carried out, and vice versa. Then, CO2 reduction in the production process (GPM01) affects the use of machines and equipment (GPM02) and vice versa because the specifications of the machines used are machines with low carbon emissions or use little energy, meanwhile, the use of machines that are not eco-friendly will increase the amount of CO2 consumed generated by the production process.

CONCLUSION

This research examines the critical success factors in implementing green supply chain management in the Indonesian automotive industry. This research also explores the relationships and interrelationships between factors and dimensions.

Top management perspective is the most critical success factor for GSCM implementation in Indonesian automotive companies because they have the authority and power to make strategic decisions that affect all company operations, including changing the company culture by providing demonstrations of sustainable practices so that it can motivate employees. Green transportation and distribution is the most important dimension for GSCM implementation in Indonesian automotive companies. This is supported by the background because the transportation sector is the sector with the second largest CO2 contributor after the electricity sector.

Future studies: The potential for green packaging in implementing GSCM can still be developed, currently there are not many types of environmentally friendly packaging materials that can replace conventional types of packaging materials, especially in the automotive industry, such as poly boxes, bubble wrap, corrugated boxes and carton boxes.

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