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SALES ANALYSIS USING APRIORI ALGORITHM

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Abstract

PT JR Pangan Semesta is a company that produces fast food in the form of Donuts and Sweet Bread under the Deroti brand. The sales and promotion methods that have been carried out have weaknesses because the company has difficulty ensuring the right amount of bread production, so there is often excess or lack of stock. In addition, the promotional strategy used has not included the concept of bundling, so the maximum promotional potential has not been fully explored. To overcome these problems, the use of data mining methods is proposed, one of which is the Apriori Association Rule algorithm. Apriori algorithm is used to find consistent sales patterns and find strong product relationships by analyzing sales transaction data. In this study, sales patterns were analyzed at PT JR Pangan Semesta with a minimum support value of 16% and a minimum confidence value of 60%. The analysis results show that there are three products that are often purchased together by consumers, namely Fried Bread, Deroti Donuts, and Eco Donuts. The three products form one valid association rule, so that the rule can be used as a reference for developing efficient production methods for bread and donuts and implementing sales strategies in the form of bundling products to maximize profits.

Keywords: Apriori algorithm; data mining; sales patterns; product bundling; production efficiency.

Abstrak

PT JR Pangan Semesta adalah perusahaan yang memproduksi fast food berupa Donat dan Roti Manis dengan merek Deroti. Metode penjualan dan promosi yang telah dilakukan memiliki kelemahan karena perusahaan sulit memastikan jumlah produksi roti yang tepat, sehingga sering terjadi kelebihan atau kekurangan stok. Selain itu, strategi promosi yang digunakan belum memasukkan konsep bundling, sehingga potensi promosi maksimal belum tergali sepenuhnya. Untuk mengatasi masalah tersebut, diusulkan penggunaan metode data mining, salah satunya algoritma Association Rule Apriori. Algoritma Apriori digunakan untuk menemukan pola penjualan yang konsisten dan menemukan hubungan produk yang kuat dengan menganalisis data transaksi penjualan. Dalam penelitian ini, dilakukan analisis pola penjualan di PT JR Pangan Semesta dengan nilai minimal support 16% dan nilai minimal confidence 60%. Hasil analisis menunjukkan terdapat tiga produk yang sering dibeli bersamaan oleh konsumen, yaitu Roti Goreng, Donat Deroti, dan Donat Eco. Ketiga produk tersebut membentuk satu aturan asosiasi yang valid, sehingga aturan tersebut dapat digunakan sebagai acuan untuk mengembangkan metode produksi yang efisien untuk roti dan donat serta menerapkan strategi penjualan berupa produk secara bundling untuk memaksimalkan keuntungan.

Kata kunci: Algoritma apriori; data mining; pola penjualan; produk bundling; efisiensi produksi.

INTRODUCTION

One of the important parts of a marketing strategy is sales, which is crucial to achieving the company's goals (A. F. Lestari & Hafiz, 2020). The sales process doesn't just include transactional activities (Ali & Isyanto, 2024), but it also involves marketing strategy, customer relationship management, and market analysis. In addition, the sale also involves a price agreement that is favorable to both parties (Yunita & Lestari, 2022). Along with the importance of sales in marketing strategies, in-depth data analysis is key to optimizing the process (Nabilah, 2023). Data mining has emerged as an effective tool for mining information (Putra et al., 2023) and useful patterns of large datasets (Purwadi, Ramadhan, & Safitri, 2019).

Data mining is the process of extracting information (Ikhwan & Aslami, 2020) and useful

patterns from large amounts of data (Arhami, Kom, Muhammad Nasir, & others, 2020). There are many techniques in data mining, namely description, estimation, prediction, classification, clustering, and association. Of the six methods, to analyze consumer sales patterns, the association method can be used (Amna; S, Wahyudi; Sudipa, I Gede Iwan; Putra, Tri Andi E; Wahidin, Ahmad Junaidi; Syukrilla, Wara Alfa; Wardhani, Anindya Khrisna; Heryana, Nono; Indriyani, Tutuk; Santoso, 2023).

The Association method on data mining is tasked with finding attributes that appear at a certain time (Prasetya, Yanti, Purnamasari, Dikananda, & Nurdiawan, 2022). The basic principle a priori is that if an itemset is considered to appear frequently, then all of its subsets must also appear frequently. The process begins by finding the single item that appears most frequently in the transaction data (frequent 1-itemset) (Darmawan, Randy, Yunianto, Mutoffar, & Salis, 2022). Then, gradually, create larger combinations of items and calculate their frequency. Until the item combination does not meet the minimum *support* and *confidence* threshold that has been determined, the process stops. In situations like this, the A priori algorithm is suitable for use because it can identify the pattern of relationships between products based on sales transaction data. This way, businesses can identify what items are frequently purchased by consumers at the same time. Marketing strategies such as stock management, bundling sales, and product placement are very useful with this data.

PT JR Pangan Semesta Bogor is a company that produces fast food in the form of Donuts and Sweet Bread under the Deroti brand. Currently, PT JR Pangan Semesta Bogor uses methods such as bazaars, advertisements, websites, social media, brochures, banners, billboards and posters to conduct sales and promotions (Ayunda, 2021). This method has the disadvantage that it is difficult for the company to ensure the right amount of bread production to avoid over- or under-stocking. In addition, the promotional strategy used has not been included in the form of bundling, so the maximum potential of promotion has not been fully explored. To overcome this problem, this study was conducted using an A priori algorithm to find sales patterns at PT Pangan Semesta Bogor, which had never been analyzed using data mining techniques before. In addition, the study uses minimum support and trust parameters that are tailored to the company's transaction features, resulting in support rules that are more suited to business needs.

Using this method, effective and attractive promotions can be created, such as frequent co-purchases, as well as more measurable production strategies. Therefore, PT JR Pangan Semesta Bogor can reduce unnecessary production amounts, reduce waste, and increase customer satisfaction. This study aims to identify consumer purchasing patterns by using a priori algorithm to support more efficient promotion and production strategies. It is hoped that this research will help make better decisions and increase the company's profitability.

RESEARCH METHODS

To reduce overproduction, waste, and increase customer satisfaction at PT JR Pangan Semesta, the use of data mining methods with the Apriori algorithm is proposed. It is expected to help in making better decisions and increase company profitability.

Types of research

This study uses a quantitative and applied approach.

Time and Place of Research

The research was carried out for 11 months, starting from September 2023 to July 2024. The research was carried out by analyzing and calculating the data obtained.

Data Mining

The complex decomposition of a set of data into information that has implicit potential (not real or obvious) that was previously known is known as data mining (Larasanti, 2020). In addition, data mining can also be defined as mining and analysis using automated or semi-automated equipment from most data with the aim of finding patterns that have meaning or intent (Amna; S, Wahyudi; Sudipa, I Gede Iwan; Putra, Tri Andi E; Wahidin, Ahmad Junaidi; Syukrilla, Wara Alfa; Wardhani, Anindya Khrisna; Heryana, Nono; Indriyani, Tutuk; Santoso, 2023).

Association Rule

Association rule mining is a data mining technique to find the rules of a combination of items (Rusdianto, Zaelani, & others, 2020) as well as useful for finding interesting hidden relationships in large Datasets (Latifah, Furqon, & Santoso, 2018). It is common to use the term antecedent to represent the "if" part and consequent to represent the "then" part (T. A. Lestari, Ramadhanti, & Windarto, 2021).

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Apriori Algorithm

The priori algorithm is divided into two stages, namely (Rahayu et al., 2024) (Tarigan, Hardinata, Qurniawan, Safii, & Winanjaya, 2022):

1. High-Frequency Pattern Analysis
   At this stage, look for the minimum eligible item pools to have a support value in the database. The support value of each item is calculated using the equation 1.

$$Support\ (A) = \frac{\sum Transaction\ Contains\ A}{\sum Transaction} \quad (1)$$

   Equation 1 is used to calculate the support of an itemset.

$$Support\ (A,B) = \frac{\sum Transaction\ Contains\ A\ and\ B}{\sum Transaction} \quad (2)$$

   Equation 2 to generate support values for two items.

2. Establishment of Associative Rules
   Once all the high-frequency patterns have been found, the associative rules that meet the minimum confidence requirements are sought by calculating the confidence of associative rules A → B with the equation 3.

$$Confidence\ P(A|B) = \frac{\sum Transaction\ Contains\ A\ and\ B}{\sum Transaction\ Contains\ A} \quad (3)$$

   To evaluate the strength of the association rules, the Lift Ratio test is performed with the equation 4.

$$Lift\ ratio = \frac{Confidence\ (A,B)}{Benchmark\ Confidence(A,B)} \quad (4)$$

   Where,

$$Benchmark\ Confidence = \frac{NC}{N} \quad (5)$$

   With,
   NC = the number of transactions with the item that became consequent
   N = Number of Database Transactions

Steps of the Algorithm a priori (Saputra & Iskandar, 2023)(Rahayu et al., 2024):

1. Define a support minimum value.
2. Iteration 1: The algorithm finds and calculates the frequency of each item in the data or frequency that is greater than or equal to the previously set support threshold.
3. Iteration 2: A candidate itemset consisting of two or more items is created using the results from the first stage (iteration 1).
4. The process will stop if the minimum value does not match.
5. The candidate formation process, which consists of a join and prune process, will continue until the itemset candidate set becomes null or no more candidates are formed.
6. After that, association rules are made from the results of frequent itemsets that meet the values of support and confidence.
7. Lift ratio testing is carried out to determine the validity of the association rules that have been created.

Procedure

The following is the procedure in this study:

1. Data Collection
   Sales data must be collected first. This data contains sales transactions that include information Id_Transaksi, Id_Pelanggan, Tanggal_Transaksi, Burger Buns, Colored Burger Buns, Hotdog Buns, Colored Hotdog Buns, Roti Donuts, Colored Roti Donuts, Eco Donuts, Unyil Donuts, Ant Donuts, Ant Buns, Mini Pao, Fried Buns and Subtotal.
2. Preprocessing Data
   The collected data must be processed to ensure that the data is clean and ready for use (Rahmadani, Rahim, & Rudiman, 2024). Several preprocessing steps are carried out to check for lost data and duplicate data.
3. A priori algorithm implementation
   A priori algorithms are used to find associations between products purchased together (Mardiyantoro, Utomo, Ihsannuddin, & others, 2023), done using Python.
4. Final Evaluation
   At the evaluation stage, the association rules are tested for validity using the lift ratio method. This method measures how successful a product is when sold alongside other products, which is useful for package sales analysis or bundling.
5. Exporting Analysis Results to Streamlit Library
   Once the analysis is complete, the clean, encoded results are exported to the website system using Streamlit for additional analysis.
6. Development of web-based systems or applications
   The next stage is to build a website that uses a priori algorithm to analyze sales patterns. The purpose of this website is to help the management of PT JR Pangan Semesta analyze sales and make data-driven decisions to

improve the company's operational efficiency and profitability.

7. Web-based system or application testing
   In the final stage, the website is tested to ensure that its operations are as expected and that the results of the analysis are accurate. The main components tested include promotional suggestions, buying pattern analysis, and an interactive dashboard. In addition, testing ensures a priori algorithm is valid, a user-friendly interface, and bug fixes before full implementation.

Data, Instruments, and Data Collection Techniques

This study uses 505 primary data. The criteria and alternative data collection techniques to be used in the system test were obtained by collecting sales transaction datasets through interviews and observations. As information on bread and donut sales data, this study uses 12 attributes, namely Burger Bread, Colored Burger Bread, Hotdog Bread, Colored Hotdog Bread, Bread Donuts, Colored Bread Donuts, Eco Donuts, Unyil Donuts, Ant Donuts, Ant Bread, Mini Pao, and Fried Bread.

Data analysis technique

This study has qualitative and quantitative data. Quantitative research uses numerical data and statistical techniques to analyze purchasing patterns, with a priori algorithm identifying the frequency and relationships between items in sales transactions. Meanwhile, applied research applies the results of a priori analysis in a practical context.

RESULTS AND DISCUSSION

The results of the observation and interview process conducted on the company produced sales transaction data from August 2022 to August 2023. By using association methods and a priori algorithms, association methods can identify customer sales patterns.

In this study, the implementation of a priori algorithm uses the python programming language.

Importing Module dan Dataset

The first step in this study is to install the Apriori library for association analysis, as shown in Table 1. The imported modules include Pandas and NumPy for data preprocessing, as well as 'drive' and 'auth' for accessing files from Google Drive. In addition, the related module for modeling data with a priori algorithm is also imported. The file is imported and the Data Frame of the dataset is displayed according to Table 3 and Figure 1.

Table 1. Installing a priori library

```
# Menginstall Library
!pip install apyori
!pip install efficient-apriori
!pip install apriori_python
```

Table 1 shows the steps to install the Apriori library.

Table 2. Import Library

```
# Memanggil library yang dibutuhkan
import pandas as pd
import numpy as np
from apyori import apriori
from efficient_apriori import apriori
from apriori_python import apriori
from mlxtend.frequent_patterns import
apriori, association_rules

# google drive & authentication
from google.colab import drive, auth
from google.auth import default
drive.mount('/content/drive')
auth.authenticate_user()

Mounted at /content/drive
```

Table 2 shows a list of libraries imported and used in this study.

Table 3. Import Dataset

```
df =
pd.read_excel("/content/drive/MyDrive/Colab
Notebooks/SKRIPSI/Data PT Jr Pangan Semesta
- Transaksi Harian(2).xlsx", sheet_name =
"Agu_22-Agu_23")
#Menampilkan dataset
df
```

Table 3 shows the dataset import process used in this study.

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transfo
  and should_run_async(code)
```

	Id_Transaksi	Id_pelanggan	Tanggal_transaksi	Roti Burger	Roti Burger Warna	Roti Hotdog	Roti Hotdog Warna	Donat Deroti	Donat Deroti Warna	Donat Eco	Donat Unyil	Donat Semut	Roti Semut	M
0	1	1356	1 Agustus 2022	0	31	0	0	34	0	31	0	0	33	
1	2	1499	1 Agustus 2022	30	0	0	32	31	0	35	0	40	0	
2	3	1567	1 Agustus 2022	0	0	30	35	0	40	40	30	0	37	
3	4	1893	3 Agustus 2022	0	0	37	0	32	31	34	31	0	0	
4	5	1630	5 Agustus 2022	32	0	30	33	38	35	38	36	40	37	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
500	501	1997	26 Agustus 2023	68	0	68	0	0	65	61	0	61	0	
501	502	1656	26 Agustus 2023	62	63	60	67	61	0	0	0	67	64	
502	503	1249	28 Agustus 2023	0	0	64	0	69	61	0	0	61	61	
503	504	1070	28 Agustus 2023	62	62	0	0	0	67	0	68	64	0	
504	505	1037	28 Agustus 2023	0	0	63	65	0	0	0	61	61	0	

505 rows × 16 columns

Figure 1. Data frame Dataset

Figure 1 shows the results of the dataset import displayed in the form of a dataframe.

Preprocessing

At this stage, the Dataset will be processed by checking for missing or missing values as well as duplicate data. Because a priori algorithms require data that is of the same shape, an encoding process is necessary. In this study, missing grades have been checked using the pandas module. Missing values can be seen in Table 4.

Table 4. Number of Missing Values in the Dataset

```
#Cek Missing Value
df.isna().sum()
```

```
Id_Transaksi          0
Id_pelanggan          0
Tanggal_transaksi     0
Roti Burger           0
Roti Burger Warna     0
Roti Hotdog           0
Roti Hotdog Warna     0
Donat Deroti          0
Donat Deroti Warna    0
Donat Eco             0
Donat Unyil           0
Donat Semut           0
Roti Semut            0
Mini Pao              0
Roti Goreng           0
Subtotal              0
dtype: int64
```

Based on Table 4, the dataset used in the study is quite clean, because the check shows that there is no missing value. Next, duplicate grades are checked.

Table 5. Number of Missing Values in the Dataset

```
#Cek Duplikat Data
df.duplicated().sum()
```

```
0
```

Based on Table 5 after checking duplicate values using pandas, there are no duplicate values.

Variable Selection

Of the sixteen (16) unique attributes, twelve (12) attributes will be used, namely the various types of products sold.

The variables that will be used in this dataset are burger buns, colored burger buns, hotdog buns, colored hotdog buns, roti donuts, colored roti donuts, eco donuts, unyil donuts, ant donuts, ant buns, mini pao, and fried buns.

```
data = df.iloc[:, 3:15]
data
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automat
  and should_run_async(code)
```

	Roti Burger	Roti Burger Warna	Roti Hotdog	Roti Hotdog Warna	Donat Deroti	Donat Deroti Warna	Donat Eco	Donat Unyil	Donat Semut	Roti Semut	Mini Pao	Roti Goreng
0	0	31	0	0	34	0	31	0	0	33	0	30
1	30	0	0	32	31	0	35	0	40	0	38	40
2	0	0	30	35	0	40	40	30	0	37	40	0
3	0	0	37	0	32	31	34	31	0	0	40	0
4	32	0	30	33	38	35	38	36	40	37	0	40
...	...	...	...	...	...	...	...	...	...	...	...	...
500	68	0	68	0	0	65	61	0	61	0	60	61
501	62	63	60	67	61	0	0	0	67	64	68	0
502	0	0	64	0	69	61	0	0	61	61	0	0
503	62	62	0	0	0	67	0	68	64	0	0	64
504	0	0	63	65	0	0	0	61	61	0	64	0

505 rows × 12 columns

Figure 2. Variable Selection

Figure 2 is the dataframe display of the variable to be used.

Encode Data

The data encoding method used here is One-Hot Encoding, One-Hot Encoding encodes these category variables into binary vectors with values 0 and 1, with one element per category valued at 1 (hot), and the other valued at 0 (cold).

Table 6. Proses Encoding

```
# Mendefinisikan fungsi pengodean panas untuk membuat data sesuai
def hot_encode(x):
    if x <= 0:
        return 0
    else:
        return 1

# Apply the hot_encode function to each element in the DataFrame
df_encoded = data.applymap(hot_encode)

# Update df with the encoded DataFrame
data = df_encoded
```

In Table 6, the process of transforming data into encode form.

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```
data
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` aut
  and should_run_async(code)
```

	Roti Burger	Roti Burger Warna	Roti Hotdog	Roti Hotdog Warna	Donat Deroti	Donat Deroti Warna	Donat Eco	Donat Unyil	Donat Semut	Roti Semut	Mini Pao	Roti Goreng
0	0	1	0	0	1	0	1	0	0	1	0	1
1	1	0	0	1	1	0	1	0	1	0	1	1
2	0	0	1	1	0	1	1	1	0	1	1	0
3	0	0	1	0	1	1	1	1	0	0	1	0
4	1	0	1	1	1	1	1	1	1	1	0	1
...	...	...	...	...	...	...	...	...	...	...	...	...
500	1	0	1	0	0	1	1	0	1	0	1	1
501	1	1	1	1	1	0	0	0	1	1	1	0
502	0	0	1	0	1	1	0	0	1	1	0	0
503	1	1	0	0	0	1	0	1	1	0	0	1
504	0	0	1	1	0	0	0	1	1	0	1	0

505 rows × 12 columns

Figure 3. Encoding Results

Figure 3 shows that the encoding results have been successfully carried out.

Modeling

This method helps in finding common buying patterns, finding frequently purchased products together and making the right suggestions for an effective sales or marketing strategy.

```
#Menentukan nilai minimal support = 0.16 => 16%
support = 0.16
frq_items = apriori(data, min_support = support, use_colnames = True)

#Menentukan nilai minimal confidence = 0.6 => 60%
metric ="lift"
min_threshold = 1 #Lift Ratio

rules = association_rules(frq_items, metric =metric, min_threshold = min_threshold)
rules.sort_values('confidence', ascending =False, inplace=True)
rules[rules["confidence"] >=0.6]
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automa
  and should_run_async(code)
/usr/local/lib/python3.10/dist-packages/mlxtend/frequent_patterns/fpcommon.py:110: DeprecationWarning: DataFrames with non-bool types result in
  warnings.warn(
```

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction	zhangs_metric
60	(Roti Goreng, Donat Deroti)	(Donat Eco)	0.269307	0.538614	0.162376	0.602941	1.119431	0.017324	1.16201	0.146011

Figure 4. Results of Analysis Rules

Based on Figure 4, the results of the analysis obtained with a minimum support value of 0.16 or 16% and a minimum confidence value of 0.6 or 60% are the best results from several experiments that have been carried out. A relationship rule to combine three valid sets of items was successfully found with these values. The highest confidence value is 60%, indicating that the rule is often bought together and has a high level of confidence. Therefore, the results of the relevant and significant data analysis have been produced by the minimum support and minimum confidence values.

Website Creation Using Streamlit

Export the encoded frame data into CSV format as shown in Figure 3. This will be imported into a priori's algorithm on the website.

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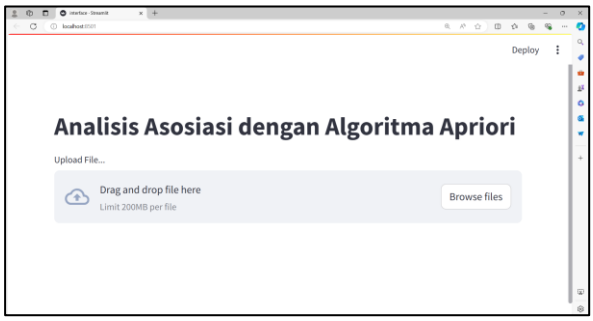

Figure 5. Dashboard Display

Figure 5, is the display of the website interface of the priori algorithm that has been created. Where the user is required to import a CSV file.

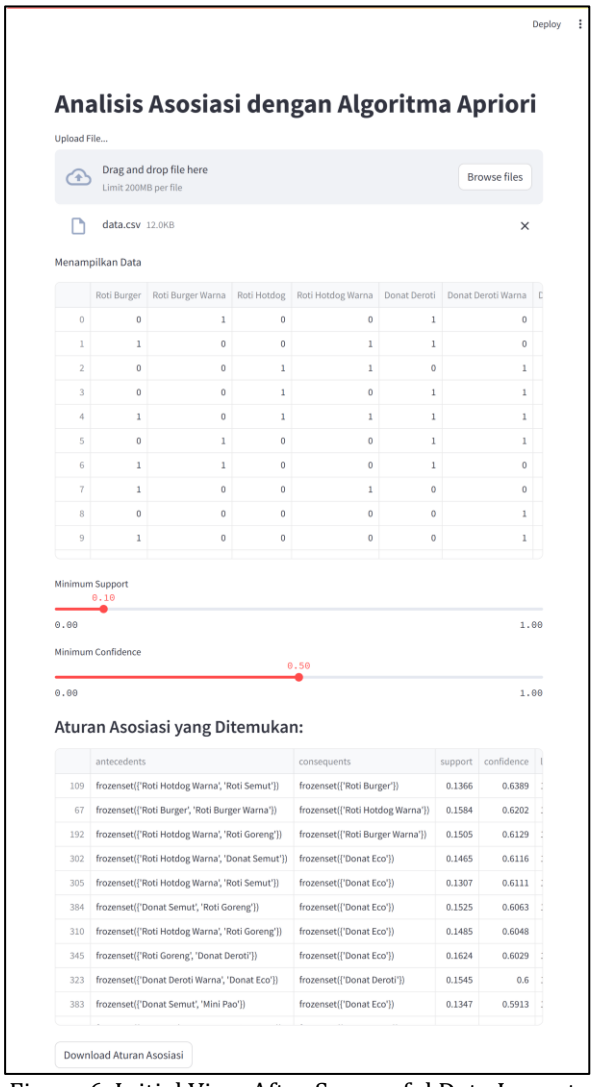

Figure 6. Initial View After Successful Data Import

Figure 6 is the initial view when the data is successfully imported, but the user can set the minimum support and minimum confidence values.

Figure 7. Dashboard View When Setting Minimum Values

Figure 7 shows the results of the analysis with a minimum support of 16% and a minimum confidence of 60% resulting in the same association rule as the previous analysis, namely "If you buy Fried Bread and Bread Donuts, then buy Eco Donuts" with a lift ratio of > 1, indicating the validity of the rule. These findings can be used to develop efficient production methods and implement product bundling strategies such as Fried Bread, Bread Donuts, and Eco Donuts to maximize profits.

CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the analysis of the Apriori algorithm at PT JR Pangan Semesta, it was found that bread and donut products are often purchased together with a minimum support of 16%, a confidence of at least 60%, and a lift ratio of more than 1, indicating the validity of the association rules. The company can focus production on product combinations such as Roti Goreng, Deroti Donuts, and Eco Donuts, as well as implement bundling promotions with the highest confidence to increase purchases and average transaction value.

This strategy will help in demand forecasting, inventory management, and profit increase.

Suggestion

This study used 13 months of sales transaction data, but the limited amount of data limited the use of the minimum support value. Further research can use a larger dataset to explore various minimum support values, so that the results of the analysis of buying patterns become more accurate.

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