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Analysis of Best Vendor Selection with AHP and TOPSIS Methods at PT XYZ

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Abstract: At this time there are problems owned by vendors, including quality that does not match the criteria owned by the Company and goods that do not arrive at the specified time. From these problems can result in re-work and choosing a new vendor which results in the risk of additional costs. Vendor selection is very important for companies that implement outsourcing programs where other parties help make the company's supply chain successful. The analysis that must be done when choosing a vendor is quality, cost, delivery accuracy, flexibility. In selecting vendors, the methods we use are AHP and TOPSIS. Based on the results of the analysis using the AHP method, the order of the criteria is obtained as follows: cost (0.422), quality (0.352), delivery (0.141), and flexibility (0.084). The best alternative for natural raw materials that meets the highest priority is vendor 2 with a preference value of 0.7095.

Keywords: *Vendor Selection, AHP, TOPSIS, Supply Chain, Preference Value*

1. Introduction

Vendors are the most important thing in the company because they can affect the company's performance. If the vendor has poor performance, it will have an impact on reducing company performance. As said (Mursid & Sutopo, 2017) that the company's failure to choose a vendor can cause the project to be hampered or even canceled because the company chosen does not have sufficient credibility.

In the era of globalization, the construction industry is growing rapidly, creating fierce business competition. PT XYZ, a construction company, must provide the best results to customers in order to face this business competition. One of the keys is the selection of the right and qualified vendors. According to (Moechlis et al., 2023) Vendors are the initial providers of the materials required in the distribution chain. These materials can be raw materials, auxiliary materials, semi-finished goods, finished goods, sub-assembly, component parts, and other types. Mistakes in vendor selection can lead to losses, such as rework and increased costs. Another mistake is the poor quality of work that causes dissatisfaction from the client.

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Based on the problems described above, there are results from previous research. The following are the results of research that has been done before: According to (Susetyo et al., 2019), vendor selection is carried out by combining the AHP method with the TOPSIS method which aims to identify the best suppliers based on criteria that are in accordance with company needs. Meanwhile, according to (Rivaldi et al., 2023), in order to set priorities in selecting bolt suppliers, this study utilizes AHP to generate individual probability values for each criterion, as well as the TOPSIS method which provides guidance for users in determining the most suitable bolt supplier to choose.

Therefore, researchers are interested in further research on the use of AHP (Analitycal Hierarchy Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methods to select the best vendor. This method is known to be accurate in making decisions with various criteria. Choosing the right vendor is important for a company's success, and these methods help avoid assumptive decisions and unwanted risks. The use of AHP and TOPSIS provides a structured and accurate guide in selecting vendors that suit business needs.

2. Literature review

Management is a concerted effort to achieve organizational goals through the functions of planning, organizing, implementing, and supervising. Management is needed to achieve goals, maintain a balance between conflicting goals, and achieve efficiency and effectiveness (Maspeke et al., 2017). (Krisnaldy et al., 2020) state that management is an art in the realm of science that involves aspects of planning, organizational structure formation, coordination, implementation, and supervision. Meanwhile, (Krismiyati, 2017) defines management as the science and art of managing the effective and efficient use of human resources and other resources to achieve predetermined goals.

Management has an important role for the company. Just like Supply Chain Management (SCM) where supply chain management is part of management. According to Heizer and Barry Render (2015), as cited by (Ishak, 2019), SCM is a concept that covers all aspects of activities in the supply chain, from raw materials to meeting customer needs. Supply Chain Management (SCM) is the management and supervision of the supply chain starting from raw materials, payments, and information exchange from suppliers to manufacturers, wholesalers, to consumers. The main goal of SCM is to achieve maximum value for customers and create a competitive advantage (Nabila et al., 2022). According to (Setyadi et al., 2023) Management is a series of steps starting from planning, organizing, implementing, and supervising which are carried out in order to achieve goals by optimizing the use of human resources and available facilities.

Supply chain management requires logistics management in the flow of activities in order to run well. Logistics management is the main key in managing the supply chain, which includes designing, implementing, monitoring, and efficiently managing resources, storage of goods, services, and information along the supply chain path. The goal is to meet customer

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needs and increase their satisfaction (Larici & Abdul, 2019). According to (Krismiyati, 2017), logistics management is an activity that includes planning, determining needs, procurement, storage, distribution, maintenance, and elimination of goods that are no longer needed. Definition by (Seasafira et al., 2023) Supply chain management is a process that involves the acquisition of materials and services, the transformation process from raw materials to semi-finished or finished products, and the delivery of products to consumers. The supply chain in the construction industry has the following characteristics: (1) Installation of materials is carried out at the construction site, where the project is underway, and then the materials are delivered. (2) The construction project includes only one stage of production; it is made for the repetitive arrangement of the project's organizational structure separate from its design. (3) Supply chains are often produced on demand, where each project creates a new product or a new prototype (Ricardianto et al., 2023).

Logistics Management encompasses a wide range of planned logistics activities with the aim of organizing and maximizing the movement of goods, data, and services throughout the supply chain. Logistics activities in a business are a series of activities that are usually related to each other. These include customer service, demand estimation, inventory management, logistics communication, materials handling, order processing, packaging, components and support services, plant and storage site selection, procurement, reverse logistics, transportation, warehousing, and storage (Sutini Sutini & Radian Wismana, 2022). Logistics activities are activities that include planning, implementing, and controlling the flow of goods, services, and information from their sources to end use to meet customer needs with efficiency and effectiveness (Eriandani, Pudjolaksono, 2018). In (Setiadi, 2014) it is stated that logistics activities include supplier selection, material purchasing, storage, production, and selection of transportation equipment. These activities have a major impact on the flow of logistics processes within the company.

Logistics activities are often carried out by vendors or third parties to meet all company needs. In order for the company to meet all its needs according to the required criteria, Vendor Managed Inventory (VMI) is needed. Vendor Managed Inventory (VMI) is an approach to efficiently manage inventory in the supply chain system between suppliers and consumers. In VMI, the supplier delivers the inventory to the consumer, but the ownership of the inventory passes to the consumer when the inventory runs out. The benefits of implementing VMI include a reduction in the inventory ordering process and a reduction in the use of inventory storage space at suppliers (Martono (Sekolah Tinggi Manajemen PPM), 2018). According to Anthony (2007) in (Dwisa et al., 2019), Vendor Management is a process that includes planning, organizing, controlling, directing, and evaluating individual businesses or companies that want to become vendors or partners of a company. The goal is to achieve maximum results in the process. In a journal by (Rosyida et al., 2015), it is stated that Vendor Managed Inventory (VMI) is a collaboration strategy in the supply chain where distributors, acting as vendors, have the authority to determine the number of orders that must be delivered to retailers, which in this context is retail.

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A company must be able to assess and measure the right vendor. Measurement in vendor selection can be done using the AHP and TOPSIS methods. According to Asadabadi et al., (2019) cited in (Rivaldi et al., 2023) AHP, or Analytical Hierarchy Process, is a multi-criteria decision-making method (MCDM) developed by Saaty in the 1990s. This method involves pairwise comparisons between criteria and sub-criteria for ranking purposes. AHP (Analytic Hierarchy Process) is a measurement theory used to find the ratio scale of pairwise comparisons, both discrete and continuous. AHP helps break down complex problems with multiple factors or multiple criteria into a more structured hierarchy (N & Eko, 2014). In (Parhusip, 2019), it is stated that AHP is a method used to decompose complex problems into hierarchical components by giving a subjective value to the relative importance of each variable. This method helps determine the variables that have the highest priority in influencing the outcome of a problem.

Meanwhile, Lei et al. (2020) in (Siddiq & Bandung, 2012) mention that TOPSIS, which stands for Technique for Order Preference by Similarity to Ideal Solution, is a method developed to solve decision-making problems based on many attributes (MADM). In (Trise Putra et al., 2020), TOPSIS is a multi-criteria decision-making method based on selecting alternatives that have the closest distance to the positive ideal solution and the farthest distance from the negative ideal solution. According to Murnawan (2021) in (Nasution & Hanum, 2020), TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a Multi Criteria Decision Making (MCDM) method. The TOPSIS method is based on the concept that the best alternative not only has the closest distance from the positive ideal solution, but also has the longest distance from the negative ideal solution.

3. Research method

This research is descriptive with a quantitative approach. The population in this study were employees of PT XYZ who were in the Operation Control & Supply Chain Management division. The sample we used in this study were 4 PT XYZ employees who were in the Operational Control & Supply Chain Management division. Data collection is done through interviews with four of PT XYZ employees, and collecting data that we get from PT XYZ and articles that are relevant to our research. For the calculation of AHP and TOPSIS methods in vendor selection we use Ms. Excel.

Vendor management is an important process within PT XYZ, which focuses on managing and monitoring relationships with third parties or vendors that provide goods, services, or services required by the company. Before being allowed to participate in Supply Chain Management tenders, all new vendors at PT XYZ are required to register and be evaluated.

Evaluation criteria are set out in the Pre-Qualification Form and Proposal for Vendor Approval. Upon receipt of the completed registration form, the Purchaser/Subcontracting Engineer may schedule a vendor survey to verify and confirm the vendor's ability to meet PT XYZ criteria of cost, quality, on-time delivery, and flexibility.

The definition of each criterion according to (Susetyo et al., 2019) is as follows:

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1. Quality
   Quality refers to the overall characteristics and properties of a product or service that demonstrate its capacity to meet needs. This aspect is used to judge providers based on the outcome of the products they produce. For example, the quality of raw materials, such as natural materials, can be assessed through factors such as color, size, and physical shape.
2. Cost
   Cost refers to the expenses that a company incurs to obtain goods or services. The criterion of cost in providing raw materials from suppliers is a financial consideration that companies must consider in supplier selection.
3. Delivery
   Delivery accuracy involves assessing the supplier's ability to fulfill and manage requests from the company. This criterion has high significance because it relates to how the company can meet customer needs.
4. Flexibility
   Flexibility is the supplier's ability to provide convenience to the company. This criterion has importance because the supplier's level of flexibility will provide an advantage when the company has to adapt to changes in its operational conditions.

Thus, Vendor Management at PT XYZ has a crucial role in ensuring that the company works with competent and reliable vendors to achieve efficiency and quality in its operations. After the survey is carried out, it is necessary to calculate the weight or priority of the importance of each criterion in order to get the best vendor. The hierarchical structure of vendor selection can be seen in the following figure.

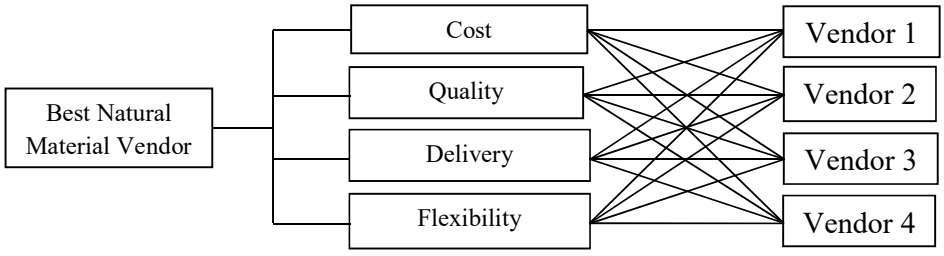

Fig. 1. Hierarchical Structure

In this study, the authors analyzed the selection of the best vendor using the AHP and TOPSIS methods. The problem solving procedure using the AHP method, as stated by Mukherjee (2017), can be summarized as follows:

1. Problem Definition: The first step is to define the problem by creating a hierarchy that

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includes objectives, supplier criteria, supplier sub-criteria, and relevant suppliers.
2. Pairwise Comparison: Next, a pairwise comparison matrix is formed by individuals who have a good understanding of the problem and employment. This matrix is used to assess the importance of criteria and sub-criteria.
3. Normalization and Consistency: The pairwise comparison matrix is normalized, the eigenvalues of the vectors are calculated, and the consistency is checked.
4. Iteration for Hierarchy Components: Steps 2 and 3 are repeated for each component in the hierarchy.
5. Data Validity Testing: The validity of the data and documents provided was checked to ensure that the data used in the analysis was correct and relevant.

By following these steps, the AHP method is used to support more informed decision-making, especially in the context of supplier selection or other problems involving multiple criteria. The basic principles of AHP are also applied in this process. There are 3 basic principles to the AHP method:

1. Decomposition: This principle involves dividing a complex problem structure into smaller components and arranging them in a hierarchy. Objectives are defined from general to more specific, as shown in Figure 1 as a hierarchical structure.
2. Comparative Assessment: This principle involves forming pairwise comparisons for all the elements, with the aim of generating a relative scale of the importance of each element. This assessment produces values in the form of a rating scale. When the pairwise comparisons are combined in the form of a matrix, this results in prioritization. As shown in Table 1, there is a pairwise comparison scale.

Table 1
Pairwise comparison rating scale

Intensity	Description
1	Both elements are equally important
3	One element is slightly more important than the second element
5	One element is more important than the other
7	One element is very more important than the other
9	One element is absolutely more important than the other
2,4,6,8	Values between two adjacent value considerations

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Opposite	If activity i gets a number compared to activity j, then j has the opposite value when compared to i.

Source: Saaty (1993) in the book Supriadi, A et al (2016)

3. Priority Synthesis: This stage involves multiplying the local priorities with the priorities of the relevant criteria at the hierarchy level above, then summing them for each element affected by the criteria. The result of this step is a combination known as global priorities, which are then used to weight the local priorities for elements at the lowest level according to the applicable criteria.

4. Results and discussion

4.1 AHP Calculation

In the first AHP calculation carried out, namely pairwise comparisons of criteria. Pairwise comparison of criteria can be seen in table 2 below.

Table 2
Pairwise comparison between criteria

CRITERIA	Cost	Quality	Delivery	Flexibility
Cost	1	1	4	5
Quality	1	1	3	3
Delivery	0.25	0.25	1	3
Flexibility	0.2	0.2	0.8	1
Amout	**2.45**	**2.45**	**8.8**	**12**

Normalization is a process that involves dividing each value in a column by the total number of values in that column. Table 3 below illustrates the normalization results, where eigenvectors have been calculated for each of the main criteria. The eigenvectors are the weights of each criterion.

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Table 3
Normalization

CRITERIA	Normalization				Amount	Eigen Vector
	Cost	Quality	Delivery	Flexibility		
Cost	0.4082	0.4082	0.4545	0.4167	1.6875	0.4219
Quality	0.4082	0.4082	0.3409	0.25	1.4072	0.3518
Delivery	0.1020	0.1020	0.1136	0.25	0.5677	0.1419
Flexibility	0.0816	0.0816	0.0909	0.0833	0.3375	0.0844

The next process is to perform calculations using equations that are in accordance with the steps in the AHP method until results are found that have an adequate level of consistency. This level of consistency is evaluated using the consistency ratio (CR), which will be considered good and accountable if the CR value is ≤ 0.10.

Table 4
Consistency ratio calculation

Lamda Max	4.1570	
CI	0.0523	
CR = CI/IR	0.0582	**CONSISTENT**

Table 4 shows the calculation of the consistency ratio based on existing criteria. The formula of this CR is CI/IR, CI or consistency index obtained from the calculation of CI=(Lamda Max-n)/(n-1). While IR can be seen from the number of criteria used, researchers use 4 criteria so that the IR value is 0.90. From the results of these calculations, the CR result is 0.0582. Since the CR value (0.0582) < 0.10, it can be concluded that the calculation results are consistent and do not need to be repeated.

4.2 TOPSIS Calculation

After obtaining weights for criteria and sub-criteria through processing using the AHP method, the next step is to apply the TOPSIS method to the data. The TOPSIS method utilizes the weighting results or eigenvector values that have been generated by the AHP method. Then determine whether each criterion is included in the cost/benefit classification which can be seen in table 5 below.

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Table 5
Table criteria

Kriteria	Weight	Cost/Benefit
Cost	0.4219	Cost
Quality	0.3518	Benefit
Delivery	0.1419	Benefit
Flexibility	0.0844	Benefit

There are four criteria and 4 alternatives used as the basis for decision making, namely:

- Criteria to be used:
  1. Cost (cost)
  2. Quality (benefit)
     1 = less quality 2 = quality enough 3 = quality and 4 = high quality
  3. Delivery (benefit)
     1 = less timely 2 = punctual enough 3 = on time and 4 = very punctual
  4. Flexibilitas (benefit)
     1 = less adaptable 2 = adaptable enough 3 = adapt and 4 = highly adaptable
- Alternatives to use :
  1. Vendor 1
  2. Vendor 2
  3. Vendor 3
  4. Vendor 4

Table 6
Pairwise comparison table between criteria and vendors

Alternative/Criteria	Cost (in million)	Quality	Delivery	Flexibility
Vendor 1	7.565	4	4	4
Vendor 2	6.823	4	3	4
Vendor 3	6.795	4	3	3
Vendor 4	7.256	3	3	3

After making the comparisons that can be seen in table 6, then the next step is to calculate the square root of the sum of the squares of each column contained in table 6. The results of the quadratic can be seen in table 7.

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Table 7
Squaring table

Amount	Cost	Quality	Delivery	Flexibility
	14.234	8	7	7

Next is to normalize the decision matrix as found in table 8 with the following formula.

$$r_{ij} \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}}$$

Table 8
Normalized matrix (R)

Alternative/Criteria	Cost	Quality	Delivery	Flexibility
Vendor 1	0.5315	0.5298	0.6100	0.5657
Vendor 2	0.4793	0.5298	0.4575	0.5657
Vendor 3	0.4774	0.5298	0.4575	0.4243
Vendor 4	0.5098	0.3973	0.4575	0.4243

After preparing the normalized decision matrix, the next step is to calculate the weighted multiplication. The overall weight value for each alternative is multiplied by the weight corresponding to each criterion, which is obtained through the calculation of the AHP method. The results of this calculation will be reflected in Table 9, which illustrates these results.

$$y_{ij} = w_i r_{ij}$$

Table 9
Weighten normalized matrix (Y)

Alternative/Criteria	Cost	Quality	Delivery	Flexibility
Vendor 1	0.2242	0.1864	0.0866	0.0477
Vendor 2	0.2022	0.1864	0.0649	0.0477
Vendor 3	0.2014	0.1864	0.0649	0.0358
Vendor 4	0.2151	0.1398	0.0649	0.0358

After completing the normalization process of the weighted matrix, the next step is to determine the value of the positive ideal solution by finding the maximum value for each criterion that is included in the benefit classification. Meanwhile, for criteria that fall into

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the cost classification, we look for the minimum value. The results of this step will be reflected in Table 10.

$$y_j^+ = \begin{cases} max_i\, y_{ij} : if\ j\ is\ a\ benefit\ attribute \\ min_i\, y_{ij} : if\ j\ is\ a\ cost\ attribute \end{cases}$$

Table 10
Positive ideal solution

Positive Ideal Solution	Cost	Quality	Delivery	Flexibility
	0.2014	0.1864	0.0866	0.0477

Next is to determine the value of the negative ideal solution. This is the opposite of the positive ideal solution in table 10. The negative ideal solution is to find the minimum value for each criterion that is included in the benefit classification. Meanwhile, for criteria that fall into the cost classification, we look for the maximum value. So that the results are obtained as in table 11 below.

$$y_j^- = \begin{cases} min_i\, y_{ij} : if\ j\ is\ a\ benefit\ attribute \\ max_i\, y_{ij} : if\ j\ is\ a\ cost\ attribute \end{cases}$$

Table 11
Negative ideal solution

Negative Ideal Solution	Cost	Quality	Delivery	Flexibility
	0.2242	0.1398	0.0649	0.0358

After determining the positive and negative ideal solutions, the next step is to find the distance between the weighted values to the positive and negative ideal solutions in a way like the following formula. the results of the distance between the weighted values to the positive and negative ideal solutions can be seen in table 12.

$$D_i^+ = \sqrt{\sum_{j=1}^{a} \left(y_i^+ - y_{ij}\right)^2} \qquad D_i^- = \sqrt{\sum_{j=1}^{n} \left(y_{ij} - y_i^-\right)^2}$$

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Table 12
Distance between weighted values to positive and negative ideal solutions

Positive		Negative	
Cost+	0.0228	Cost-	0.0527
Quality+	0.0217	Quality-	0.0529
Delivery+	0.0247	Delivery-	0.0519
Flexibility+	0.0545	Flexibility-	0.0091

The last step taken in this TOPSIS calculation is to calculate the preference value. This preference value is done to determine the ranking of each alternative. The preference value is done by dividing each positive criterion contained in table 12 by the sum of each positive and negative criterion in table 12. So as to get the results in table 13.

Table 13
Preference value

Preference Value		RANKING
Vendor 1	0.6980	2
Vendor 2	0.7095	1
Vendor 3	0.6773	3
Vendor 4	0.1439	4

To determine the ranking of each alternative, it can be seen from the number of preference values. If the alternative gets the largest number of preference values, then the alternative is the first ranked alternative. It can be seen in table 13, that vendor 2 gets the largest preference value (0.7095) so vendor 2 ranks first. Then vendor 1 ranked 2nd, with a preference value of 0.6980. Vendor 3 placed 3rd by obtaining a preference value of 0.6773. And the last rank was obtained by vendor 4 with a preference value of 0.1439.

Vendor 2 can be ranked first because it has an advantage in the cost criteria, where the cost criteria are the most dominant in vendor selection decisions. In addition to cost, vendor 2 also excels at other criteria such as quality. The quality of goods owned by vendor 2 is in accordance with the cost set. Vendor 2 has a low cost with the quality needed by the company. In addition, vendor 2 is always on time in sending goods so as not to hamper the company's performance. Vendor 2 also has good flexibility criteria, where if changes occur in company operations, vendor 2 can immediately adapt.

Similar to the previous article, our research can help select the best vendor based on the criteria used by the company such as cost, quality, delivery, and flexibility. This is reinforced by (Dwi Nurfahrizal, 2023) research, to get the best vendor through the AHP and TOPSIS calculation process.

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4. Conclusion

Based on the results of the analysis that the researchers conducted to determine the best vendor using the AHP and TOPSIS methods, it can be concluded that in the vendor selection process as a supplier of PT XYZ natural materials, there are four criteria that are evaluated, namely Cost (0.422), Quality (0.352), Delivery Accuracy (0.141), and Flexibility (0.084). The results of this evaluation indicate that the Cost criterion is the most dominant in vendor selection decisions.

And by applying the AHP and TOPSIS methods in data analysis, the results show that vendor 2 is the vendor that has the highest potential to meet the needs of natural raw materials at PT XYZ. The results of the analysis using the TOPSIS method show that vendor 2 achieves the highest value with a distance weight to the ideal solution of 0.709, which indicates that this vendor is the optimal choice in meeting the criteria required by the company.

5. Implications

The utilization of the AHP method can help assess criteria and their weights in selecting vendors, and TOPSIS allows for a more appropriate selection. This results in a more informed and efficient decision in vendor selection. In addition, the utilization of AHP and TOPSIS methods can also help control production or procurement costs, which contributes to the profitability of the company.

Therefore, vendor selection using AHP and TOPSIS methods has the potential to improve efficiency, quality, and safety aspects in the operations of PT XYZ or other construction companies, while supporting better achievement of business goals.

6. Research limitations

This study has a number of limitations that must be acknowledged. First, the sample size is very limited, consisting of only four alternatives. This limits the ability to generalize the results of the analysis to a wider range of business situations as it does not cover all possible variations. Secondly, the data used was obtained over a short period of time, thus not reflecting long-term fluctuations or slower trend changes in the business situation. In addition, the limited time frame for analyzing the data is also a constraint that limits the depth of the analysis.

Given these limitations, suggestions for future research are to expand the sample size to provide more representative results and stronger generalizability. Then, consider broader long-term data to reflect slower trend changes in the business. And, have a longer time to analyze so that the analysis can be done more deeply.

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