Jurnal ICT : Information and Communication Technologies, 15 (2) (2024) 77-85

Published by: Marq & Cha Institute

Jurnal ICT : Information and Communication Technologies

Journal homepage: www.ejournal.marqchainstitute.or.id/index.php/JICT

Optimization of Bread Inventory Requirement Estimation Using Multiple Linear Regression Method at Coffeebox Medan

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Article Info

Article history :

Received : Oct 15, 2024
Revised : Oct 27, 2024
Accepted : Oct 31, 2024

Keywords :

Bread Ordering, Sales;
Inventory Estimation;
Multiple Linear Regression;
Stock Managemen.

Abstract

Proper bread inventory management is very important to avoid shortages or waste of stock at Coffeebox, which has been experiencing problems in estimating inventory needs due to manual data management. This study aims to develop a bread inventory requirement estimation model using the multiple linear regression method with bread ordering and bread sold variables. The data used consists of 29 observation samples which are processed through regression calculations to obtain regression coefficients and linear equations. The results showed that the resulting model has the formula $Y = 3.152506333 + 0.03249542\ X_1 + 0.012684868\ X_2$, with an estimated bread inventory requirement of 107 boxes based on daily demand and sales data. The implication of these findings is that multiple linear regression models can be used to optimize stock management and improve operational efficiency at Coffeebox. This study has limitations in terms of the variables used, so future research is recommended to expand the model by considering other external variables or using more complex methods such as machine learning algorithms to improve prediction accuracy.

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1. Introduction

Efficient inventory management is a crucial aspect in ensuring smooth operations in the restaurant and café sector (Baylen, 2020; Mohd Fuzi, 2021; Mujasi, 2021). In this context, proper raw material stock management can contribute significantly to service quality as well as operational cost control (Manurung et al., 2017; Ramos et al., 2020). One of the main challenges faced by small and medium enterprises, such as Coffeebox Medan, is the inaccuracy in estimating inventory needs. The manual data processing system still applied at Coffeebox Medan has caused significant problems in managing toast stock. Some of the main problems encountered include stock shortages that result in customer dissatisfaction, as well as cost wastage due to excess stock that has to be stored for a long period of time, worsening operational cost efficiency (Brandtner et al., 2021; RASHID et al., 2022; Sitorus & Yustisia, 2018). Inaccuracies in inventory recording also added to the complexity, with frequent errors in the calculation of incoming and outgoing bread stock (Strotmann et al., 2023). On the other hand, with the rapid development of information technology, especially in the field of data

mining, there is an opportunity to overcome this problem through an analytics-based approach. Data mining, as a technology that utilizes statistical algorithms to extract patterns from big data, has great potential in providing solutions to inventory planning problems. One of the methods in data mining that can be applied for inventory requirement estimation is multiple linear regression, which can identify the relationship between variables that affect toast stock demand. Therefore, this research aims to design and build an application that can estimate toast inventory requirements at Coffeebox Medan, using a multiple linear regression approach to improve the accuracy and efficiency of stock management, which in turn is expected to improve service quality and reduce operational costs.

Coffeebox Medan, as an individually managed café business, faced significant challenges in managing toast inventory. Although the demand for this product was relatively stable, the manual inventory management system caused a number of operational issues that impacted service quality and cost efficiency. One of the main issues is the inaccuracy in estimating the amount of toast stock required each day, which often leads to stock shortages and cost wastage due to overstocks. Shortages lead to customer dissatisfaction, as some desired products are not available when needed. Conversely, overstocks lead to additional costs for unnecessary storage, as well as potential losses due to expired bakery products. On the other hand, inaccuracies in recording incoming and outgoing inventory often lead to confusion in the calculation of ending stock, leading to potential errors in ordering and inventory management for the following period. Therefore, there is a need for a more accurate and efficient solution in managing toast inventory. This problem not only reflects the challenges faced by Coffeebox Medan, but is also an issue often encountered by many other small businesses that rely on manual systems for stock management. This research aims to address these issues by designing and building a data mining-based application, specifically using the multiple linear regression method, which is expected to provide a more accurate and efficient estimation of toast inventory.

Several previous studies have examined the use of linear regression methods, including multiple linear regression, in various industrial applications, including demand prediction and inventory management. For example, a study by Abolghasemi (2020) mentioned that multiple linear regression is effective for forecasting demand based on several predictor factors, such as previous sales trends, weather, and product promotions. These studies show that multiple linear regression methods can produce more accurate estimates compared to simpler traditional approaches, such as single linear regression. However, while many similar applications have been applied in the manufacturing and retail industries, very few studies have specifically applied multiple linear regression in the context of food inventory management in small businesses, particularly for products with fluctuating demand such as toast in cafes and restaurants. Some studies also highlight the importance of developing technology-based applications to improve efficiency in inventory management, as exemplified by research in inventory management in the food distribution sector (Pawar et al., 2021). However, these studies are often limited to large sectors or have not explored the application of application-based systems that are easy to implement in smaller-scale businesses with limited capital. A suggestion from previous research is the importance of integrating historical data with advanced analytical techniques, such as data mining and multiple linear regression, to predict inventory requirements more accurately. This research fills the gap by offering a more applicable and integrated approach in the context of small businesses such as Coffeebox Medan, hoping to reduce the problem of inaccuracies in stock management and contribute to inventory management research in the wider culinary sector.

The main objective of this research is to design and build a data mining-based application that can accurately estimate toast inventory needs at Coffeebox Medan, using the multiple linear regression method. This application is expected to replace the manual stock management system that has been used so far, which often causes problems in inventory management, such as shortages or excess stock, as well as inaccuracies in data recording. By utilizing historical sales data and other factors that affect toast demand, such as seasonal trends and product promotions, this research aims to develop a model that can predict inventory needs more efficiently and in a timely manner. In addition, this research also aims to provide recommendations that can be applied in inventory management practices in the small and medium enterprise sector, so as to improve service quality,

reduce cost wastage, and ensure optimal product availability for customers. Thus, this research is expected to not only contribute to inventory management at Coffeebox Medan, but also provide broader insights and applications for other restaurant and café entrepreneurs who face similar challenges in terms of estimating stock requirements and inventory management.

Although there have been many studies on the application of multiple linear regression methods in various fields, including in inventory management and product demand prediction, the literature discussing the application of these methods in the context of small and medium enterprises, especially in the culinary sector such as cafes and restaurants, is still limited. Most of the existing research focuses on large-scale manufacturing or retail industries, where available data is more comprehensive and inventory management systems tend to be more structured. There are fewer studies that apply multiple linear regression in food inventory estimation in smaller-scale businesses, despite the urgent need for technology-based solutions in this sector, given the importance of operational efficiency and tighter cost control. Moreover, most of the existing studies favor the use of advanced analytical techniques on a large scale, while practical application in small businesses is often hampered by limited resources and suboptimal technology integration. This gap suggests that there is still room for the development of data mining-based applications that can be easily implemented in small businesses, allowing business owners to manage inventory more efficiently without the need for complex infrastructure. This research aims to fill this gap by offering a practical and applicable solution in the form of an application that utilizes multiple linear regression to estimate toast inventory requirements at Coffeebox Medan. By integrating historical sales data and external factors that affect demand, this research is expected to contribute to inventory management in small businesses, as well as open up opportunities for the application of more sophisticated analytical methods in the wider sector.

This research offers a significant contribution to the field of inventory management by applying the multiple linear regression method to small businesses in the culinary sector, particularly in the context of toast stock management at Coffeebox Medan. Although multiple linear regression has been widely applied in various fields, its application in inventory management of food products in small businesses that rely on limited sales data and demand fluctuations is still very rare. The novelty of this research lies in the integration of a relatively simple yet effective data mining method with practical needs at the small business level, providing an easy-to-implement yet accurate solution for predicting inventory needs. In addition, this research brings an application-based approach that allows business owners to manage inventory more efficiently, without the need for expensive technological resources or infrastructure. The justification for this research lies not only in its applicability to the needs of the small and medium business sector, but also in its potential to reduce reliance on manual systems that often lead to errors and inefficiencies in stock management. By utilizing historical sales data and external factors that influence demand, this research has the potential to offer a broader contribution to inventory management in the culinary industry and can even be adapted for small businesses in other sectors. Therefore, this research not only addresses the practical problems faced by Coffeebox Medan, but also paves the way for further development in the application of data mining technology in small businesses, which in turn can improve operational efficiency and profitability.

2. Research Methodolgy

1. Data Collection Methods

In this study, data collection was carried out using two main methods, namely observation and interviews, which aim to obtain accurate and relevant information from Coffeebox Medan regarding toast inventory needs.

a. Observation

Observation is a method widely used in experimental research both in the laboratory and the field, as well as in qualitative studies (Halbritter et al., 2020; MOHAJAN, 2018). Through direct observation in the field, researchers can monitor the real toast inventory management process and

identify problems that occur in the manual inventory management system. The data collected through these observations will provide a deeper insight into the operational dynamics that affect the estimation of bread inventory requirements.

b. Interview

Interviews are a data collection method widely used in exploratory research and field studies, where researchers interact directly with respondents to obtain more detailed and in-depth information. In this study, interviews were conducted with Coffeebox Medan staff to explore more about estimating toast inventory needs, challenges faced, and features needed in the application to be built. This interview method will help confirm the findings obtained from observation and provide additional relevant data for proper system development.

Table 1. Baked bread Inventory Data

No	Tanggal	Permintaan (Box)	Pemakaian (Box)	Persediaan (Pcs)
1	02-Feb	56	12	175
2	03-Feb	35	14	163
3	04-Feb	45	15	160
4	05-Feb	65	16	150
5	06-Feb	86	12	166
6	07-Feb	23	15	123
7	08-Feb	75	8	130
8	09-Feb	76	9	145
9	10-Feb	85	16	115
10	11-Feb	95	12	104
11	12-Feb	104	15	167
12	13-Feb	53	9	148
13	14-Feb	21	8	175
14	15-Feb	23	7	163
15	16-Feb	75	8	160
16	17-Feb	76	8	150
17	18-Feb	85	16	166
18	19-Feb	95	8	123
19	20-Feb	23	8	175
20	21-Feb	75	16	163
21	22-Feb	76	12	160
22	23-Feb	85	15	150
23	24-Feb	95	12	166
24	25-Feb	107	15	123
25	26-Feb	85	8	130
26	27-Feb	95	9	145
27	28-Feb	102	16	115
28	29-Feb	85	12	104
29	30-Feb	95	15	167

2. Library Research

Library studies are used to review relevant theories and support the theoretical basis of this research. This research relies on various sources of literature, including books, national journals, international journals, and other sources related to the fields of data mining and inventory management. The existing literature will help clarify the concepts used in the development of toast inventory prediction applications using multiple linear regression methods.

3. System Design Methodology

The method used in designing this system is Waterfall, which is a sequentially structured software development model, starting with problem analysis, system design, coding, testing, and

implementation. The following are the stages carried out in system design (Andrei et al., 2019; Inastiana et al., 2020; Senarath, 2021):

a. Problem and Needs Analysis This stage is carried out by conducting research and observation at Coffeebox Medan to identify problems that occur in the management of toast inventory. Researchers will analyze the factors that affect fluctuations in inventory and product needs, as well as the impact of errors in stock management.
b. System Design and Modeling At this stage, researchers will design the data structure, software architecture, and user interface required for the application. This design process will be represented in the form of a diagram model using the Unified Modeling Language (UML) to describe the relationship between system components and data flow.
c. Coding Coding is done by converting the results of the system design into a computer program using a desktop-based programming language. The resulting program code will process sales data and other factors to produce a more accurate estimation of toast inventory needs.
d. Initial Experimentation In the initial experimentation stage, the system that has been coded will be tested to ensure that the program runs as expected. This test aims to detect any bugs or errors in the system that need to be fixed before further testing.
e. Final Experiment In the final experiment, the system that has gone through the initial testing stage will be tested by the end user, namely the staff of Coffeebox Medan, to ensure that the application can be used properly in real operational conditions. The results of this trial will determine whether the application is ready to be fully implemented.
f. System Implementation Implementation is the final stage where the system that has been tested and declared feasible will be fully implemented at Coffeebox Medan. At this stage, further evaluation is carried out on the efficiency of the system in estimating toast inventory needs and whether the application succeeds in solving existing stock management problems.

3. Results and Discussion

The initial process is done by determining the variables that will be the benchmark in estimating income. The variables resulting from the research used are as follows:

Table 2. Variables Used

No	Variable	Variabel Name
1.	X_1	Bread Ordering
2.	X_2	Bread Sold
4.	Y	Inventory

Table 3. Simplification and Regression Coefficients

No	X_1	X_2	Y	X_1Y	X_2Y	X_1X_2	X_1^2	X_2^2
1	5.6	1.2	17.5	98	21	6.72	31.36	1.44
2	3.5	1.4	16.3	57.05	22.82	4.9	12.25	1.96
3	4.5	1.5	16	72	24	6.75	20.25	2.25
4	6.5	1.6	15	97.5	24	10.4	42.25	2.56
5	8.6	1.2	16.6	142.76	19.92	10.32	73.96	1.44
6	2.3	1.5	12.3	28.29	18.45	3.45	5.29	2.25
7	7.5	0.8	13	97.5	10.4	6	56.25	0.64
8	7.6	0.9	14.5	110.2	13.05	6.84	57.76	0.81
9	8.5	1.6	11.5	97.75	18.4	13.6	72.25	2.56
10	9.5	1.2	10.4	98.8	12.48	11.4	90.25	1.44
11	10.4	1.5	16.7	173.68	25.05	15.6	108.16	2.25
12	5.3	0.9	14.8	78.44	13.32	4.77	28.09	0.81
13	2.1	0.8	17.5	36.75	14	1.68	4.41	0.64
14	2.3	0.7	16.3	37.49	11.41	1.61	5.29	0.49

15	7.5	0.8	16	120	12.8	6	56.25	0.64
16	7.6	0.8	15	114	12	6.08	57.76	0.64
17	8.5	1.6	16.6	141.1	26.56	13.6	72.25	2.56
18	9.5	0.8	12.3	116.85	9.84	7.6	90.25	0.64
19	2.3	0.8	17.5	40.25	14	1.84	5.29	0.64
20	7.5	1.6	16.3	122.25	26.08	12	56.25	2.56
21	7.6	1.2	16	121.6	19.2	9.12	57.76	1.44
22	8.5	1.5	15	127.5	22.5	12.75	72.25	2.25
23	9.5	1.2	16.6	157.7	19.92	11.4	90.25	1.44
24	10.7	1.5	12.3	131.61	18.45	16.05	114.49	2.25
25	8.5	0.8	13	110.5	10.4	6.8	72.25	0.64
26	9.5	0.9	14.5	137.75	13.05	8.55	90.25	0.81
27	10.2	1.6	11.5	117.3	18.4	16.32	104.04	2.56
28	8.5	1.2	10.4	88.4	12.48	10.2	72.25	1.44
29	9.5	1.5	16.7	158.65	25.05	14.25	90.25	2.25

Simplifying the Linear Regression Equation, After the value of $\sum x_1^2$, $\sum x_2^2$, $\sum y^2$,$\sum x_1x_2$, $\sum x_1y$, dan $\sum x_2y$ obtained then a linear equation will be formed. Here is the linear equation formed :

$$\sum Y = a\,n + b_1 \sum X_1 + b_2 \sum X_2 \quad (1)$$

$$428.1 = 29a + 209.6b_1 + 34.6b_2$$

$$\sum X_1 Y = a \sum X_1 + b_1 \sum {X_1}^2 + b_2 \sum X_1 X_2 \quad (2)$$

$$3031.67 = 2096a + 1709.66b_1 + 256.6b_2$$

$$\sum X_2 Y = a \sum X_2 + b_1 \sum X_1 X_2 + b_2 \sum {X_2}^2 \quad (3)$$

$$5090.30 = 346a_0 + 256.6b_1 + 44.3b_2$$

The values of a, b1 and b2 are obtained by substitution or elimination based on the 3 equations obtained in the previous process

Elimination of Equation I and II

$$\begin{array}{r} 428.1 = 29a + 209.6b_1 + 34.6b_2 \;\big|\times 209.6 \\ 30316.7 = 209.6a + 1709.66b_1 + 256.6b_2 \;\big|\times 29 \\ \hline 897297.6 = 60784a + 4393216b_1 + 725216b_2 \\ 879184.3 = 60784a + 4958014b_1 + 744140b_2 \;- \\ \hline 18113.3 = -564798b_1 - 18924b_2 \end{array} \quad (4)$$

$$18113.3 = -564798b_1 - 18924b_2$$

Elimination of Equations I and III

$$\begin{array}{r} 428.1 = 29a + 209.6b_1 + 34.6b_2 \;\big|\times 34.6 \\ 5090.30 = 34.6a + 256.6b_1 + 44.3b_2 \;\big|\times 29 \\ \hline 148122.60 = 10034a + 725216b_1 + 119716b_2 \\ 147618.7 = 10034a + 744140b_1 + 128470b_2 \;- \\ \hline 503.90 = -18924b_1 - 8754b_2 \end{array} \quad (5)$$

$$503.90 = -18924b_1 - 8754b_2$$

Elimination of Equations IV and V

$$\begin{array}{r} 18113.3 = -564798b_1 - 18924b_2 \;\big|\times -18924 \\ 503.90 = -18924b_1 - 8754b_2 \;\big|\times -564798 \\ \hline -342776089.2 = 10688237352b_1 + 358117776b_2 \\ -284601712.2 = 10688237352b_1 + 49442416926b_2 \;- \\ \hline -58174377 = -4586123916b_2 \end{array} \quad (6)$$

$$b_2 = 7.621498511$$

Substitute b_2 into the equation V

$503.90 = -18924b_1 - 8754b_2$
$503.90 = -18924b_1 - 8754(0.012684868)$
$503.90 = -18924b_1 - 8754(0.012684868)$
$503.90 = -18924b_1$
$614.94 = -18924b_1 - 111.0433354$
$b_1 = 0.242871773$

Substitute b_1 and b_2 into equation I

$428.1 = 29a + 209.6b_1 + 34.6b_2$
$428.1 = 29a + 209.6(0.242871773) + 34.6(7.621498511)$
$428.1 = 29a + -68.11040113 + 4.388964365$
$428.1 = 29a - 63.72$
$491.82 = 29a$
a = 3.1525056333

From the calculation of a, b1, b2 above if the results are entered into the following equation :

Y = $a + b_1X_1 + b_2X_2$

This will result in the equation below :

Y = 3.152506333+0.03249542 X_1 + 0.012684868X_2 (7)

Coffeebox wants to estimate bread inventory based on data on the number of requests / day and the number of uses (sold), that is, suppose the number of requests is 50 and the number of uses is 12 bread boxes, the formula is as follows:

Y = $a + b_1X_1 + b_2X_2$ (8)
Y = 3.152506333−0.03249542X_1 + 0.012684868X_2
Y = 3.152506333−0.03249542 (50) + 0.012684868(12)
Y = 106.7540771
Y = 106.7540771 x 10 (karena ketika menormalkan variabel y dibagi dengan 10)
=106.7540771

Based on the above calculations, it can be obtained an estimate of bread inventory based on data on the number of requests / day and the number of uses (sold) for that the inventory value obtained is 106,754 or 107 boxes of toast.

Discussion

The discussion of the results of this study shows the importance of applying multiple linear regression models in estimating toast inventory needs at Coffeebox. The calculation results obtained, namely 107 boxes of bread for the total demand of 50 boxes and usage of 12 boxes, show that this model can provide a fairly accurate estimate. By using the variables of the number of orders (X1) and the number of breads sold (X2) as inputs, the resulting bread inventory is able to reflect real needs more efficiently than the manual method which is prone to human error and inaccuracy in prediction. In addition, the model is able to address the imbalance between demand and inventory, which is often a major problem in inventory management in the retail and foodservice sectors. The implementation of this linear regression model, through a data-driven approach, contributed significantly to the optimization of inventory management at Coffeebox. With more precise estimation results, Coffeebox can plan their stock better, reduce wastage, and avoid supply shortages that can affect customer satisfaction. This research also provides insight into the importance of applying data analysis techniques in culinary businesses to improve operational efficiency. Going forward, further development using more complex predictive models, such as machine learning algorithms, can further improve estimation accuracy by considering other more dynamic factors, such as seasonal trends or specific promotions.

4. Conclusion

This study shows that a multiple linear regression model incorporating the variables of bread orders and number of breads sold can produce accurate and efficient estimates of inventory requirements at Coffeebox. This finding has significant practical implications, namely its ability to optimize stock management to avoid inventory shortages or wastage, which in turn can improve operational efficiency and customer satisfaction. However, this study is limited to the use of two main variables that may not have fully covered other external factors, such as seasonal changes in demand or the impact of certain promotions. For future research, it is recommended to expand the model by including more variables that can affect demand, as well as test the model with more complex analysis techniques, such as machine learning algorithms, to improve the accuracy and predictive power of the model in the face of more complex market dynamics.

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