

## **REFRIGERATED TRUCK VENDOR SELECTION: A MATHEMATICAL MODELLING APPROACH**

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### **ABSTRACT**

Facing the post-Covid-19 pandemic era, food companies are starting to received orders for their products from various regions in Indonesia, this is because food is a basic need, therefore when public activities outside are allowed, food products have an increase in demand. One of the important processes is the distributing goods from producers to consumers. This research was conducted on a food company whose products must be stored in the range of 5-10 degrees celsius. Indonesia is an archipelagic country where each region has different road characteristics, accordingly it is essential for companies to select reliable refrigerated truck vendors. This study aims to prove whether the mathematical approach can be used to a refrigerated truck vendor by predicting their performance according to the company's needs. At the end of the research, the assessed vendors will be divided into two categories, namely efficient vendors who will be retained and inefficient vendors who will be fostered or replaced with other vendors.

**Keywords:** vendor selection; food company; mathematical modelling; linier regression.

### **1. Introduction**

Facing the post-Covid-19 pandemic era, food companies are starting to received orders for their products from various regions in Indonesia, this is as a result of the improving economy, so there is an increase in the need for various food products as a basic need (Barman et al., 2021).

One of the food products that has increased is dairy food products, because they have good health benefits, and what is important is the distribution process using refrigerated trucks that have a temperature range of 5-10 degrees Celsius with the aim of maintaining the benefits that exist in the product when it is received by the consumer. Indonesia has various characteristics of distribution channels for goods (Hadiguna et al., 2014), so the distribution process must be analyzed properly, one of which is the selection of refrigerated truck vendors.

The mathematical model that will be used to predict vendor assessments is the linear

regression method, this choice is due to the fact that the goal of the conventional regression analyzes is: (a) to find an appropriate mathematical model and (b) to determine the best fitting coefficients of the model from the data (Kazemi & Hosseinzadeh, 2012).

This study aims to prove whether the mathematical approach can be used to a refrigerated truck vendor by predicting their performance according to the company's needs when accepting a new project.

The data will collect from dairy food company (PT. ABC) that located in Bekasi. There are currently five refrigerated truck vendors in this company.

In this linear regression, there are two variables that are used as prediction calculations, namely the effect variable (Y) is the value of the quality or performance of the refrigerated truck vendor and the causal variable (X) is the number of distributions (Uyanik & Güler, 2013).

The obtained equations will be tested for accuracy using MAPE, it is another performance metric for regression models (Kumari & Yadav, 2018), having a very intuitive interpretation in

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terms of relative error: due to its definition, its use is recommended in tasks where it is more important being sensitive to relative variations than to absolute variations (De Myttenaere et al., 2016).

## 2. Research Methods

### 2.1. Research Framework

The research framework is depicted in Figure 1. In the first stage, the data collection are explored. Scholars had defined the number of distributions as the causal variable (X) and the quality value as the effect variable (Y). We collected data from food industry vendors which delivers food products by refrigerated truck. A pre-processing stage is provided to ensure data is ready to analyze, therefore we analyze data to be final score of vendor performance, therefore we can decide X and Y, additionally based on the data we can look for linear regression equation. To prove the linear accuracy of the regression, MAPE was used. Below are details stage of the data processing stage.

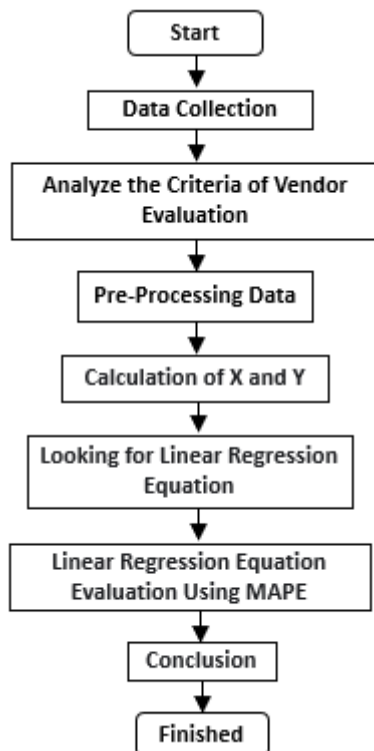


Figure 1. Research Framework

### 2.2. Linier Regression Method

Linear regression can be used as a simple tool to study the linear relationship between the dependent variable and independent variables (Bakar & Tahir, 2009). It can be concluded that

linear regression can be used to forecast the right vendor for future projects.

The formula for Linear Regression with the least squares or simple method is:

$$a = \frac{(\sum Y_i)(\sum X_i^2) - (\sum X_i)(\sum X_i Y_i)}{n \sum X_i^2 - (\sum X_i)^2} \quad (1)$$

$$b = \frac{n \sum X_i Y_i - (\sum X_i)(\sum Y_i)}{n \sum X_i - (\sum X_i)^2} \quad (2)$$

$$Y = a + b X \quad (3)$$

The causal variable (X) is the number of distributions, and the effect variable (Y) is the value of the performance of the vendor, a is a constant that indicates the magnitude of the value of variable Y if X = 0, and b is the magnitude of the change in the value of Y.

### 2.3. Accuracy Test

A prediction must be analyzed for accuracy, in this case the linear regression method can be analyzed how big the deviation is. The prediction model can be tested for accuracy by calculating the magnitude of the error or deviation between the actual data and the predicted data (Montgomery et al., 2021). In calculating the deviation of a mathematical model used for prediction, we can use a statistical indicator of accuracy, namely the mean absolute percentage error (MAPE), this index indicates an average of the absolute percentage errors (Equation 4), the lower the MAPE, the higher is the accuracy (Chen et al., 2018).

Here is the MAPE formula:

$$MAPE = \sum_{i=1}^n \left| \frac{y_i - \hat{y}_i}{y_i} \right| \times 100\% \quad (4)$$

Any forecast with a MAPE value of less than 10% can be considered highly accurate, in detail we can see in table 1.

Table 1. Table of MAPE percentage (Kenneth & Ronald, 1982)

| Value          | Accuracy        |
|----------------|-----------------|
| Less than 10 % | Highly Accurate |
| 11–20 %        | Good            |
| 21-50%         | Reasonable      |
| More than 50%  | Inaccurate      |

### 3. Results and Discussion

In this section, the researcher collects data on the performance appraisal of the refrigerated truck vendor PT. ABC, which consists of five transportation companies for four years, from January 2018 to December 2021.

The causal variable (X) in this study is the amount of distribution of goods from the warehouse of PT. ABC to distributor warehouses located in several big cities in Indonesia, which are then categorized into five areas namely Sumatra, Java & Bali, Kalimantan, Sulawesi, and Papua.

The performance assessment data from the five vendors is then pre-processed to get the final value which is then called the quality value which is used as a result variable (Y).

Based on research conducted in measuring vendor performance in the food industry, there are five assessment criteria, namely price, customer care, quality, on time delivery, quantity (Wahyudi & Asrol, 2022). After collecting existing assessment data and brainstorming with the company (PT. ABC), here we can see the description of each criterion and the weight of the assessment in table 2.

**Table 2.** Table of Refrigerated Truck Vendor Performance of PT. ABC (2018-2021)

| Criteria               | Description                                                       | Weight |
|------------------------|-------------------------------------------------------------------|--------|
| Price (P)              | Total cost billed by vendor                                       | 25%    |
| Customer Service (CS)  | Service for update delivery & complaintsan                        | 15%    |
| Quality (Q)            | Cleanliness and suitability of temperature (5-10 degrees celsius) | 20%    |
| On Time Delivery (OTD) | On time delivery according to lead time                           | 20%    |
| Quantity (QTY)         | The number of goods received is in accordance with the goods sent | 20%    |

The final performance score of each vendor in table 3.

**Table 3.** Table of Refrigerated Truck Vendor Performance of PT. ABC (2018-2021)

| PT  | Area        | P   | CS  | Q   | OTD | QTY | Y  |
|-----|-------------|-----|-----|-----|-----|-----|----|
|     |             | 25% | 15% | 20% | 20% | 20% |    |
| AAA | Sumatera    | 81  | 82  | 76  | 73  | 74  | 77 |
|     | Java & Bali | 83  | 83  | 82  | 83  | 78  | 82 |
|     | Kalimantan  | 78  | 78  | 74  | 72  | 79  | 76 |
|     | Sulawesi    | 81  | 84  | 72  | 78  | 76  | 78 |
|     | Papua       | 79  | 79  | 74  | 71  | 78  | 76 |
| BBB | Sumatera    | 80  | 82  | 76  | 74  | 74  | 77 |
|     | Java & Bali | 83  | 81  | 85  | 85  | 86  | 84 |
|     | Kalimantan  | 78  | 74  | 71  | 70  | 77  | 74 |
|     | Sulawesi    | 77  | 71  | 70  | 70  | 71  | 72 |
|     | Papua       | 78  | 74  | 75  | 70  | 73  | 74 |
| CCC | Sumatera    | 81  | 76  | 73  | 71  | 73  | 75 |
|     | Java & Bali | 80  | 82  | 85  | 89  | 79  | 83 |
|     | Kalimantan  | 82  | 81  | 77  | 79  | 81  | 80 |
|     | Sulawesi    | 78  | 82  | 70  | 78  | 74  | 76 |
|     | Papua       | 79  | 80  | 72  | 72  | 73  | 75 |
| DDD | Sumatera    | 82  | 79  | 72  | 77  | 78  | 78 |
|     | Java & Bali | 88  | 89  | 89  | 89  | 88  | 89 |
|     | Kalimantan  | 81  | 82  | 73  | 72  | 76  | 77 |
|     | Sulawesi    | 80  | 81  | 78  | 77  | 77  | 79 |
|     | Papua       | 78  | 71  | 70  | 70  | 70  | 72 |
| EEE | Sumatera    | 83  | 79  | 78  | 77  | 76  | 79 |
|     | Java & Bali | 81  | 80  | 77  | 77  | 79  | 79 |
|     | Kalimantan  | 84  | 79  | 71  | 70  | 71  | 75 |
|     | Sulawesi    | 80  | 71  | 71  | 72  | 70  | 73 |
|     | Papua       | 81  | 79  | 70  | 70  | 71  | 74 |

#### 3.1. Vendor AAA

Vendor AAA is a transportation company located in Bekasi, West Java. It has 15 refrigerated trucks.

These vendors distribute goods to five areas throughout Indonesia. In table 4 the number of distributions of goods for four years by AAA vendors is included in the causal variable (X), then the performance or quality value is included in the effect variable

(Y), the multiplication results of each variable will produce XX and YY values.

Table 5 will show the results of calculations using formula (1) and formula (2) to find the values of a and b, which results in the equation Y with formula (3).

Similar to AAA vendors, other vendors (BBB, CCC, DDD, EEE, FFF) also use the same calculation to find the values of a and b, thus the Y equation will be generated, which will later be tested for accuracy using MAPE.

**Table 4.** Table of Calculation for Vendor AAA

| Area        | Distribution (X) | Performance (Y) | XY    | XX    |
|-------------|------------------|-----------------|-------|-------|
| Sumatera    | 27               | 77              | 2079  | 729   |
| Java & Bali | 188              | 82              | 15416 | 35344 |
| Kalimantan  | 21               | 76              | 1596  | 441   |
| Sulawesi    | 19               | 78              | 1482  | 361   |
| Papua       | 11               | 76              | 836   | 121   |

**Table 5.** Table of Liner Regression Equation Calculation Vendor AAA

| Constant               | Value |
|------------------------|-------|
| a                      | 76.13 |
| b                      | 0.03  |
| Persamaan Y            |       |
| $Y = 76.13 + 0.03 (X)$ |       |

### 3.2. Vendor BBB

Vendor BBB is a transportation company located in Karawang, West Java. have about 18 refrigerated trucks.

**Table 6.** Table of Calculation for Vendor BBB

| Area        | Distribution (X) | Performance (Y) | XY    | XX    |
|-------------|------------------|-----------------|-------|-------|
| Sumatera    | 23               | 77              | 1771  | 529   |
| Java & Bali | 201              | 84              | 16884 | 40401 |
| Kalimantan  | 18               | 74              | 1332  | 324   |
| Sulawesi    | 19               | 72              | 1368  | 361   |
| Papua       | 9                | 74              | 666   | 81    |

**Table 7.** Table of Liner Regression Equation Calculation Vendor BBB

| Constant               | Value |
|------------------------|-------|
| a                      | 72.48 |
| b                      | 0.06  |
| Persamaan Y            |       |
| $Y = 72.48 + 0.06 (X)$ |       |

### 3.3. Vendor CCC

Vendor CCC is a transportation company located in PuloGadung, Jakarta. have about 14 refrigerated trucks.

**Table 8.** Table of Calculation for Vendor CCC

| Area        | Distribution (X) | Performance (Y) | XY    | XX    |
|-------------|------------------|-----------------|-------|-------|
| Sumatera    | 25               | 75              | 1875  | 625   |
| Java & Bali | 176              | 83              | 14608 | 30976 |
| Kalimantan  | 14               | 80              | 1120  | 196   |
| Sulawesi    | 22               | 76              | 1672  | 484   |
| Papua       | 8                | 75              | 600   | 64    |

**Table 9.** Table of Liner Regression Equation Calculation Vendor CCC

| Constant               | Value |
|------------------------|-------|
| a                      | 76.45 |
| b                      | 0.04  |
| Persamaan Y            |       |
| $Y = 76.45 + 0.04 (X)$ |       |

### 3.4. Vendor DDD

Vendor DDD is a transportation company located in Bogor, West Java. have about 9 refrigerated trucks.

**Table 10.** Table of Calculation for Vendor DDD

| Area        | Distribution (X) | Performance (Y) | XY    | XX    |
|-------------|------------------|-----------------|-------|-------|
| Sumatera    | 27               | 78              | 2106  | 729   |
| Java & Bali | 195              | 89              | 17355 | 38025 |
| Kalimantan  | 18               | 77              | 1386  | 324   |
| Sulawesi    | 14               | 79              | 1106  | 196   |
| Papua       | 5                | 72              | 360   | 25    |

**Table 11.** Table of Liner Regression Equation Calculation Vendor DDD

| Constant               | Value |
|------------------------|-------|
| a                      | 75.04 |
| b                      | 0.07  |
| Persamaan Y            |       |
| $Y = 75.04 + 0.07 (X)$ |       |

### 3.5. Vendor EEE

Vendor EEE is a transportation company that the farthest vendor location from PT ABC, the address in Bogor, West Java. have about 12 refrigerated trucks.

**Table 12.** Table of Calculation for Vendor EEE

| Area        | Distribution (X) | Performance (Y) | XY    | XX    |
|-------------|------------------|-----------------|-------|-------|
| Sumatera    | 29               | 79              | 2291  | 841   |
| Java & Bali | 231              | 79              | 18249 | 53361 |
| Kalimantan  | 16               | 75              | 1200  | 256   |
| Sulawesi    | 14               | 73              | 1022  | 196   |
| Papua       | 10               | 74              | 740   | 100   |

**Table 13.** Table of Liner Regression Equation Calculation Vendor EEE

| Constant               | Value |
|------------------------|-------|
| a                      | 73.69 |
| b                      | 0.02  |
| Persamaan Y            |       |
| $Y = 73.69 + 0.02 (X)$ |       |

Based on the linear regression equation from each vendor, then use formula (4) to find the percentage value of the mean absolute percentage error (MAPE) from each vendor, it can be seen on table 14.

**Table 14.** Table of Equation Accuracy Results

| Vendor | MAPE  |
|--------|-------|
| AAA    | 0.73% |
| BBB    | 3.94% |
| CCC    | 2.47% |
| DDD    | 3.74% |
| EEE    | 4.29% |

#### 4. Conclusions

In this study, the use of linear regression method in the selection of refrigerated truck vendors at PT. ABC for future projects can be concluded in the very good category, so that it can be used and applied. This is evidenced by the MAPE value below 10%.

The linear regression method is proven to be used as a decision-making tool to get the maximum service quality of refrigerated truck vendors.

In future research, the researcher proposes to compare this method with other mathematical methods and then compare the level of accuracy.

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