INTISARI

Industri transportasi barang di Jawa menghadapi peningkatan kompleksitas yang didorong oleh faktor lingkungan dan fluktuasi harga bahan bakar. Penggabungan transportasi di antara produsen yang berbagi pelanggan telah meningkat, terutama di sektor produk *ultra-fresh*, di mana penjadwalan distribusi yang tepat sangat penting untuk pengiriman hari berikutnya atau hari yang sama. Reservasi kendaraan seringkali perlu dilakukan beberapa hari sebelumnya untuk memastikan kapasitas dan organisasi yang efektif. Untuk mengatasi tantangan ini, pengembangan alat pengambilan keputusan berbasis data di bawah ketidakpastian sangat penting. Metode peramalan tradisional sering kali gagal menangkap keseluruhan hasil yang mengarah pada masalah operasional. *Probabilistic forecasting*, yang mengintegrasikan nilai interval dan probabilitas terkait, menawarkan alternatif yang menjanjikan.

Penelitian ini mengusulkan pendekatan probabilistik kondisional diskret, menggunakan *conditional probability* untuk mengintegrasikan distribusi probabilitas dari berbagai dataset. Penelitian ini menggunakan dataset dari sektor *ultra-fresh*, yang mencakup data permintaan dan ramalan. *Exploratory Data Analysis* (EDA) mengungkapkan pola 7 hari yang signifikan. Data dibagi berdasarkan hari, dan distribusi probabilitas dalam setiap kelompok dianalisis. Diskretisasi data dengan *binning* digunakan untuk melakukan prediksi menggunakan *conditional probability*. Pendekatan klasifikasi *multiclass ordinal* juga dilakukan sebagai pembanding. Metode yang diusulkan dievaluasi terhadap algoritma seperti *KNN, Decision Tree, Gradient Boosting, Random Forest,* dan *SVM*, menggunakan metrik seperti *Accuracy, Weighted Cohen Kappa,* dan *Matthew's Correlation Coefficient*.

Hasil menunjukkan bahwa metode Original Klien memiliki *Root Mean Squared Error* (RMSE) rata-rata terendah sebesar 0.17875, yang menunjukkan akurasi ramalan yang terbaik, sementara metode *General Classifier* mencapai persentase *Backorder* rata-rata terendah sebesar 0.8975%, menyoroti efektivitasnya dalam mengurangi *backorder*. Metode *Conditional Probability* menawarkan pendekatan yang seimbang, meningkatkan baik akurasi ramalan maupun pengurangan backorder. Penelitian ini menunjukkan efektivitas yang memberikan keuntungan dibandingkan metode tradisional. Penelitian selanjutnya dapat diarahkan pada penggabungan pola permintaan dinamis dan mencoba teknik *machine learning* yang lebih maju. Sementara itu, tantangan seperti ketersediaan data, akurasi ramalan, dan penyesuaian dengan lingkungan yang dinamis harus diatasi untuk meningkatkan akurasi.

Kata Kunci: prediksi probabilistik; analisis data; perencanaan transportasi

ABSTRACT

The freight transportation industry in Java is experiencing competition and complexity due to environmental concerns and energy prices. This situation has led to an increase in transport pooling among producers sharing customers, particularly in the ultra-fresh products sector where precise distribution scheduling is essential for next-day or same-day deliveries. However, despite the need for accurate planning, vehicle reservations must often be made days in advance to ensure sufficient capacity and effective organization. Traditional forecasting methods frequently fail to capture the full range of possible outcomes. To address this, the development of data-driven decision-making tools under uncertainty is vital. Probabilistic forecasting, which integrates interval values and associated probabilities, presents a promising alternative for enhancing forecasting accuracy.

This research introduces a discrete conditional probabilistic approach, leveraging conditional probability to integrate probability distributions from various datasets. The study utilizes a time series dataset from the ultra-fresh sector, encompassing historical demand and existing forecasts. Exploratory Data Analysis (EDA) was conducted, revealing a 7-day seasonality pattern. The dataset was then segmented by day, and probability distributions within each group were analyzed. Discrete histogram bins with associated probabilities were employed for prediction purposes. To evaluate the performance of the proposed method, it was compared against conventional algorithms such as KNN, Decision Tree, Gradient Boosting, Random Forest, and SVM, using metrics including Accuracy, Weighted Cohen Kappa, and Matthew's Correlation Coefficient.

The results demonstrated that the Client's Original method achieved the lowest average Root Mean Squared Error (RMSE) of 0.17875, indicating superior forecast accuracy. However, the General Classifier method attained the lowest average Backorder Percentage of 0.8975%, underscoring its effectiveness in minimizing backorders. The Conditional Probability method provided a balanced approach, improving both forecast accuracy and backorder reduction. This research highlights the effectiveness of the proposed method, which successfully balances accuracy and operational efficiency, offering a notable advantage over traditional forecasting techniques. Future research should aim to incorporate dynamic demand patterns, explore advanced machine learning techniques such as deep learning, and develop a robust scenario generation model. Addressing challenges related to data availability, forecasting accuracy, and adaptation to dynamic environments will be crucial for enhancing forecasting precision and operational efficiency in the freight transportation industry.

Keywords: probabilistic prediction; data analysis; transportation planning