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Analysis of Barriers to Sustainable Supply Chain Implementation Using DEMATEL and ISM Integration

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Abstract

CV. XYZ found barriers that could hinder the implementation of a sustainable supply chain in the company. However, the company does not have a resolution method for determining the priority barriers that most influence the implementation. The aim of this research is to determine the barriers that influence the implementation of a sustainable supply chain. Settlement is carried out using the DEMATEL-ISM method. The research results show that the most influential barriers are lack of regulation and guidance from the government (A9) and high initial investment (A1). Because in the DEMATEL-ISM integration, these two factors were found to be located at the lowest level, which is the level with the most influential barriers, which are the main drivers. As a result, companies need to prioritize lack of regulation and guidance from the government and high initial investment as a basis for evaluation and improvement in implementing sustainable supply chains.

Introduction

With the development of the manufacturing industry, competition in the industrial world is getting tougher. Many companies are competing to survive in this competition. There are many things needed in order to survive and compete in the world of the manufacturing industry, but one of the most important is supply chain management. Implementing supply chain management will help ensure long-term benefits for the company, customers, and the environment (Shukla et al., 2020). In its development, supply chain management has also developed a commitment to create continuity between economic, social, and environmental factors towards a sustainable process (Menon & Ravi, 2021). According to Gbolarumi et al. (2021), sustainability is carried out by evaluating performance assessments from environmental, social, and economic aspects. Developments in supply chain management have not escaped the insistence of researchers and practitioners in addressing environmental issues that have become increasingly prevalent in the last decade (Adwiyah et al., 2023).

Sustainable supply chain management (SSCM) is a supply chain management approach that considers the social, environmental, and economic impacts of the entire supply chain (Menon & Ravi, 2021). The main goal of sustainable supply chain management (SSCM) is to meet customer demand. In SSCM, there are participants from the material procurement cycle, production cycle, and distribution cycle, all of whom have different interests. Since all entities are interconnected, their actions will impact each other. For example, all organizations, down to suppliers, must meet consumer needs for environmentally friendly products. These three factors can also interact to influence each other's ability to achieve their respective goals (Alam & Wahyuningsih, 2023). In transforming the supply chain management system into

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sustainable supply chain management (SSCM), of course, there are many factors that need to be considered, including the barriers that exist in the implementation process (Zayed & Yaseen, 2021). Many studies have been conducted to solve problems in the implementation of SSCM recently. Liu et al. (2021), in their research, used the DEMATEL method to analyze the inhibiting factors in the field of sustainable food consumption and production in China.

CV. XYZ in this study produces various types of nails, among the types of nails produced include wooden nails, tacks of various sizes. The main raw material in making nails is wire rod. In the production process, it also uses several types of machines including wire winding machines, nail cutting machines, and polishing machines. To support a good production process, of course, good and sustainable supply chain management is needed. The existing supply chain in this company still uses a supply chain based on the traditional supply chain, which is a supply chain that is only oriented towards the economic sector.

In this research, the company wants to transform their supply chain management to be based on sustainable supply chain management. However, in this implementation, of course, it is necessary to know what inhibiting factors exist in the company, so that the company can evaluate, reduce, and remove these barriers. However, the company has not found the right method to analyze the barriers that exist in the company and how to determine the priority barriers that are most dominant in influencing the implementation of SSCM in the company.

Based on these problems, there are several methods that can be used, including the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method which can be used to formulate causal relationships between factors (Jalali et al., 2022; Liu et al., 2021; Singh & Bhanot, 2020), interpretive structural modeling (ISM) method which helps in modeling relationships between factors (Raut et al., 2019; Zayed & Yaseen, 2021; Zhao et al., 2019). Can also use hybrid models such as DEMATEL-WASPAS (Gulo, 2021), DEMATEL-ANP integration model (Permadi et al., 2019), DEMATEL-ISM integration model (Shakeri & Khalilzadeh, 2020; Shanker & Barve, 2021).

Therefore, the company needs a method to analyze the barriers that affect the implementation of a sustainable supply chain. This study will be done to solve these problems by using the DEMATEL-ISM method and the and the integration method to find out which inhibiting factors are most dominant in hindering the implementation of a sustainable supply chain. The results of this study are expected to assist companies in evaluating, reducing, and removing barriers that exist to this problem.

Methods

In this research, data was collected by conducting field observations, conducting direct interviews with company experts, and distributing questionnaires. There are two types of questionnaires used, namely the DEMATEL questionnaire and the ISM questionnaire. The questionnaire will be filled out by five experts in the company.After obtaining the results of the questionnaire from five experts, the data was processed using the DEMATEL and ISM methods. then the DEMATEL-ISM method was integrated to obtain the priority barriers that most influence and obtain a model that shows the relationship between barrier factors.

The stages of DEMATEL work are as follows:

The first stage is the initial direct relation matrix. In the first stage, respondents are asked to determine a scale regarding how factor i influences factor j. Pairwise comparisons between two factors are have a scale of 0, 1, 2, 3, and 4, which represent no influence (0), little influence (1), moderate influence (2), strong influence (3), and very strong influence (4). Next, the average of the answers from the experts is calculated into a matrix A.

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The second stage is normalizing the direct relationship matrix. The normalized initial direct-relation matrix S is obtained from the average matrix A, which is normalized by:

$$K = max\left(\max_{1\leq i\leq n} \sum_{j=1}^{n} a_{ij}, \max_{1\leq j\leq n} \sum_{i=1}^{n} a_{ij}\right) \quad (1)$$

$$S = \frac{A}{K} \quad (2)$$

The third stage calculates the total relation matrix. The total relation matrix can be calculated using the following formula:

$$M = S(I - S)^{-1} \quad (3)$$

Then r is calculated which is the total of the row horizontal, and c which is the total of the column vertical.

The fourth stage determines the inner dependency matrix. In this stage, the threshold value (α) is calculated by taking the average of the 'M' matrix. Threshold values help filter out unimportant relationships. Values greater than 'α' are significant and are chosen to indicate a cause-and-effect relationship (Gardas et al., 2019).

The fifth stage is creating an impact diagram map. The final stage in DEMATEL is to create an impact diagram map, which will obtain a map of the relationships between criteria. After adding the columns and rows as in stage 3, continue by finding the x and y coordinates with the formula:

$$x = r + c \quad (4)$$

$$y = r - c \quad (5)$$

The next stages of ISM work are as follows:

The first stage determines the structural self-interaction matrix (SSIM). The first stage is to analyze contextual relationships with the types of leads. So there will be one factor that can influence other factors. There are four symbols used to show the direction of the relationship between two factors, namely: V relationship from factor i to factor j; factor i will influence factor j; A relationship between factor j and factor i; factor i will be influenced by factor j; X two-way relationship; factors i and j will influence each other; O there is no relationship between factors; factors i and j are not related.

The second stage determines the reachability matrix (RM). The second stage is developing the reachability matrix from SSIM. Reachability matrix (RM) is a representation of SSIM in the form of binary numbers.

The third stage determines the partition level. In the third stage, the final reachability matrix is obtained for each factor, and the reachability set and antecedent set are obtained. The reachability set consists of the factor itself and other factors that may influence it, while the antecedent set consists of the factor itself and other factors that may influence it. Then we will obtain an interaction set for all factors, determined by different factor levels. Factors that have the same reachability and interaction set will occupy the top level of the hierarchy. Top-level factors are factors that do not move other factors in the hierarchy (Ahmad & Qahmash, 2021).

The fourth stage creates a canonical matrix (CM). A conical matrix has rows and columns ordered by rank. Then the level of each variable is recorded at the end of the row and column in CM. This matrix can help in drawing digraphs to get the first visual output of the hierarchical direction structure of all variables. Next, the drive power and dependence power rankings are calculated by giving the highest ranking to the factor that has the maximum number of ones in the row and column.

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The fifth stage builds the ISM model. In this final stage, a creation is carried out. In this final stage, an ISM model is created based on a known sequence of partition levels and the relationship between factors (Rifaldi et al., 2021).

Next, the DEMATEL-ISM method was integrated. This integration is carried out by adding inner dependency matrix values to the ISM model. This inner dependency matrix value is the significance value of the relationship between factors, so that the direction of the relationship and the significance value of the relationship between these factors can be known.

Results and Discussion

After conducting literature studies and interviews with companies, it was found that the barriers that were successfully identified and verified by the company were in table 1.

Table 1. Barriers that exist within the company

Category	Barriers	Code
Economy	High initial investment	A1
Technology	Inadequate assessment system for suppliers	A2
	Old equipment and machines	A3
	Lack of research and development regarding sustainability	A4
Policy	Lack of management of incentive mechanisms	A5
	Lack of commitment and support from top level management	A6
	Lack of performance measurement, monitoring and evaluation standards	A7
	Lack of strategic planning	A8
	Lack of regulation and guidance from the government	A9
Human Resources	Lack of human skills, experience, and tools necessary to implement SSCM practices	A10
	Behavioral and psychological barriers	A11
	Lack of human training/expertise regarding sustainability	A12

12 barriers were found and identified as barriers to implementing sustainable supply chains in companies. Then, data processing was carried out using the DEMATEL and ISM methods, and the integration of DEMATEL and ISM was carried out to determine the priority barriers that most influence the implementation of sustainable supply chains in the company.

DEMATEL method

Initial direct relation matrix

The initial direct relationship matrix results obtained from the questionnaire results are in table 2.

Table 2. Initial direct relation matrix A

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	Sum
A1	0	2,6	3,2	3,4	2,6	3,0	3,4	2,6	2,6	3,2	3,0	3,6	33,2
A2	2,8	0	0,6	2,2	0,6	2,6	1,4	2,0	0,6	2,4	0,6	2,2	18
A3	3,2	1,2	0	1,0	1,2	2,8	2,2	1,4	0,8	2,8	2,2	2,8	21,6
A4	2,4	3,0	2,8	0	2,6	2,4	2,6	2,4	2,0	2,8	2,0	2,6	27,6
A5	1,2	1,0	1,8	1,2	0	1,6	1,4	0,6	0,6	1,6	1,4	1,6	14
A6	3,4	2,8	3,0	2,4	2,6	0	2,6	2,8	1,6	3,0	2,8	3,2	30,2
A7	2,2	2,6	2,6	2,2	2,6	2,6	0	2,2	1,4	2,2	2,2	2,4	25,2
A8	2,0	2,2	2,4	1,8	1,4	2,0	1,2	0	0,4	1,0	1,0	1,0	16,4
A9	0,6	2,4	0,8	3,2	0,6	3,4	1,8	2,0	0	2,8	1,6	2,8	22
A10	2,4	1,6	2,0	1,4	1,8	2,0	2,2	1,2	0,4	0	1,2	2,2	18,4
A11	1,4	1,6	0,8	1,0	1,4	1,4	1,0	0,6	0,8	1,6	0	1,6	13,2

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A12	3,0	2,2	1,6	2,4	2,8	3,2	2,8	2,6	1,6	2,6	2,4	0	27,2
Sum	24,6	23,2	21,6	22,2	20,2	27	22,6	20,4	12,8	26	20,4	26	

In the table 2, it can be seen that the values represent the direct influence of one barrier on other barriers. It can be seen that these values represent the direct influence of one barrier on other barriers. Higher values indicate a stronger influence, indicating that a particular barrier has a more pronounced impact on the network of barriers. For example, in the table, a high value at the intersection of "high initial investment" (A1) and "old equipment and machinery" (A3) indicates that the financial burden of investment significantly exacerbates the challenges posed by outdated technology.

Furthermore, based on formula (1), the K value is obtained from the maximum value for the number of rows and the number of columns. So the K value is 33.2. Next, the K value is used as a dividing number in normalizing matrix A.

Normalized direct relation matrix

The Normalized dirrect relation matrix calculation is calculated using formula (2).The results of the normalized direct relation matrix that have been obtained are in table 3.

Table 3. Normalized direct relation matrix S

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
A1	0	0,0783	0,0964	0,1024	0,0783	0,0904	0,1024	0,0783	0,0783	0,0964	0,0904	0,1084
A2	0,0843	0	0,0181	0,0663	0,0181	0,0783	0,0422	0,0602	0,0181	0,0723	0,0181	0,0663
A3	0,0964	0,0361	0	0,0301	0,0361	0,0843	0,0663	0,0422	0,0241	0,0843	0,0663	0,0843
A4	0,0723	0,0904	0,0843	0	0,0783	0,0723	0,0783	0,0723	0,0602	0,0843	0,0602	0,0783
A5	0,0361	0,0301	0,0542	0,0361	0	0,0482	0,0422	0,0181	0,0181	0,0482	0,0422	0,0482
A6	0,1024	0,0843	0,0904	0,0723	0,0783	0	0,0783	0,0843	0,0482	0,0904	0,0843	0,0964
A7	0,0663	0,0783	0,0783	0,0663	0,0783	0,0783	0	0,0663	0,0422	0,0663	0,0663	0,0723
A8	0,0602	0,0663	0,0723	0,0542	0,0422	0,0602	0,0361	0	0,0120	0,0301	0,0301	0,0301
A9	0,0181	0,0723	0,0241	0,0964	0,0181	0,1024	0,0542	0,0602	0	0,0843	0,0482	0,0843
A10	0,0723	0,0482	0,0602	0,0422	0,0542	0,0602	0,0663	0,0361	0,0120	0	0,0361	0,0663
A11	0,0422	0,0482	0,0241	0,0301	0,0422	0,0422	0,0301	0,0181	0,0241	0,0482	0	0,0482
A12	0,0904	0,0663	0,0482	0,0723	0,0843	0,0964	0,0843	0,0783	0,0482	0,0783	0,0723	0

In the table 3, it is known that the normalized direct relation matrix values mean that all values in the Normalized dirrect relation matrix are on the same scale, making it easier to compare and analyze the influence between factors and assists in more accurate and efficient total relation matrix calculations.

Total relation matrix

After obtaining the normalized direct relation matrix S, the total relation matrix M is then calculated. The total relation matrix M is calculated using formula (3). The results of the total relation matrix that have been obtained are in table 4.

Table 4. Total relation matrix M

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
A1	0,1998	0,2559	0,2635	0,2676	0,2387	0,2930	0,2758	0,2367	0,1781	0,2930	0,2479	0,3034
A2	0,1988	0,1107	0,1260	0,1677	0,1195	0,1974	0,1510	0,1571	0,0827	0,1896	0,1171	0,1845
A3	0,2277	0,1611	0,1222	0,1501	0,1515	0,2220	0,1893	0,1540	0,0976	0,2195	0,1777	0,2201
A4	0,2346	0,2357	0,2239	0,1452	0,2104	0,2427	0,2244	0,2041	0,1438	0,2487	0,1932	0,2434
A5	0,1246	0,1100	0,1294	0,1112	0,0743	0,1385	0,1217	0,0907	0,0649	0,1371	0,1143	0,1371
A6	0,2765	0,2443	0,2435	0,2260	0,2241	0,1911	0,2390	0,2273	0,1418	0,2695	0,2282	0,2749
A7	0,2159	0,2124	0,2071	0,1948	0,1997	0,2328	0,1390	0,1873	0,1205	0,2186	0,1879	0,2240

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A8	0,1631	0,1576	0,1604	0,1418	0,1267	0,1660	0,1305	0,0861	0,0680	0,1371	0,1156	0,1374
A9	0,1589	0,1964	0,1452	0,2101	0,1340	0,2388	0,1772	0,1725	0,0727	0,2197	0,1584	0,2191
A10	0,1864	0,1531	0,1614	0,1428	0,1505	0,1798	0,1704	0,1319	0,0755	0,1206	0,1331	0,1831
A11	0,1239	0,1220	0,0964	0,1023	0,1098	0,1276	0,1056	0,0867	0,0677	0,1315	0,0685	0,1314
A12	0,2489	0,2149	0,1935	0,2127	0,2172	0,2617	0,2294	0,2093	0,1338	0,2422	0,2045	0,1700

In Table 4, the total relationship matrix, which combines direct and indirect influences, can be used to identify key factors (cause) and factors that are influenced (effect) in a system. For example, “Lack of government regulation and guidance” (A9) shows that government policy, or the absence of government policy, has far-reaching implications, directly and indirectly affecting various aspects of a company's supply chain sustainability.

Inner dependency matrix

The stage for determining the value of the inner dependency matrix is carried out by looking for the threshold value 'α' obtained from the average of the M matrix.

Table 5. Inner dependency matrix

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
A1	0,1998	0,2559	0,2635	0,2676	0,2387	0,2930	0,2758	0,2367	0,1781	0,2930	0,2479	0,3034
A2	0,1988	0,1107	0,1260	0,1677	0,1195	0,1974	0,1510	0,1571	0,0827	0,1896	0,1171	0,1845
A3	0,2277	0,1611	0,1222	0,1501	0,1515	0,2220	0,1893	0,1540	0,0976	0,2195	0,1777	0,2201
A4	0,2346	0,2357	0,2239	0,1452	0,2104	0,2427	0,2244	0,2041	0,1438	0,2487	0,1932	0,2434
A5	0,1246	0,1100	0,1294	0,1112	0,0743	0,1385	0,1217	0,0907	0,0649	0,1371	0,1143	0,1371
A6	0,2765	0,2443	0,2435	0,2260	0,2241	0,1911	0,2390	0,2273	0,1418	0,2695	0,2282	0,2749
A7	0,2159	0,2124	0,2071	0,1948	0,1997	0,2328	0,1390	0,1873	0,1205	0,2186	0,1879	0,2240
A8	0,1631	0,1576	0,1604	0,1418	0,1267	0,1660	0,1305	0,0861	0,0680	0,1371	0,1156	0,1374
A9	0,1589	0,1964	0,1452	0,2101	0,1340	0,2388	0,1772	0,1725	0,0727	0,2197	0,1584	0,2191
A10	0,1864	0,1531	0,1614	0,1428	0,1505	0,1798	0,1704	0,1319	0,0755	0,1206	0,1331	0,1831
A11	0,1239	0,1220	0,0964	0,1023	0,1098	0,1276	0,1056	0,0867	0,0677	0,1315	0,0685	0,1314
A12	0,2489	0,2149	0,1935	0,2127	0,2172	0,2617	0,2294	0,2093	0,1338	0,2422	0,2045	0,1700

Based on table 5, it can be seen that the value of the relationship between significant factors is based on the threshold value used to describe the cause and effect relationship. This value will be included in the DEMATEL-ISM integration.

Impact diagraph

This impact diagram map stage begins with calculating R and C in the M matrix. R is calculated which is the total of the row horizontal, and C which is the total of the column vertical. For the results of ranking and identification of causal groups, the results obtained are as shown in the table 6.

Table 6. Ranking and grouping of barriers

Barriers	**R + C**	**R - C**	**Identify**	**Ranking**
Lack of regulation and guidance from government (A9)	3,350	0,856	*Cause*	1
High initial investment (A1)	5,412	0,694	*Cause*	2
Lack of research and development regarding sustainability (A4)	4,622	0,478	*Cause*	3
Lack of commitment and support from top level management (A6)	5,278	0,295	*Cause*	4
Lack of performance measurement, monitoring and evaluation standards (A7)	4,493	0,187	*Cause*	5

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Lack of training/human expertise regarding sustainability (A12)	4,966	0,109	*Cause*	6
Old equipment and machines (A3)	4,165	0,020	*Cause*	7
Lack of strategic planning (A8)	3,534	-0,353	*Effect*	8
Inadequate assessment system for suppliers (A2)	3,976	-0,372	*Effect*	9
Equal distribution of salaries and health benefits (A5)	3,310	-0,603	*Effect*	10
Lack of human skills, experience, and tools necessary to implement SSCM practices (A10)	4,216	-0,638	*Effect*	11
Behavioral and psychological barriers (A11)	3,220	-0,673	*Effect*	12

Based on the results of the analysis, it is known that barriers with high R+C values (number of influences given and received) are influential and influenced, which shows their central role in the system. For example, "old equipment and machinery" (A3) having a high R+C value indicates that it is a significant barrier and is a symptom of other underlying problems such as financial constraints (A1) and lack of research and development (A4).

After knowing the values (R+C) and (R-C), an impact diagram map is created to describe the distribution of barriers. The distribution of barriers based on the impact digraph can be seen in Figure 1.

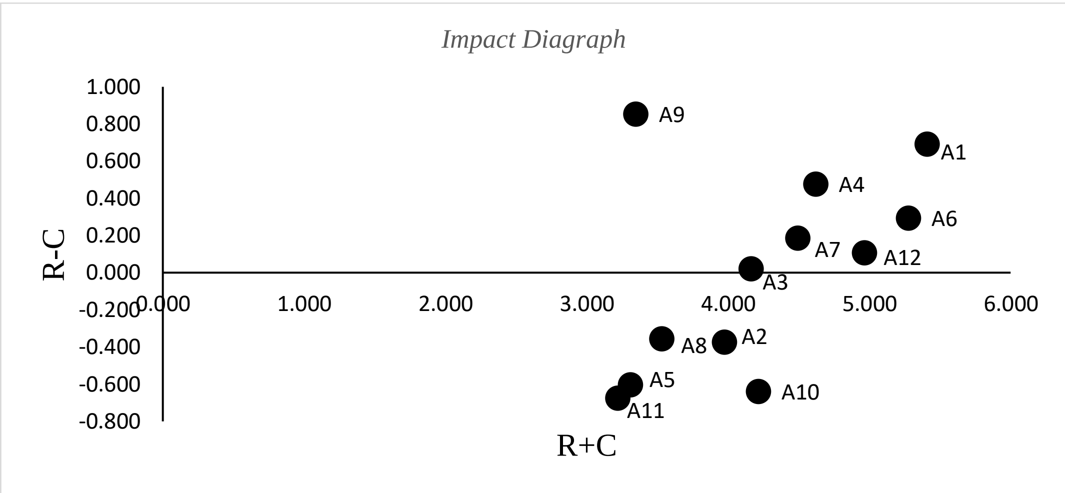

Figure 1. Impact diagraph

ISM method

Final Structural Self Iteration Matrix (SSIM)

From the average of the results of questionnaire ISM, 5 respondents obtained the final structural self iteration matrix as in table 7.

Table 7. Final Structural Self Iteration Matrix (SSIM)

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
A1		X	X	V	V	V	V	V	O	V	O	V
A2			O	A	O	A	O	X	O	O	O	A
A3				A	O	A	A	X	O	X	X	A
A4					V	A	V	V	O	X	V	A
A5						X	X	X	A	X	X	A
A6							V	V	O	X	O	V
A7								X	X	X	O	A
A8									A	X	X	A

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A9										V	O	O
A10											X	A
A11												X
A12												

Completing ISM requires 1 SSIM, which includes 5 expert opinion answers that have been obtained. The decision making based on these 5 expert opinions is based on two provisions, the first is that the highest quantity of symbols is selected, and the second is that if there is a balanced or equal quantity, then the decision will be based on the priority of the VAXO symbol. The order of priority is that the V symbol has the highest priority while the O symbol has the lowest priority.

Initial Reachability Matrix

Build an initial reachability matrix, where at this stage the VAXO symbol in the SSIM table will be changed to the numbers 1 and 0 which express the relationship between one factor and another. The results of the initial reachability matrix carried out can be seen in the table 8.

Table 8. Initial reachability matrix

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
A1	1	1	1	1	1	1	1	1	0	1	0	1
A2	0	1	0	0	0	0	0	0	0	0	0	0
A3	0	0	1	0	0	0	0	1	0	1	1	0
A4	0	1	1	1	1	0	1	1	0	1	1	0
A5	0	0	0	0	1	0	0	0	0	1	0	0
A6	0	1	1	1	1	1	1	1	0	1	0	1
A7	0	0	1	0	1	0	1	0	0	0	0	0
A8	0	1	1	0	1	0	1	1	0	0	1	0
A9	0	0	0	0	1	0	1	1	1	1	0	0
A10	0	0	0	1	1	1	1	1	0	1	0	0
A11	0	0	0	0	1	0	0	1	0	1	1	1
A12	0	1	1	1	1	0	1	1	0	1	0	1

After the reachability matrix is formed, as shown in Table 8, make corrections using transitivity rules. Transitivity is the completeness of a causal loop for example, if A influences B and B influences C, then A must influence C. The aim of this transitivity correction is to correct the suitability of the answers produced by respondents. Then the dependence power and drive power values are also determined. The final results of the affordability matrix, which has undergone transitivity correction, can be seen in Table 9.

Table 9. Final reachability matrix

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**Drive Power**
A1	1	1	1	1	1	1	1	1	0	1	**1***	1	11
A2	0	1	0	0	0	0	0	0	0	0	0	0	1
A3	0	**1***	1	**1***	**1***	**1***	**1***	1	0	1	1	**1***	10
A4	0	1	1	1	1	**1***	1	1	0	1	1	**1***	10
A5	0	0	0	**1***	1	**1***	**1***	**1***	0	1	0	0	6
A6	0	1	1	1	1	1	1	1	0	1	**1***	1	10
A7	0	0	1	0	1	0	1	**1***	0	**1***	**1***	0	6
A8	0	1	1	0	1	0	1	1	0	**1***	1	**1***	8

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A9	0	**1***	**1***	**1***	1	**1***	1	1	1	1	**1***	0	10
A10	0	**1***	**1***	1	1	1	1	1	0	1	**1***	**1***	10
A11	0	**1***	**1***	**1***	1	**1***	**1***	1	0	1	1	1	10
A12	0	1	1	1	1	**1***	1	1	0	1	**1***	1	10
Dependence Power	1	10	10	9	11	9	11	11	1	11	10	8	

Table 9 is a table that has been corrected using transitivity rules. Comparison cell (A1,A11) = 0, because (A1,A3) = 1 and (A3,A11) = 1, then (A1,A11) is changed to 1. Cell (A1,A11) is changed to 1 because factor A1 influences A3 and A2 influences A11, then A1 must influence A11, and so on for a table of other factor relationships that need to be corrected.

Level partition

At the level partition stage, the level will be determined for each factor. Determining the level by determining a variable that has a value of 1 in the horizontal position (j) for the reachability set and vertical (i) for the antecedent set. After that, determine the intersection variables for the intersection set of the reachability set and antecedent set. The partition level results that have been carried out are as shown in the table 10.

Table 10. Level partition iteration

	Reachability set	**Antesedent set**	**Intersection set**	**level**
A2	A2	A1 A2 A3 A4 A6 A8 A9 A10 A11 A12	A2	1
A5	A4 A5 A6 A7 A8 A10	A1 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12	A4 A5 A6 A7 A8 A10	1
A7	A3 A5 A7 A8 A10 A11	A1 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12	A3 A5 A7 A8 A10 A11	1
A3	A3 A4 A6 A8 A10 A11 A12	A1 A3 A4 A6 A8 A9 A10 A11 A12	A3 A4 A6 A8 A10 A11 A12	2
A8	A3 A8 A10 A11 A12	A1 A3 A4 A6 A8 A9 A10 A11 A12	A3 A8 A10 A11 A12	2
A10	A3 A4 A6 A8 A10 A11 A12	A1 A3 A4 A6 A8 A9 A10 A11 A12	A3 A4 A6 A8 A10 A11 A12	2
A11	A3 A4 A6 A8 A10 A11 A12	A1 A3 A4 A6 A8 A9 A10 A11 A12	A3 A4 A6 A8 A10 A11 A12	2
A12	A3 A4 A6 A8 A10 A11 A12	A1 A3 A4 A6 A8 A10 A11 A12	A3 A4 A6 A8 A10 A11 A12	2
A4	A4 A6	A1 A4 A6 A9	A4 A6	3
A6	A4 A6	A1 A4 A6 A9	A4 A6	3
A1	A1	A1	A1	4
A9	A9	A9	A9	4

The results of the partition level iteration above can be obtained from 4 group levels, with details at level 1 obtained by factors A2, A5, and A7. Factors at level 2 are A3, A8, A10, A11, and A12. Level 3 factors are A4 and A6. Level 4 factors are A1 and A9.

Canonical Matrix

At the canonical matrix stage, grouping and arrangement are carried out based on the highest level, namely level 1, which has been obtained in the final reachability matrix table. The results of preparing the canonical matrix can be seen in table 11.

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Table 11. Canonical matrix

	A2	A5	A7	A3	A8	A10	A11	A12	A4	A6	A9	A1	Drive Power
A2	1	0	0	0	0	0	0	0	0	0	0	0	1
A5	0	1	**1***	0	**1***	1	0	0	**1***	**1***	0	0	6
A7	0	1	1	1	**1***	**1***	**1***	0	0	0	0	0	6
A3	**1***	**1***	**1***	1	1	1	1	**1***	**1***	**1***	0	0	10
A8	1	1	1	1	1	**1***	1	**1***	0	0	0	0	8
A10	**1***	1	1	**1***	1	1	**1***	**1***	1	1	0	0	10
A11	**1***	1	**1***	**1***	1	1	1	1	**1***	**1***	0	0	10
A12	1	1	1	1	1	1	**1***	1	1	**1***	0	0	10
A4	1	1	1	1	1	1	1	**1***	1	**1***	0	0	10
A6	1	1	1	1	1	1	**1***	1	1	1	0	0	10
A9	**1***	1	1	**1***	1	1	**1***	0	**1***	**1***	1	0	10
A1	1	1	1	1	1	1	**1***	1	1	1	0	1	11
Dependence Power	10	11	11	10	11	11	10	8	9	9	1	1	

After preparing the canonical matrix as shown in table 11, So from this table, a drive power dependence diagram can be created, which can classify factors into 4 clusters, as in the figure 2.

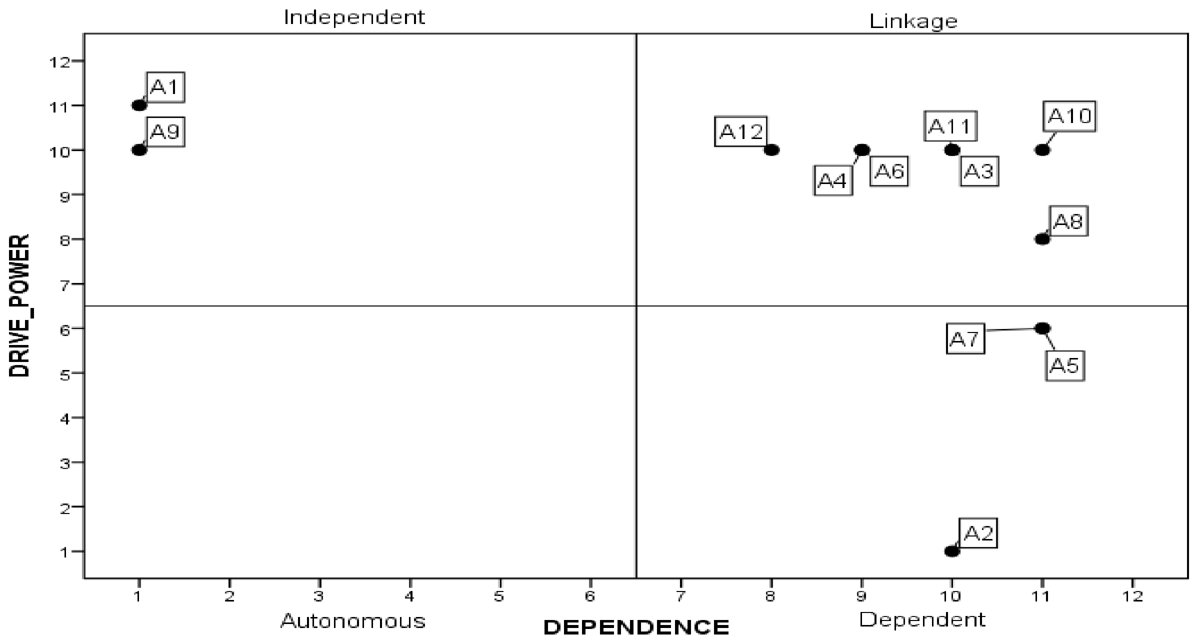

Figure 2. Drive Power-Dependence Diagram

ISM Model Structure

The ISM model structure contains levels and relationships between factors, which are depicted by arrows, both with unidirectional and bidirectional relationships. The results of the ISM model structure can be seen in Figure 3.

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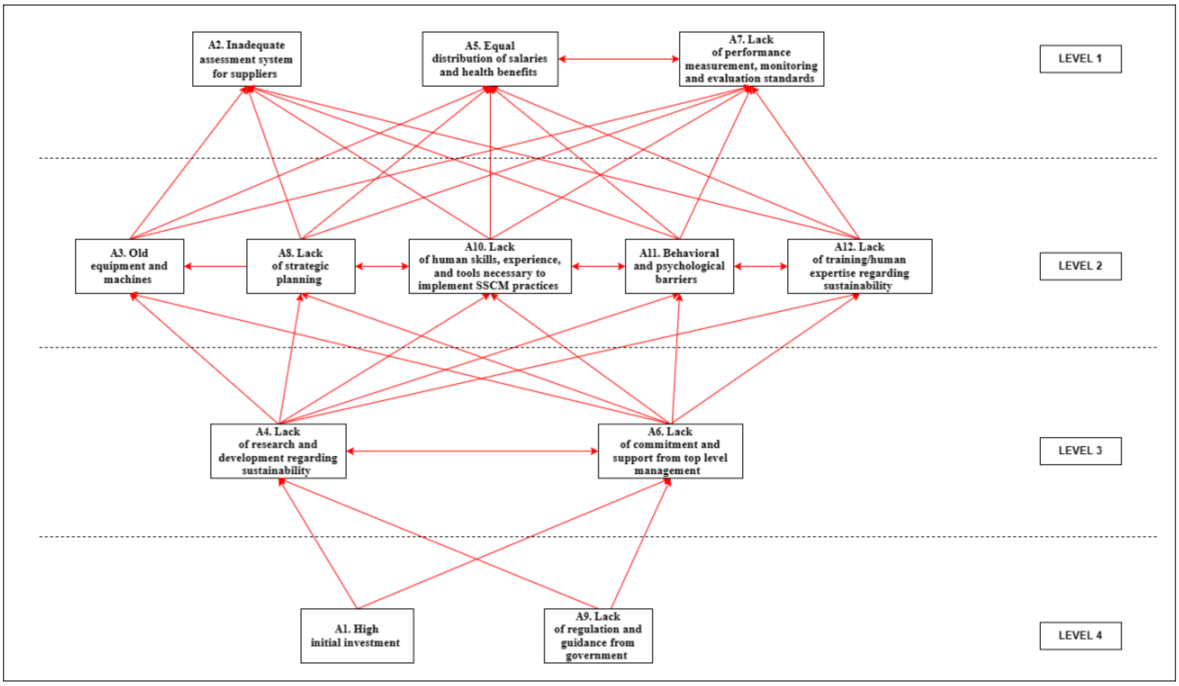

Figure 3. ISM model structure

DEMATEL-ISM integration model

After obtaining the output results of the DEMATEL method and ISM method, an integrated DEMATEL-ISM model can be created. Model creation was carried out using the initial ISM model base by adding inner independence matrix values to it. The results of the DEMATEL-ISM integration model can be seen in Figure 4.

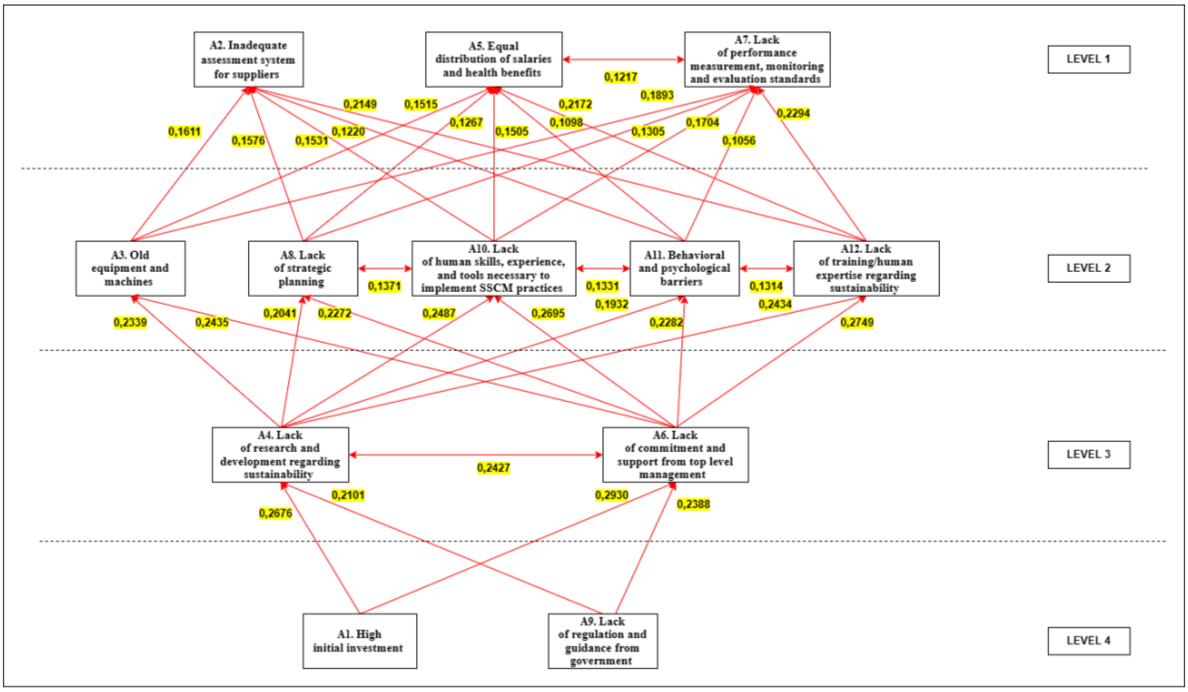

Figure 4. DEMATEL-ISM integration model

In the DEMATEL-ISM integration model structure, a model is obtained with a sequence of barriers that have a major influence on the implementation of a sustainable supply chain at CV. XYZ with level 4, lack of regulation and guidance from the government (A9) and high initial investment (A1) as the most influential levels are the main drivers. Followed by level 3, lack of research and development regarding sustainability (A4); lack of commitment and

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support from the top management level (A6). At level 2, old equipment and machines (A3); lack of strategic planning (A8); lack of human skills, experience, and tools necessary to implement SSCM practices (A10); behavioral and psychological barriers (A11); lack of human training and expertise regarding sustainability (A12). As well as Level 1 inadequate assessment systems for suppliers (A2), lack of management of incentive mechanisms (A5), and lack of performance measurement and monitoring and evaluation standards (A7).

Conclusion

Based on the research results, the most dominant inhibiting factors that influence the implementation of sustainable supply chains at CV. XYZ that use DEMATEL-ISM integration are the lack of regulation and guidance from the government (A9) and high initial investment (A1). Because in the DEMATEL-ISM integration, it was found that these two factors were at the lowest level, namely the level with the most influential barriers, which were the main drivers. Followed by a lack of research and development regarding sustainability (A4) and a lack of commitment and support from top management levels (A6). Old equipment and machines (A3); lack of strategic planning (A8); lack of human skills, experience, and tools necessary to implement SSCM practices (A10); behavioral and psychological barriers (A11); lack of human training and expertise regarding sustainability (A12). Inadequate supplier assessment system (A2); lack of management of incentive mechanisms (A5); and lack of standards for performance measurement and monitoring and evaluation (A7). Furthermore, in the results of the DEMATEL-ISM integration model in Figure 4 there are arrows depicting the relationship between factors along with the significance value of the relationship. So that the significance value of the relationship between factors can be known. Companies can use the research results and methods used in this research as a reference in implementing sustainable supply chains in analyzing inhibiting factors.

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