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Application of Data Mining for Ceramic Sales Data Association Using Apriori Algorithm

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A B S T R A C T

This research is conducted to provide an understanding of consumer purchasing patterns at CV. Sukses Bersama by applying data mining using the association rules method and the Apriori algorithm to identify the relationships between one item that influences other items within a ceramic sales dataset at CV. Sukses Bersama. This information is expected to serve as a foundation for improving sales strategies, optimizing customer satisfaction, and expanding the company's market share. The Apriori algorithm is a popular algorithm implemented to identify association rules in data mining. The Apriori algorithm was chosen due to its ability to efficiently identify association rules and its good scalability in handling large datasets. This research begins with the collection of ceramic sales data, followed by data preprocessing to clean and prepare the data. The Apriori algorithm is then applied to discover the association rules, which generate two matrices: support and confidence, and the results are subsequently evaluated. This research was conducted using Google Colaboratory, a web application that is a cloud-based platform provided by Google to run Python code. The results of the study show that the Apriori algorithm can depict significant association structures between different ceramic brand types in the sales data of CV. Sukses Bersama. The calculation results show that the rule has the maximum support and confidence value, namely 67% support value and 84% confidence value in the rule "if you buy the DIAMD brand, you will buy the TOTAL brand".

1. Introduction

The decline in sales was due to a lack of innovation in its products, causing Nyonya Meneer to incur significant debt and be declared bankrupt by the District Court (PN) in Semarang in 2017. Similarly, the poor management of sales data led to the bankruptcy of 7-Eleven, as the company was burdened by high operational costs that it could not sustain [1].

Due to poor sales data management, many companies face financial collapse. This situation creates an urgent need to improve data governance. The research aims to optimize the use of sales data, thereby increasing efficiency, accuracy, and supporting strategic decision-making to prevent future business losses.

Therefore, sales data is required to serve as a reference source that can be utilized in the business decision-making process. However, the majority of sales data is merely stored as documents and is not used optimally, being limited only to the creation of sales reports [2]. The increase in product sales within a company can be achieved by using data mining methods [3]. Data mining is the process of processing and identifying valuable information from a database by applying techniques from machine learning, statistics, mathematics, and artificial intelligence [4].

By applying data mining, companies can collect data on customers, transactions, and products, which can be used to determine customer purchasing patterns, identify the best-selling products, and discover new market opportunities. One of the commonly used methods in data mining is the data association technique, which is utilized to identify relationships between items in a transaction using the Apriori algorithm.

As time progresses, the implementation of data mining has been amplified across various disciplines, including business and commerce [5]. This study will discuss a case regarding the implementation of data mining for the association of ceramic sales data at CV. Sukses Bersama.

CV. Sukses Bersama is a company operating in the ceramic sales sector. As a retail business specializing in building materials with a focus on ceramic sales, the company often faces highly competitive market conditions. To maintain its sales reputation within the ceramic industry, the company needs to adopt preventive measures to understand market trends and ensure that sales meet expected outcomes. The primary focus of this study is to facilitate the company's management in decision-making and to provide insights into which items are frequently purchased together, enabling all sales transactions to align with customer needs.

This study employs a quantitative approach by implementing the Apriori Method. The Apriori Method is utilized in data mining to identify association rules within the data, commonly referred to as Association Rule Mining (ARM) [6]. The data used in this study consists of ceramic sales data from CV. Sukses Bersama. The results of this research are expected to reveal consumer purchasing patterns and the extent to which one item influences another. Furthermore, the findings can be utilized by CV. Sukses Bersama to enhance marketing strategies and increase profitability.

Results of the research [7] This study examines the application of the Apriori algorithm in analyzing library book borrowing data. The results reveal a pattern indicating that students who borrow books in the project management category tend to also borrow books in the programming category, with a confidence value of 81%. Additionally, a similar tendency is observed among students who borrow books in the expert systems category, as they are also inclined to borrow books in the programming category, with a confidence level of 77%. These findings illustrate the emergence of relational patterns between specific book categories, which can assist in optimizing library collection management.

Results of the research [3] The use of the Apriori algorithm has proven effective in supporting the development of marketing strategies for the distribution of snack products. The research findings indicate that the best-selling snacks at Usaha Rumah DAPOERIN'S include *putu ayu*, *lontong*, *piscok*, and *risoles*. Based on the identified association rules, purchases of *putu ayu* are often followed by purchases of *lontong*, with a support level of 50% and a confidence level of 88%. Similarly, customers purchasing *risoles* or *piscok* tend to also purchase *lontong*, with relatively high support and confidence values.

The study [8] on the application of the Apriori algorithm focuses on determining association techniques by calculating the support value of each item. If the support value meets the standard threshold, the item becomes part of the frequent itemset. The Apriori method continues generating frequent itemsets until no new candidates can be formed. The next step involves calculating the confidence value of the frequent itemsets, and those meeting the minimum confidence threshold are considered valid. The implementation of the Apriori algorithm at Toko Prima Motor Sidomulyo resulted in 13 association rules that met the minimum support and confidence thresholds. These include 2 association rules for Suzuki, 6 for Honda, and 5 for Yamaha, all

satisfying the minimum confidence parameter of 50%. These results can assist the store in identifying spare parts that require higher inventory levels and minimizing stock shortages.

The study on the use of the Apriori method in data mining sales transactions of food and beverages at LA Steak Restaurant shows that with a support value of 3% and a confidence value of 80%, significant association patterns were identified. 44 association rules were generated[9]. It demonstrates efficiency in accelerating the formation of itemset combination structures derived from food and beverage sales at LA Steak Restaurant. This combination structure can serve as an important information system for managing inventory of food and beverage supplies and enhancing sales by offering discounts on related menu packages. With this research, restaurant owners can easily formulate sales strategies by increasing stock of frequently ordered food and beverages together, thereby reducing the likelihood of customer disappointment when the ordered menu is unavailable.

The research [10] titled "Implementation of Data Mining Using the Apriori Algorithm to Improve Drug Sales Patterns" shows that the application of the Apriori method within the system successfully identified frequently occurring item combinations and generated association structures from these item combinations, with a support value of 20% and a confidence value of 50%. This application produces data on the types of drug products that are frequently purchased together by consumers, thereby supporting the analysis of drug sales patterns.

The results of the calculations and analysis from the implementation of data mining using the Apriori method revealed 142 association rules that met the thresholds of support greater than 10% and confidence of 50%, based on the sample data of consumer sales [11]. After testing using RapidMiner, it was found that products preferred by consumers have a minimum confidence value above 50%. These results indicate a relationship between products that are frequently purchased together, which can be leveraged for more effective marketing planning and product management.

The study on the application of the Apriori method in data mining for product sales at Indomaret Galang Kota demonstrates that the implementation of the Apriori algorithm for analyzing product sales shows the highest support and confidence values, with a standard confidence ≥ 25%. Consequently, the identified association rule is product code = A, F, with the product names *Potabee Chip Bbq 35g* and *Plattos Snack S.pg 30g*, yielding a confidence value of 33% [12]. Based on these results, it can be concluded that Indomaret can group the most frequently purchased items together on the same shelf, allowing customers to save time while shopping.

The research titled [13] "*Application of the Apriori Method for Counter Sales Analysis Using a Web System*" conducted three system tests by adjusting the minimum support and confidence parameters. Two association patterns were identified, which would later be used for promotional item packages. Each item package includes two quotas from the three trials, with a confidence standard of 90%. The suggested combination of items, according to the author, is: *Voucher Tri 1.5 GB* and *Voucher Tri 1.5 GB mini*, with a confidence value of 99.07%.

The final study compares two calculations using Weka, specifically Apriori and FP-Growth, which generated 10 association rules with different combinations, including 2 combinations that met the minimum support. The results indicate that if clients purchase P390 and P459, the lift value is 85%, the confidence is 98%, and the lift ratio is 2.03. On the other hand, if consumers do not purchase P46 and P74, it can be confidently predicted they will not purchase P45, with a lift value of 85%, confidence of 100%, and a lift ratio of 1.08. Based on the analysis of both algorithms, it can be concluded that the Apriori algorithm provides a more optimal confidence value for association rules than the FP-Growth algorithm, due to the lower standard support value of item combinations in the association rules across all sales transactions [14]. This is highly beneficial for PT Agung Toyota Denpasar in making optimal orders and avoiding both stock shortages and overstocking of goods.

2. Method

The research methodology refers to the steps or work structure that are systematically followed to achieve the expected objectives of the study. These stagess provide clear guidance for conducting the research. Below are the research stagess applied in this study, as shown in Figure 2.1.

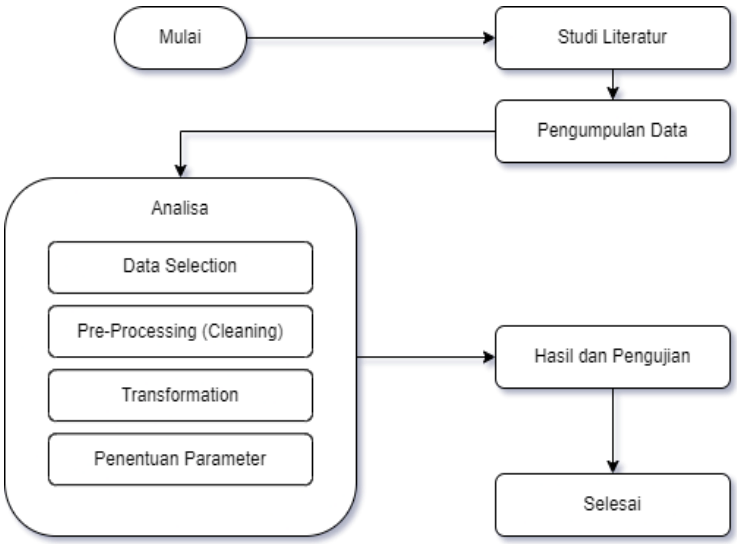

Figure 2.1 Research Methodology Flowchart

A. Literature Study

The research stagess involve investigation and analysis of literature or sources such as journals and scholarly works to support understanding and strengthen the theoretical foundation related to the research topic being studied.

B. Data Collection

This study collects data through a data acquisition process according to the research requirements. The data analyzed consists of ceramic sales data from CV. Sukses Bersama, which serves as the primary source to support the research.

C. Analysis

The Data Analysis stages will involve the data mining process commonly referred to as KDD (Knowledge Discovery in Database)[15] This involves mining and analyzing data sets to extract useful information and knowledge. The details of the analysis will be explained as follows :

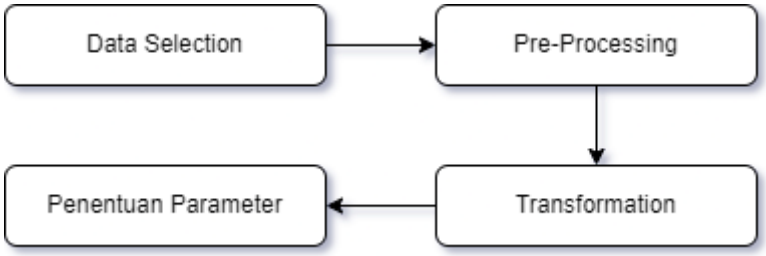

Figure 2.2 Analysis Diagram

a. Data Selection

Data selection is a stages of data analysis where relevant data is selected from the available data set. [16], representative and has accurate and meaningful quality for use in further analysis. In ceramic sales data there is an attribute called TGL which will later be processed to identify association patterns between dates.

b. Pre-Processing (Cleaning)

Pre-processing or what is often called data cleaning will involve the process of cleaning data from noise or irrelevant information [17]. This includes removing duplicates, handling missing values, and addressing outliers. The primary goal of pre-processing is to prepare the data so it can be used effectively before proceeding to the next stages.

c. Transformation

Transformation is the process of converting data into a relevant format or grouping [17]. This starts with converting the data into transaction format, followed by the formation of itemsets.

d. Parameter Determination

Determining parameters is a crucial step in the Apriori algorithm. The primary parameter that needs to be set is the minimum support, which serves as the threshold for itemsets to be considered significant.

D. Implementation

Implementation is the stage of executing and realizing the analysis and design conducted previously. At this stage, it can be determined how the algorithm performs as expected. This study implements the association method using the Apriori algorithm with the Google Colab tool, using the Python programming language.

E. Results and testing

After implementation, the next step is the result processing and testing stages. At this stage, the support and confidence values are calculated from the ceramic sales data to obtain analysis results that illustrate the association patterns between the items.

3. Results and Discussion

This study uses ceramic sales data from CV. Sukses Bersama. The data consists of 15,897 records with 10 relevant attributes. Detailed information regarding the data used in this study is presented in Table 3.1 :

Table 3.1 Research Data

NAME	GOODS NAME	DATE	NOTA	QTY	SATUAN	CODE	GOODS CODE	POF	BRAND
GUNUNG MAS JAYA, TOKO	FRISTA YELLOWISH 25X40	2022-08-01	JL*9946.3810	90	DUS	235	1297	BARI	MST
RANGKUTI KERAMIK, TOKO	KAWA STONE ABU 40X40	2022-08-01	JL*5351.7786	78	DUS	445	7505	BARI	PICASSO
CAHAYA PELANGI, TOKO	FOCUS GREYISH 25X25	2022-08-01	JL*1417.1031	40	DUS	107	4525	BARI	MAJESTIC
CAHAYA PELANGI, TOKO	HEXOS GREY KW2 40X40	2022-08-01	JL*1417.1031	40	DUS	107	4525	BARI	MST

CAHAYA PELANGI, TOKO	CENTRO BIRU 25X25	2022-08-01	JL*1417.1031	40	DUS	107	4525	BARI	GEMILANG
ISU MANDIRI, TOKO	CENTRO BIRU 25X25	2022-08-01	JL*9968.9007	49	DUS	468	3828	ROBBY	GEMILANG
SEMANGAT BANGUN, TOKO	CENTRO BIRU 25X25	2022-08-01	JL*2606.9513	48	DUS	230	9194	BARI	EXCELENTE
TERA UTAMA STEEL, TOKO	HEXAGON ABU-ABU 25X40	2022-08-01	JL*6525.6888	14	DUS	816	2273	ROBBY	EXCELENTE
fCAHAYA BARU, TOKO	HEXOS BROWN KW2 40X40	2022-08-01	JL*8297.3056	80	DUS	784	5517	BARI	EXCELENTE

A. Cleaning Data

The data cleaning process in this study uses Google Colaboratory, a cloud-based platform provided by Google for running Python programming. Data cleaning is used to remove unnecessary spaces at the beginning or end of strings that may cause discrepancies during calculations. Below are the results of the data cleaning process in this study:

	NAMA	NAMABARA	TGL	NOTA	QTY	SATUAN	KODE	KODEBARA	POF	MERK
0	GUNUNG MAS JAYA, TOKO	FRISTA YELLOWISH 25X40	2022-08-01	JL*9946.3810	90	DUS	235	1297	BARI	MST
1	RANGKUTI KERAMIK, TOKO	KAWA STONE ABU 40X40	2022-08-01	JL*5351.7786	78	DUS	445	7505	BARI	PICASSO
2	CAHAYA PELANGI, TOKO	FOCUS GREYISH 25X25	2022-08-01	JL*1417.1031	40	DUS	107	4525	BARI	MAJESTIC
3	CAHAYA PELANGI, TOKO	HEXOS GREY KW2 40X40	2022-08-01	JL*1417.1031	40	DUS	107	4525	BARI	MST
4	CAHAYA PELANGI, TOKO	CENTRO BIRU 25X25	2022-08-01	JL*1417.1031	40	DUS	107	4525	BARI	GEMILANG

Figure 3.1 Data Cleaning Results

B. Frequency

After the data cleaning process, the next step is the Frequency process, where the goal is to calculate the frequency of an item or combination of items (itemsets) that frequently appear in sales or transactions related to the brands in the dataset used in this study. The data includes the quantity of each brand sold in a single day of transactions, and brands with no transactions on that date are marked as zero. Below are the results from the frequency process :

MERK / TGL	ALBATROS	ANTARES	DIAMD	EFL	EIFFEL	EXCELENTE	EXCELSIOR	FORTUNER	G M	G T	...	HRM	MAJESTIC	MCC	MST	MYLEANO	PICASSO	PISSCASO	RAYMOND	TOTAL	VALENSIA
2022-08-01	0.0	97.0	27.0	4.0	163.0	100.0	0.0	96.0	175.0	216.0	...	61.0	108.0	129.0	19.0	0.0	93.0	100.0	140.0	0.0	36.0
2022-08-02	122.0	3.0	0.0	224.0	68.0	96.0	0.0	0.0	57.0	198.0	...	42.0	2.0	0.0	95.0	130.0	58.0	78.0	114.0	13.0	0.0
2022-08-03	33.0	99.0	99.0	164.0	27.0	142.0	0.0	248.0	39.0	168.0	...	0.0	148.0	96.0	17.0	82.0	84.0	91.0	0.0	0.0	0.0
2022-08-04	0.0	293.0	0.0	225.0	62.0	101.0	48.0	153.0	0.0	134.0	...	5.0	47.0	41.0	54.0	99.0	116.0	70.0	141.0	78.0	43.0
2022-08-05	188.0	0.0	178.0	87.0	42.0	79.0	17.0	44.0	75.0	80.0	...	114.0	57.0	373.0	87.0	47.0	0.0	26.0	90.0	107.0	25.0

Figure 3.2 Results of Frequency Calculation

C. Transformation (Encoding Data)

Next, the Transformation/Encoding process is used for association analysis in the Apriori algorithm. The goal is to convert quantitative data into binary data, which has two values: 0 and 1, commonly referred to as binary encoding. Encoding data into binary format allows computers to store, process, and transfer data efficiently, facilitating the computation process. The quantity data of ceramic brands, which was summed in the previous process, is transformed into the number 1, while ceramic brands with a quantity of zero are represented as 0. Below are the results of the transformation process

MERK TGL	ALBATROS	ANTARES	DIAMD	EFL	EIFFEL	EXCELENTE	EXCELSIOR	FORTUNER	G M	G T	...	HRM	MAJESTIC	MCC	MST	MYLEANO	PICASSO	PISSCASO	RAYMOND	TOTAL	VALENSIA
2022-08-01	0	1	1	1	1	1	0	1	1	1	...	1	1	1	1	0	1	1	1	0	1
2022-08-02	1	1	0	1	1	1	0	0	1	1	...	1	1	0	1	1	1	1	1	1	0
2022-08-03	1	1	1	1	1	1	0	1	1	1	...	0	1	1	1	1	1	1	0	0	0
2022-08-04	0	1	0	1	1	1	1	1	0	1	...	1	1	1	1	1	1	1	1	1	1
2022-08-05	1	0	1	1	1	1	1	1	1	1	...	1	1	1	1	1	0	1	1	1	1

Figure 3.3 Transformation Process Results

D. Implementasi Apriori

The Apriori Algorithm is an association method in data mining aimed at identifying itemsets that frequently appear together within a dataset. The fundamental concept of this algorithm is :

1. Using the principles of support and confidence to identify items that appear with sufficiently high frequency and meet the minimum support threshold in the transaction database [18].
2. Eliminating itemsets with low support levels in accordance with the predefined minimum support threshold [18]. Support represents the frequency at which an itemset appears in the data, while confidence indicates the likelihood of an itemset appearing together compared to other itemsets.

Association Rules is a method for identifying combinations of items that appear simultaneously [19] as well as identifying the relationship between one item and its influence on other items within a dataset. The values for support, confidence, and lift ratio can be calculated using the following formulas:

The main methodology in the implementation of the association is divided into three stages:

1. High Frequency Pattern Analysis
   This stage identifies combinations that meet the standard criteria for the support value. Support measures how frequently an association rule appears in the dataset and is calculated using the following formula:

$$\text{Support (A)} = \frac{\sum \text{Transaksi Mengandung Item A}}{\sum \text{Transaksi}} \times 100\% \quad (1)$$

Information:

∑ Transactions Containing Items A = The number of transactions containing item A

∑ Transactions = Total transaction of all items

In equation 2, two items are formulated for the support value.

$$\text{Support (A,B)} = P(A \cap B) = \frac{\sum \text{Transaksi Mengandung Item A,B}}{\sum \text{Transaksi}} \times 100\% \quad (2)$$

Information:

∑ Transactions Containing Items A,B = Number of transactions containing items A and B

∑ Transaction = Total transactions of all items

Meanwhile, in equations 3 and 4 three items are formulated for the support value.

$$\text{Support (A,B, and C)}=P(A\cap B\cap C)=\frac{\sum\text{Transaksi Mengandung Item A,B, dan C}}{\sum\text{Transaksi}}\times 100\% \quad (3,4)$$

Information:

∑ Transactions Containing Items A,B and C= Number of transactions containing items A,B and C

∑ Transaction = Total transactions of all items

2. Formation of Assoication Rules
After successfully identifying high frequency patterns, the next process is to find association rules that meet the minimum criteria for confidence in association rules A → B and A → B → C. Confidence is done to measure how often the association rules are proven correct. The confidence value of rule A → B is calculated using equation 5.

$$\text{Confidence } (A|B)=P(A|B)=\frac{\text{Support } (A\cup B)}{\text{Support A}}\times 100\% \quad (5)$$

Information:

Support (A∪B) = Support value containing both items A and B

Supoort (A) = Support value containing item A

The confidence value of the rule A → B → C is obtained from equation 6.

$$\text{Confidence } (A|B|C)=P(A|B|C)=\frac{\text{Support } A\cup B\cup C}{\text{Support A}}\times 100\% \quad (6)$$

Information:

Support (A∪B∪C) = Support value containing all three items A, B and C

Supoort (A) = Support value containing item A

3. Lift Ratio
Lift ratio in Association Rule serves to measure the significance of the strength of the association based on the support and confidence values, determining whether a rule is valid. The results of the association rules are useful for identifying emerging patterns that evaluate the relationship between two items within the association rule, which will subsequently be used as a basis for decision-making. Below is the formula:

$$\textit{Lift ratio} = \frac{\text{Confidence } (A, B)}{\text{Benchmark Confidence } (A, B)}$$

Information:

Confidence (A,B) = Confidence from items A and B purchased simultaneously

Benchmark Confidence = Minimum confidence value threshold

The benchmark confidence value itself is obtained using the following formula:

$$Benchmark\ Confidence = \frac{Nc}{N}$$

Information:

Nc = Total transactions using the item as a consequent

N = Total of all transactions in the database

A Rule or combination of itemsets is considered valid and accurate if the lift ratio value > 1

In this study, the minimum support value provided is 0.25, which is used as the threshold for identifying frequently occurring itemsets. The next step is to calculate the association rules by identifying patterns from the frequent itemsets and measuring the strength of the relationships between items. This process helps uncover significant relationships in the data. The implementation was carried out using specific coding designed to effectively generate association rules. Below is the code for setting the minimum support and implementing association rules:

```
Support & Association Rules
# Menentukan Support Minimum
Frequent_itemsets = apriori(group_sets, min_support=0.25,us_colnames=True)
# Membuat Association Rules
Rules = association_rules(frequent_itemsets, metric='lift', min_threshold 1
```

After determining the association rules, the next step is the filtering process for the association rules. In this study, filtering was performed based on a lift value of 1. A combination or itemset is considered valid if the lift ratio is greater than 1 and the confidence is 0.8, as this criterion provides the most optimal iteration results. Below is the filtering code used in this study:

```
Lift Rasio & Confidence
# Membuat Filter Nilai Lift Ratio = 1 dan Confidence = 0.8
Rule = rules[ (rules['lift'] >= 1) & (rules['confidence'] >= 0.8) ]
Print(rule)
```

It can be observed that the DIAMD brand, as the antecedent, produces TOTAL as the consequent with a support of 67% and a confidence of 84%. This indicates that 67% of all transactions contain both DIAMD and TOTAL, and 84% of transactions involving the DIAMD brand also include TOTAL. In the second row, the combination of DIAMD and TOTAL as the antecedent yields VALENSIA as the consequent with a support of 55% and a confidence of 81%. This means that 55% of all transactions involve these three items, and 81% of transactions containing DIAMD and TOTAL also include VALENSIA. Table 3.2 presents the results of the data analysis using the Apriori Association method :

Table 3.2 Results of the Apriori Association Process

No	Attecendants	Consequente	Support	Confidence
1	DIAMD	TOTAL	67%	84%
2	DIAMD, TOTAL	VALENSIA	55%	81%
3	ANTARES, DIAMD, TOTAL	VALENSIA	44%	82%

4	GM, ANTARES, ALBATROS, TOTAL	VALENSIA	33%	81%
5	DIAMD, GM, ALBATROS, EXCELENTE, ANTARES	RAYMOND	28%	84%

4. Conclusion

Referring to the conducted research, it can be concluded that the application of data mining for sales data association using Google Colab yielded significant results. The findings indicate that the rule with the highest support (67%) and confidence (84%) is: "*If a customer buys the DIAMD brand, they are likely to purchase the TOTAL brand.*" Conversely, the lowest result was obtained with a support of 28% and a confidence of 84%, which applies to the rule: "*If a customer buys the DIAMD, GM, ALBATROS, EXCELENTE, and ANTARES brands, they are likely to purchase the RAYMOND brand.*" These results illustrate the variation in the strength of relationships between items in the sales data analyzed using the Apriori algorithm.

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