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Using Backpropagation Neural Network for Polyvinylchloride Ceiling Price Modeling

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ABSTRACT *– Sales predictions on building material products today have applied an artificial neural network approach. One of the products of building material that need to be predicted for sales is polyvinylchloride (PVC) ceilings. Most companies haven't implementing prediction technique for the sale of PVC ceilings, so this study aims to predict PVC ceiling sales with the backpropagation neural network (BPNN) method using the R algorithm. Unit gradients are calculated using the average absolute per cent error value (MAPE) to minimize the total square errors of network output. The results showed that the network architecture used was 4 to 6-1 and obtained an accuracy of 88% based on the lowest MAPE value.*

Keywords *– artificial intelligence; forecasting; R algorithm; time series forecasting.*

Pemodelan Harga Pipa *Polyvinylchloride* Menggunakan Jaringan Saraf Propagasi Balik

ABSTRAK *– Prediksi penjualan pada produk bahan bangunan saat ini telah menerapkan pendekatan jaringan syaraf tiruan. Salah satu produk bahan bangunan yang perlu diprediksi penjualannya adalah plafon polyvinylchloride (PVC). Sebagian besar perusahaan belum menerapkan teknik prediksi penjualan plafon PVC, sehingga penelitian ini bertujuan untuk memprediksi penjualan plafon PVC dengan metode backpropagation neural network (BPNN) menggunakan algoritma R. Gradien unit dihitung menggunakan nilai kesalahan persen absolut rata-rata (MAPE) untuk meminimalkan total kesalahan kuadrat output jaringan. Hasil penelitian menunjukkan bahwa arsitektur jaringan yang digunakan adalah 4 sampai 6-1 dan diperoleh akurasi 88% berdasarkan nilai MAPE terendah.*

Kata Kunci *– algoritma R; kecerdasan artifisial; peramalan; prediksi seri waktu.*

1. INTRODUCTION

In recent years, the pricing of raw materials and their derivatives has become a focal point in the global manufacturing industry, particularly in the field of construction materials [1]. As an integral component of the construction industry, the pricing of raw materials significantly impacts the cost structure of construction projects [2], [3]. Among these materials, polyvinylchloride (PVC) has gained substantial importance due to its versatile application in various construction components, most notably in ceiling production [4]. Predicting the price fluctuations of PVC is, therefore, of paramount interest to construction companies and stakeholders, as it enables them to manage costs efficiently and make informed business decisions.

The complex nature of the global market, coupled with the influence of diverse factors such as economic indicators, environmental regulations, and supply chain dynamics, underscores the challenge of PVC price prediction [5], [6]. Traditionally, pricing models have been based on statistical methods and expert opinions, which may not adequately capture the intricate patterns and variables affecting PVC prices [7].

Furthermore, in the context of price forecasting using neural networks, several study reported that they appropriately to be a good prediction model for any filed of price predictions. These following study including crude oil price [8], staple food price [9], and apartment price index [10]. Proven by previous relevant research utilizing neural network approaches for predictive modeling of future prices, it would be highly beneficial for the field of materials and construction. This is especially relevant to interesting topics such as polyvinyl chloride (PVC) ceilings, a significant component of building materials with high market demand [6]. The absence of suitable prediction tools to forecast PVC building material prices represents a weakness in the construction business sector.

In light of these challenges, this research paper introduces an innovative approach to PVC ceiling price prediction. We propose the application of Backpropagation Neural Networks (BPNN) – a powerful machine learning technique renowned for its ability to model complex, non-linear relationships in data [11], [12], [13]. The integration of BNN into the pricing prediction process represents a novel and promising avenue for addressing the pricing challenges faced by the PVC industry.

This study aims to leverage the capabilities of BNN to build a robust predictive model for PVC ceiling prices. By utilizing historical pricing data, market indices, and relevant macroeconomic indicators, our research seeks to create a model that can provide accurate short-term and long-term forecasts for PVC ceiling prices. The potential impact of this research extends to the construction industry, enabling businesses to optimize pricing strategies, enhance cost management, and make more informed decisions, thus contributing to the sustainability and competitiveness of the sector [6]

2. METHOD

Data Collection

This research aims to forecast the PVC ceiling price using BPNN forecasting model that adopted from the time series dataset between January and December 2022 that consists of variables X (input data), including customer, delivery time, ceiling type, and price, as well as variable Y (output data), which is the monthly exchange rate (monthly sales results). Dataset would be determined as data training and data testing. After data was collected, the step should be in the data transformation. Figure 1 shows the research flowchart of this study.

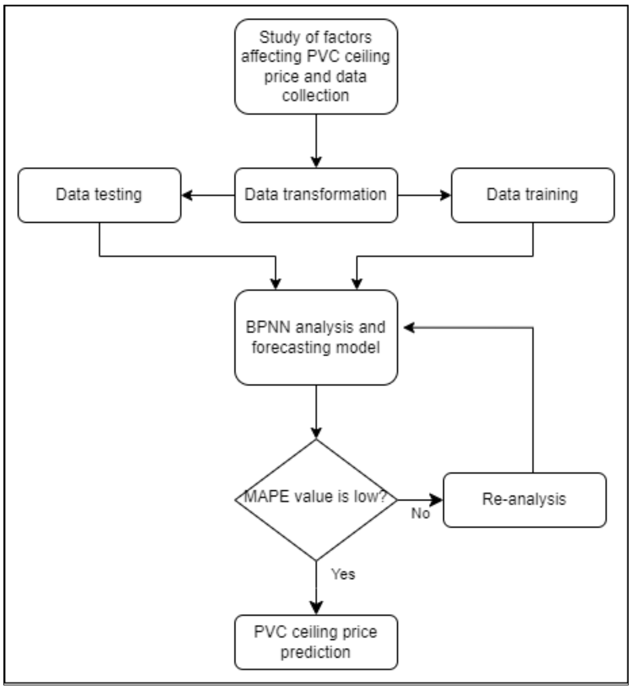

Figure 1. Research flowchart.

Data Transformation

The collected dataset would be transformed in the form of consistency values for neural network analysis. Dataset shown in Indonesian Rupiah's price and the month's exchange rate shown in various decimal values, so they need to be transformed as standard-decimal value. The following (1) detailed information on data transformation scheme.

$$Data\ transform = \frac{Raw\ data - data\ min.}{data\ max. - data\ min.} \quad (1)$$

Raw data shown as collected dataset, data minimum (data min.) shown as the lowest value of the data, and data maximum (data max.) shon as the highest value of the data.

The transformed data would be determined as data training and data testing. After all data were transformed, the step should be in the BPNN analysis procedure.

Neural Network Analysis Scheme

Data training and data testing would be analyzed using Backpropagation Neural Network (BPNN) that wrote in R algorithm. The BPNN modeling consists of variables X (input data), including customer, delivery time, ceiling type, and price, as well as variable Y (output data), which is the monthly exchange rate (monthly sales results). The obtained model would be yield the best prediction accuracy based on the smallest MAPE value. The number of layers selected is based on how many times the neural network algorithm is performed to achieve the best accuracy and MAPE values.

3. RESULT AND DISCUSSION

The R algorithm used in this study demonstrates its capability in processing neural networks for PVC ceiling sales forecasting. Fig. 2 provides a snippet of the syntax of the R algorithm used in this research. Besides, the prediction results for PVC ceiling sales prices, along with the calculation of the MAPE value for six hidden layers of PVC ceiling sales data, yield the best accuracy level of 88%.

```
data <- read_excel("C:\\Users\\DELL1-PC\\Documents\\PREDIKSI 1.xlsx")
data_ubah <- data
data_ubah$b1 <-(data_ubah$b1-min(data))/ (max (data)- min (data))
data_ubah$b2 <-(data_ubah$b2-min(data))/ (max (data)- min (data))
data_ubah$b3 <-(data_ubah$b3-min(data))/ (max (data)- min (data))
data_ubah$b4 <-(data_ubah$b4-min(data))/ (max (data)- min (data))
data_ubah$b5 <-(data_ubah$b5-min(data))/ (max (data)- min (data))
model <- neuralnet (b5~b1+b2+b3+b4,data=data_ubah,hidden = 6)
datac <-read_excel("C:\\Users\\DELL1-PC\\Documents\\PREDIKSI 2.xlsx")
datac$b1 <-(datac$b1-min(data))/ (max(data)-min(data))
datac$b2 <-(datac$b2-min(data))/ (max(data)-min(data))
datac$b3 <-(datac$b3-min(data))/ (max(data)-min(data))
datac$b4 <-(datac$b4-min(data))/ (max(data)-min(data))
prediksi <- predict (model, datac)
prediksi <-  prediksi * (max (data)-min (data))+min(data)
```

Figure 2. The snapshot of R algorithm for neural network processing.

Figure 3 shows a comparison graph between the actual sales prices before prediction and the predicted prices for PVC ceiling sales using BPNN modeling. This is based on considerations regarding the determination of error risk, guided by the calculation of the smallest MAPE value.

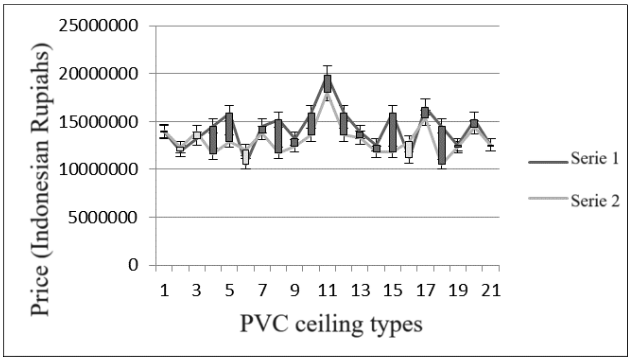

Figure 3. Comparison graph of PVC ceiling sales prices (Serie 1: actual prices, Serie 2: predicted prices).

This research yielded a neural network layer pattern of 4-6-1 (Fig. 4), with the best accuracy rate of 88% and an MAPE value of 22%. According to Widjaya et al. [14], an MAPE value between 20-50% signifies an adequately capable forecasting ability. The lower the MAPE value, the closer the forecasted value is to the actual value. This study resulted in an MAPE value of 22%, categorizing it as adequate. Therefore, the predictive model will have a reasonably significant ability to forecast PVC ceiling sales prices in the future.

Another study using the Trend Least Square (TLS) method (although this time applied in a different case, namely epidemiological forecasting) estimated the level of Covid-19 infected patients in Indonesia, resulting in MAPE values of 52.4% for infection rates, 84.2% for the recovery rate, 40.9% for the death rate, and 59.2% for the estimated number of Covid-19 patients. This study [14] concluded that with the TLS method, the obtained MAPE values tend to be significantly poor in forecasting ability, in contrast to the MAPE values obtained in this study, which are at a significantly good level of forecasting ability.

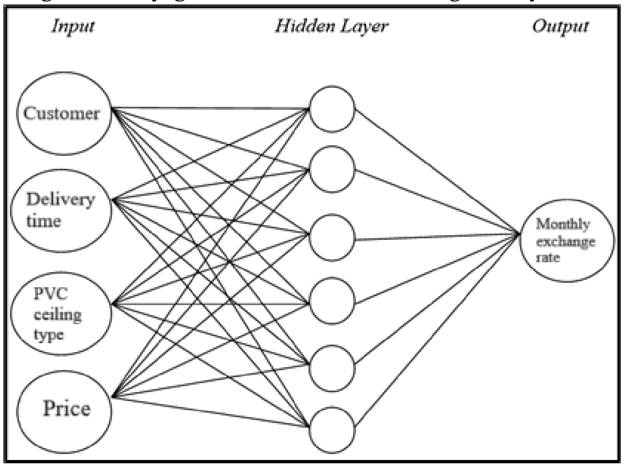

Figure 4. Neural network layer model of PVC ceiling predictions.

Another study employed the Brown Weighted Exponential Moving Average (B-WEMA) algorithm with the MAPE value approach to assess the error rate in predicting stock values based on the best alpha value, achieving a MAPE value of 2.8% with an alpha value of 0.9 [15]. The significance level in this research can be categorized as having excellent forecasting capabilities. Additionally, research related to predicting the national rice production rate in Indonesia using the BPNN method resulted in a MAPE value of 2.3394%, albeit after optimization with a genetic algorithm [16]. This study is similar to the research conducted in [15], [16], with the only difference being the algorithm used. Thus, the BPNN approach can provide a solution for predictive issues, as demonstrated in this case study to predict the sales value of PVC ceilings.

4. CONCLUSION

The implementation of the artificial neural network using the backpropagation method with the R algorithm resulted in a network architecture of 4-6-1 layers, which can be employed to predict PVC ceiling sales prices, indicating adequate forecasting capabilities with the best accuracy rate of 88% and a MAPE value of 22%.

Suggestions for future research include exploring other types of neural networks or machine learning (ML) and deep learning (DL) models in predicting PVC ceiling sales prices. This exploration aims to determine the accuracy levels of each type or model of artificial intelligence implementation in addressing prediction or forecasting issues, particularly for PVC ceiling sales prices.

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