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Rubber Spare Parts Supplier Selection Model Using Artificial Neural Network: Multi-Layer Perceptron

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Abstract. Supplier have an important role in the availability of raw materials for the ongoing production activities of a company. The selection of the right supplier is not only profitable for the company but also can increase customer satisfaction. Therefore, in the selection of suppliers the company must have a system of selection and evaluation of suppliers of raw materials and components. The main purpose of the supplier selection process is to reduce purchasing risk, maximize overall value for buyers, and build long-term relationships between buyers and suppliers. Supplier selection model is used to facilitate the strategic direction of supply chain management to take several criteria from suppliers to achieve the priorities desired by the company. This research was conducted at a manufacturing company engaged in auto parts. In this study the problem is that the company chooses suppliers to supply raw materials based solely on the list of suppliers who are willing to agree on the price offered by the company with suppliers so that the company has difficulty choosing suppliers to become long-term suppliers and delays in the supply of raw materials from each -one supplier. This study aims to create a supplier selection model framework to classify each supplier so that it can be used as a supplier in the long term. This study uses the Artificial Neural Network (ANN) method with the multi layer perceptron classification technique. Artificial Neural Network is used to create an efficient and inefficient supplier selection model. The accuracy of the ANN model is 85.9756%, the statistical kappa value is 0.7152, with an MAE error value of 0.1478, the MSE error value is 0.3107. From the ANN obtained 4 criteria used in supplier selection, namely the criteria of quality, delivery, price, and warranty and complaint services.

Introduction

Spare parts are a tool that supports the procurement of goods for the needs of the equipment used. The development of the number of motorized vehicles in Indonesia from 2012-2017 has always increased. This has an impact on the import value of motor vehicle parts with an increase of 33% from 2017 with a component market potential of 30%.

Supplier selection is a strategic activity in purchasing management in the supply chain. Many criteria need to be considered in supplier selection. Dickson said that there were 23 criteria in choosing suppliers. However, not all of these criteria will be used by the company [1]. In the selection of suppliers there are important attributes that make a large contribution, namely the quality, quantity of raw materials, reliability and price of materials [2].

Supplier selection models represent only one or more of several areas in supply chain management [3]. The model is used to facilitate the viewing of strategic directions in supply chain management to take several criteria from suppliers to achieve priorities desired by the company [4].

Research on the development of a green supplier selection model by integrating Artificial Neural Network (ANN), Multi Attribute Decision Analysis (MADA), Data Envelopment Analysis (DEA) and ANP which results in better ANN-MADA methods for evaluating green supplier performance and addressing DEA weaknesses and data accuracy limitations in decision making [5]. Evaluate suppliers and find incomplete criteria information by integrating ANN and DEA methods [6].

This research was conducted at a manufacturing company engaged in car spare parts with rubber raw materials. The problem faced by the company is that the company chooses suppliers to supply raw materials based solely on the list of suppliers who are willing in the price agreement offered by the company with suppliers so that the company has difficulty in choosing suppliers to be a long-term supplier. Another problem faced by companies is the delay in the supply of raw materials from each supplier with a total delay in the delivery of raw materials from November 2018 to March 2019 of 39 days. Delay in the delivery of raw materials will make spare parts production processes become hampered due to limited raw materials.

To make it easier for companies to choose suppliers to supply raw materials, a framework for supplier selection models is needed, so companies easily select each supplier that supplies raw materials. From this problem a supplier selection model was created to classify suppliers into efficient and inefficient suppliers using the Artificial Neural Network Method, namely Multi Layer Perceptron.

Literature Reference

Spare part

Spare parts are a tool that supports the procurement of goods for the needs of the equipment used. Spare parts are the main factors that determine the course of the production process of a mechanical system. spare parts classification according to their use can be divided into three types, namely:

1. Consumable parts are spare parts for normal use, spare parts damage can occur at any time.
2. Replacement spare parts (replacement parts) are spare parts whose replacement is usually carried out at the time of overhaul, which is when large-scale repairs are held.
3. Guarantee parts (insurance parts) are spare parts that are usually never damaged, and if damaged can stop the operation and production.

Supplier

Supplier selection is a strategic process to mitigate the risk of partial upstream supply chains, if not fully implemented. Better relationships between sellers and buyers can increase supply chain visibility and the ability to overcome high demand volatility. Thus, the selection of suppliers is an integral part of any business. Any disruption in upstream supply can cause major disasters throughout the supply chain and force organizations to take risks.

Risks in the supply chain are broadly classified as internal risks that arise in normal operations and external risks originating from outside the supply. Selection of the right supplier can minimize external risk. Supplier selection can be a single source or multiple sources. In a single source, all supplies come from one supplier. In some sources, on the other hand, all supplies come from a group of suppliers. Risks in the supply chain can be minimized by internal integration and external integration of supply chain sources. External integration strongly encourages single procurement by strengthening buyer-supplier relationships. In the supply chain concept, suppliers are a very important part because it greatly influences the survival of a company [8]. The objectives of supplier selection are as follows:

1. To reduce the risk of procurement
2. To maximize the overall value of sales
3. To build a close relationship and long-term relationship between customers and suppliers.

Supplier selection is a difficult decision because various criteria must be considered in the decision making process. Analysis of the criteria for selecting and measuring supplier performance has been the focus of attention of many procurement scientists and practitioners since the 1960s. Dickson (1966) first conducted an extensive study of identifying, determining, and analyzing what criteria were used in selecting a company as a supplier. A total of more than 23 criteria were considered in the study, where respondents were asked to give importance to each criterion [1].

Artificial Neural Network

In general, Neural Network (NN) is a network of a group of small processing units that are modeled based on human neural networks. This NN is an adaptive system that can change its structure to solve problems based on external and internal information flowing through the network. NN is simply a non-linear statistical data modeling tool. NN can be used to model complex relationships between inputs and outputs to find patterns in the data. Basically, the learning system is a process of adding knowledge to NN that is continuity so that when used, knowledge will be maximally exploited in recognizing an object. Neurons are a basic part of processing a Neural Network. Below this is the basic form of a neuron.

Method

This research was conducted at a company that manufactures motorized vehicle spare parts that use rubber raw materials. The object of the research observed was the selection of supplier's company. The variables used in supplier selection models are identified using open questionnaire and closed questionnaire. Then the next variable is identified based on the criteria that most influence supplier selection. The variables in this study are:

1. The dependent variable is the assessment of supplier capabilities and performance, and supplier selection model.
2. The independent variables are quality, delivery, price, warranty and complaint services.

The criteria and sub criteria used in this study were obtained using a questionnaire consisting of open questionnaires, closed questionnaires, supplier ability assessment questionnaires and supplier performance assessment. The stages of conducting research are:

1. A preliminary study is study of literature and supporting theories to get solutions to problem solving.
2. Determination of criteria and sub-criteria to be used
3. Data collection evaluating the ability of suppliers to assess
4. Conducting groupings of supplier determination criteria.
5. Transform artificial generate data based on the criteria of determining supplier
7. Processing data transform using classification artificial neural network with WEKA Software
8. Analysis of the results of classification artificial neural network with Multi Layer Perceptron.
9. Drawing conclusions.

Problem solving analysis begins with obtaining criteria and sub criteria, then classifying supplier selection models using the artificial neural network.

The conceptual framework is a form of framework that can be used as an approach to problem solving. Usually this research framework uses a scientific approach and shows the relationship between variables in the analysis process. The conceptual framework of this research can be seen in Figure 1.

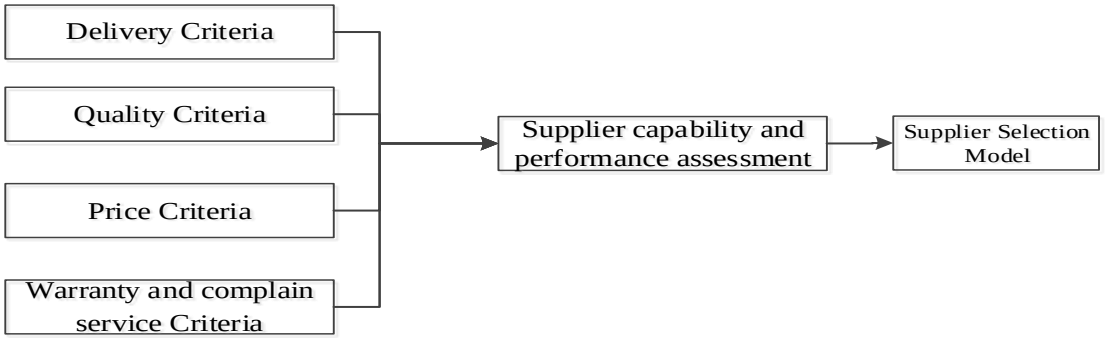

Figure 1. Research Conceptual Framework

Conclusions

Artificial Neural Network

Artificial Neural Network (ANN) is an information processing technique or approach inspired by the workings of the biological nervous system. ANN classification in data mining is used to see the relationship between each sub criteria with the criteria in determining the supplier selection model. Neural Network consists of neurons that adjust the weight values that exist in each connectivity both from input, neuron, output. Determination of criteria for efficient and inefficient suppliers can be seen in table 1.

Table 1. Supplier Determination Criteria

No.	Criteria				*Supplier*
	Quality	Delivery	Warranty and Complaint Service	Price	
1.	5	4	3	6	Efficient
2.	5	3	3	4	Efficient
3.	3	2	2	3	Not Efficient
4.	5	3	3	6	Efficient
5.	3	2	2	4	Not Efficient
6.	3	2	1	4	Not Efficient

From the table above, a criterion for determining suppliers where suppliers can be efficient if the supplier can meet a minimum of 5 sub criteria from quality criteria, 3 sub-criteria from shipping criteria, 3 sub-criteria from warranty criteria and complaint service, and 4 sub-criteria from price criteria. Whereas the criteria for suppliers are not efficient if the supplier can only fulfill a maximum of 3 sub criteria from quality criteria, 2 sub-criteria from shipping criteria, 2 sub-criteria from warranty criteria and complaint service, and 4 sub criteria from price criteria.

From the table artificial data generation is 164 data based on the criteria of determining supplier then making supplier selection model with artificial neural network using Multilayer Perceptron using WEKA Software. The purpose of data classification with Multilayer Perceptron is to find supplier selection models based on artificial neural network networks. In this study supplier criteria are used as input layers, and supplier selection criteria are used as output layers and then between inputs and outputs are limited by hidden layers containing neurons. The following are the results of the Artificial Neural Network classification process.

=== Classifier model (full training set) ===
Sigmoid Node 0
Inputs Weights
Threshold -2.9312928270143104
Node 5 3.55533701668687
Node 6 2.692669912537954
Node 7 3.338693425444473
Node 8 3.001057272857072
Sigmoid Node 1
Inputs Weights
Threshold 2.9313516018139167
Node 5 -3.5522750459893553
Node 6 -2.7120540671855893
Node 7 -3.3482910753323014
Node 8 -2.9762848709500034
Sigmoid Node 2
Inputs Weights
Threshold -0.4687474382605339
Attrib Quality -3.5214477391269514
Attrib Delivery -3.4282611869133133
Attrib Warranty and Complaint Service -0.9778081877544228
Attrib Price -4.51741195100588
Sigmoid Node 3
Inputs Weights
Threshold 1.2443475822254417
Attrib Quality -3.770123551516218
Attrib Delivery -3.7485660439629935
Attrib Warranty and Complaint Service -0.5492771545977018
Attrib Price -7.129107866130495
Sigmoid Node 4
Inputs Weights
Threshold 1.7200842520710913
Attrib Quality -4.020746974868938
Attrib Delivery -4.090011390453179
Attrib Warranty and Complaint Service - 0.8180746418698609
Attrib Price -8.043776587101783
Sigmoid Node 5
Inputs Weights
Threshold 3.191526695842993
Node 2 -2.5904207234999896
Node 3 -3.4175795583353445
Node 4 -3.8867407627037656
Sigmoid Node 6
Inputs Weights
Threshold 1.9890610942862044
Node 2 -2.098642565485674
Node 3 -2.5739246349225553
Node 4 -2.9056706238800634

Sigmoid Node 7
Inputs Weights
Threshold 2.8964713422276143
Node 2 -2.437822961954402
Node 3 -3.2425435753519376
Node 4 -3.6542576620641105
Sigmoid Node 8
Inputs Weights
Threshold 2.4012062618096253
Node 2 -2.3065917502036837
Node 3 -2.876836131474449
Node 4 -3.2106946736792317
Class efficient
Input
Node 0
Class Not efficient
Input
Node 1

Based on the rule assessment above, we can see the weight value of the threshold and the attribute weight, quality, delivery, warranty and complaint services, and price values. After entering into a neuron the input value of the criteria will be added up. The sum result will then be processed by the activation function of each neuron, and will be compared to the sum of results with a threshold. If the sum value exceeds the threshold then the activation of the next neuron will be canceled, whereas if it is still below the threshold value, the neuron will be activated and the neuron will send the output value.

=== Summary ===

Correctly Classified Instances	141	85.9756 %
Incorrectly Classified Instances	23	14.0244 %
Kappa statistic	0.7152	
Mean absolute error	0.1478	
Root mean squared error	0.3107	
Relative absolute error	30.8653 %	
Root relative squared error	63.5052 %	
Total Number of Instances	164	

The level of accuracy or data classified appropriately amounted to 141 data with an accuracy percentage of 85.9756% of the total data, and there were data that were not classified correctly amounting to 23 data with an error percentage accuracy of 14.0244%. The Kappa statistic obtained from processing results is 0.7152 which indicates that the closeness of the strength of agreement is worth fair. The mean Absolute error (MAE) error value of the supplier selection model is 0.1478 and the Mean Square error value. Error (MSE) is 0.3107 which means the model has a relatively small error so the model is made very good.

=== Detailed Accuracy by Class ===

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
0.828	0.092	0.932	0.828	0.877	0.722	0.919	0.924	efficient
0.908	0.172	0.776	0.908	0.837	0.722	0.919	0.902	not efficient

The True Positive Rate value for the efficient class is 0.828, and for the inefficient class is 0.908. While the value of False Positive Rate for the efficient class is 0.092 and for the inefficient class is 0.172

=== Confusion Matrix ===

a	b	<-- classified as
89	10	a = efficient
10	55	b = not_efficient

On the results of processing Artificial Neural Network, Confusion Matrix can be seen where in the first line "89 10" shows that there are (89 + 10) instances of efficient class suppliers and there are 10 instances that are incorrectly classified as inefficient suppliers. In the second line "10 55" shows that there are (10 + 55) class supplier instances inefficient and there are 10 instances that are incorrectly classified as efficient suppliers.

The results of the assessment above are also illustrated in the form of a Multilayer Perceptron supplier selection model which can be seen in Figure 2.

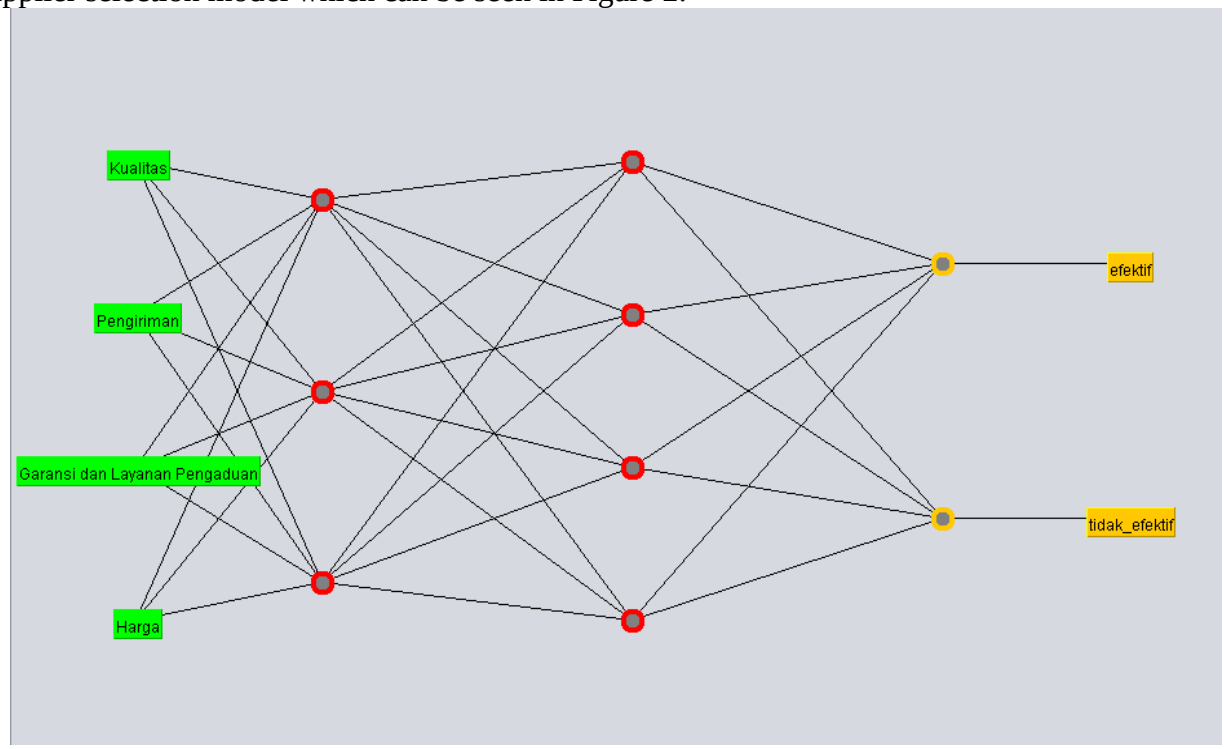

Figure 2. Multilayer Perceptron Selection of Supplier

Based on the above model the criteria chosen for selecting suppliers are quality criteria (K1), shipping (K2), warranty and complaint services (K3), price (K4). The accuracy of the model in classifying the data is 85.9756% with a kappa statistic value of 0.7152.

The method of classification of supplier selection models uses the Multilayer Perceptron method. In this method the model is divided into three parts, namely the supplier selection criteria serve as

input layers, class efficient and inefficient as output layers, and neurons or nodes as hidden layers that exist between input layer and output layer.

These neurons function as a successor that connects input and output. In the results of processing Artificial Neural Network, the supplier selection model is obtained with a combination of 3 nodes in the first hidden layer and 4 nodes in the second hidden layer. From the model can be obtained the weight value of a criterion whether it can be accepted or not accepted so as to produce an efficient or inefficient output based on the threshold weight on each node in the hidden layer.

The Artificial Neural Network model can be used as a consideration for companies in choosing suppliers. Companies can model how many criteria are needed if they want to obtain an efficient supplier in the multilayer perceptron that has been created and can determine the extent to which suppliers can provide maximum output to the company

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