

Market Basket Analysis Of Grocery Store Using Apriori Algorithm

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Abstract—With the boom in the retail industry, companies must constantly innovate if they want to keep holding the top spots in their respective markets. These Industries generate an enormous amount of data on daily. This data in its raw state is meaningless and we cannot derive any meaningful information from it. With this gigantic amount of data being generated and stored on daily basis, there is a need to make this data useful and gain meaningful insights. It is essential to recognize consumer purchasing trends. A technique called market basket analysis enables us to examine consumer behavior based on relationships between different products or sets of product. It is a method used in the marketing sector for data mining. Market basket research reveals the purchasing habits of consumers by identifying significant connections between the things they include in their shopping baskets. In this proposed system we are implementing market basket analysis using Apriori algorithm which provides association of different items in a grocery store.

Index Terms—Market Basket Analysis, Apriori algorithm, Data mining, Transaction data, Association Rule

I. INTRODUCTION

Nowadays, customers may choose from a variety of solutions in practically every industry. When a customer needed to make a purchase in the past, he could only pick an item from the store's catalogue. With the development of contemporary technology and globalisation, opportunities have expanded quickly. Customers may now pick from a variety of goods and changes. It's no longer an issue with geographic restrictions based on by the climate and other factors. These items are today viewed as commonplace items, while once being considered luxury goods. All of this gave the businesses what today seems to be boundless potential. Nonetheless, this seemingly endless potential gave rise to a number of fresh rivals entering the market. Retail businesses look for marketing approaches to entice new clients or retain existing ones. Only contemporary marketing techniques that integrate effective advertising and careful product design would be able to resolve the problem. In the retail sector, the idea of market basket analysis has grown significantly in significance. In order to find links and relationships between products frequently bought together, client purchase patterns must be analysed. This study enhances inventory control, aids targeted marketing efforts, and offers insightful information regarding consumer behaviour. This paper focuses on conducting a market basket analysis of a specific grocery store using the Apriori algorithm. The grocery store dataset contains information

about customer transactions, including the items purchased and their quantities. By applying the Apriori algorithm, we aim to discover frequent itemsets and association rules within the dataset. The Apriori algorithm, a well-known association rule mining technique, is utilized due to its effectiveness in handling large transactional datasets. This algorithm employs a two-step process: first, it identifies frequent itemsets (sets of items that frequently appear together in transactions), and then it generates association rules based on the discovered itemsets. This study aids shop owners in making a number of crucial business decisions, such as developing catalogues, identifying loyal customers, and boosting product sales. Identification of linkages between purchased commodities is the primary objective of MBA. Grouping comparable goods can all help businesses organise the positioning of their products on shelves.

II. LITERATURE SURVEY

[1] Maliha Hossain, A H M Sarowar Sattar, Mahit Kumar Paul, (2020).Market basket research sheds information on the customers' purchasing habits by revealing important connections between the products in their shopping baskets. It facilitates decision-making while also fostering trade among various commercial organisations. Apriori is the most often used technique for mining frequently occurring item sets. To recognise regularly occurring itemsets, a specific minimal support level must be obtained for all methods. Nevertheless, reducing the basic support will lead to a massive quantity of potential sets, requiring a substantial amount of computation. By restricting the items of the dataset to the most prominent commodities, this study offers a strategy to avoid this intensive calculation.

[2]I.D. Widodo, H. Ulfah and K.N. Anggraeni (2021). Due to the selling trade's rapid expansion, traders and investors constantly face stress to create new products in order to preserve their competitiveness. One method to achieve this is to improve customer service while still meeting marketing goals. Recognizing customer purchasing trends is crucial. Due to the retail industry's rapid growth, business owners must constantly innovate to remain competitive. One method to achieve this is to improve customer service while still meeting marketing goals. Recognizing customer purchasing trends is crucial. This essay will explain the creation of a new strategy

demonstrates on subconscious consumers purchasing patterns. The Association Rule-Market Basket Analysis method is used to identify similarities in consumer buying behavior.

[3] In publications that were released between 2000 and 2011, S.H. Liao, P.H. Chu, and P.Y. Hsiao investigated data mining techniques and applications. In addition to having a tendency to become more expert-oriented, these strategies also tend to have a more problem-centered application. Complex algorithms have been created as a result, and are currently employed in a variety of academic disciplines, including computer engineering, medicine, maths, geology and space.

[4] According to a 2009 paper by E. Ngai, L. Xiu, and D. Chau, data analysis in the management of customer relations is an emerging idea that helps with the research, attraction, retention, and expansion of a client. Client preservation and development are essential to forging a durable, satisfying client relationship that is highly beneficial in maximising the company's profit. Thanks to data mining, the market sector has a lot of prospects. Modelling and segmentation are the three most often used methods for client identification. Techniques for enhancing the customer experience include segmentation, modeling, association finding, pattern identification, forecasting, etc.

[5] In 2016, Solnet et al. Looked at the potential of market basket research to boost hotel revenue. The most enticing services and products that may bring guests to hotels, please them, and encourage them to make more purchases were researched and identified by the researchers. This tactic might increase sales without expanding the clientele.

[6] Kaur and Kang (2016). Intriguing similarities from a data were revealed by this effort, that also provided upcoming frequent patterns and the right techniques to spot outliers. By providing a novel viewpoint on how to consider database alterations in relation to mining static database, that work shows progress.

[7] G. Kapadia 2015 saw the completion of a research that looks at customer behaviour patterns in relation to lifestyle store items. It provides crucial details on the basket's construction. This research helped in product selection, inventory management for the most likely to sell products, marketing of the most likely to sell items, discounts for loyalty programmes, and cross-selling. One of the drawbacks of this study was that it could only focus on one shop in a specific location. Data mining techniques are widely applied in the educational sector.

[8] Aiman Mushtaq 2015's study emphasizes the ways that data analysis in retail may increase the investment's return or net profit, improve customer relationship management, perform better market research, build better marketing tactics, reduce wasteful expenditure, etc. Many tactics have been implemented to mining the data for marketing purposes and to advance organisational goals as the volume of data grows everyday.

[9] In a study on building predictive models using MBA, Roshan Gangurde discovered that by utilising MBA to build product bundles in a business store, we are leveraging past purchase behaviour to anticipate future purchase behaviour,

which is a predictive model. He also concluded that superior retailers may use market basket analysis to increase market basket value, provide more lucrative advertising and promotion, and do much more. The research also advocated for the development of intelligent prediction models in order to provide association rules that could be included into recommendation systems to enhance their usefulness.

[10] In trying to foresee the stock exchange from economic news, S.S. Umbarkar and S.S. Nandgaonkar employed association rule mining in June 2015. Predictions depend on closing stock prices and trend trading indicators.

[11] Raorane A.A, Kulkarni R.V and Jitkar B.D employed the Market Basket Analysis method, an association rule technique from data mining that is increasingly often and widely used. The support and confidence of the customers in purchasing related things had been used to analyse the frequent transactions made by the customers. Using this research, they discovered that there is some relationship between the items at the time of consumer purchase.

[12] In this study, Debaditya Barman and Nirmalya Chowdhury tried to design a method employing association rule mining to identify the most favoured and well-liked genres, which may be viewed as the trend in the movie industry. In our experiment, we were able to attain an 86.36 percent success rate, which is a respectable result given how unpredictable the movie industry is. They offered future potential in the following fields: One can look for other genres or break down an existing genre into subgenres to increase the likelihood that our predictions will be correct. Additionally, they can do study to identify characteristics of lucrative movie trends in terms of some certain genres, perhaps employing a psychological analysis of people's preferences for or interests in some particular kinds of movies.

[13] The authors, Samuel Musungwini, Tinashe Gwendolyn Zhou, Raviro Gumbo and Tinomuda Mzikamwi, of this study have made an effort to demonstrate the mathematical foundations and justification for incorporating both behavioural and demographic data when applying MBA to small-scale grocery stores. Because they think that in the end, computers will automate a lot of the job, but that this automation without a human comprehension of the underlying theory is risky, the authors purposefully picked straightforward examples. The results show that context-specific elements like product, price, place, and promotion can affect customers' perceptions of certain goods that make up a utility bundle and where they choose to purchase that priceless package.

[14] Instead of relying on textual information about the stocks, the authors', Shubhangi S. Umbarkar and Prof. S. S. Nandgaonkar used a method for predicting the stock market by simply taking into account share closing prices. As a result, fewer resources were needed to retrieve news information. The trading techniques take into account the technical trading indicators that were used to provide the best results. The technical trading indicator provides more appropriate decision-making. In a finite period of time, data mining techniques like association rule mining and the Naive Bayes algorithm

produced meaningful signals. By accepting the stock's accurate closing prices, it also improved the prediction system's accuracy.

[15] In this research carried out by Omprakash Chandrakar and Jatinderkumar R. Saini, a data mining application for higher education was provided. Association rule mining was used to examine how well students performed on their tests. The results of the upcoming test were predicted using the rules found by association rule mining. By highlighting the subjects on which they should concentrate more, this forecast may be utilized to direct the student at the very beginning of their semester.

III. PROPOSED SYSTEM

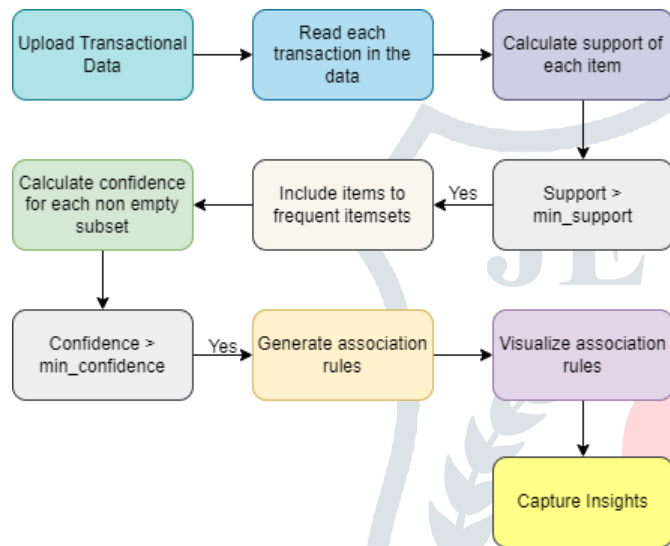


Figure (1): System Architecture

A. Methodology

1) *Data Collection*: The process of gathering and analysing data on relevant elements in order to analyse outcomes, test hypotheses, and fulfil stated research objectives is known as data collecting. The transaction data gathered for this research is acquired from a Grocery store from Pune. The dataset consists of 25 columns. The system reads the data using pandas library in python. The transaction data provided to the algorithm is of a single month. So the analysis will change according to different month's data.

Line	DATE/TIME	Name of the Invoice No	Invoice Date	Invoice No	Product No	Product Name	QTY	UNIT PRICE	TOTAL PRICE	DISCOUNT	NET PRICE	TAX	TOTAL TAX	AMOUNT PAID	PAYMENT MODE
1	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	4.12.2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure (2): Transaction Data Of March

2) *Data Preparation*: The act of obtaining and manipulating electronic data in order to provide valuable information is known as data processing. The alteration of information in any way that can be seen by an observer is known as data processing, a subset of information processing. For this study, in this process, the dataset is scaled down from 25 columns to 5 columns consisting of "Invoice Number", "Product name", "QTY", "Invoice Date", "Rate". One-hot encoding (also known as dummy coding) is used to convert categorical variables into a numerical representation that can be used by machine learning algorithms. Each category of a categorical variable is turned into a binary feature column using this method. If an observation falls into one of the categories represented by each column, the value is set to 1, whereas for all other categories, it is set to 0.

3) *Apriori Algorithm*: Python provides a built-in library for the Apriori algorithm and association rules named "apriori" and "association.rules" which are imported from 'mlx-tend.frequent.patterns'. The system utilizes these libraries to apply the Apriori algorithm to the processed data and generate association rules.

In this process, the system counts the support of each itemset, which represents the number of transactions that contain the itemset, after producing a list of candidate itemsets. The algorithm iterates by combining previously existing frequent itemsets to create new candidate itemsets until no more frequent itemsets can be generated.

The Apriori algorithm can be divided into two main phases:

1. *Generating frequent itemsets*: The Apriori algorithm searches the database for frequently occurring items. An item is considered frequent if it appears in a minimum threshold of transactions, known as the minimum support. By combining frequent items, the system creates candidate itemsets of size 2. Each candidate itemset is then examined for support, and the infrequent ones are discarded while the frequent ones are retained.

2. *Generating association rules*: After obtaining the frequent itemsets, the algorithm uses them to generate association rules using the 'association.rules' library. An association rule represents a relationship between two or more items that occur together in a transaction. The system generates potential association rules and calculates their support and confidence using the frequent itemsets. Confidence measures the strength of the association between the items, while support measures the frequency of the itemsets. The algorithm then filters out association rules that do not meet the user-specified minimum support and confidence thresholds.

4) *Data Visualization*: The rules generated table contains 9 columns out of which the system is interested in columns named "antecedents", "consequents", "support", "confidence" and "lift". Antecedents and consequents are the itemsets, which are sets of items and these rules can be described as the antecedent items implies the consequent items. The system uses these antecedents and consequents to visualize the association rules. Plotly library is one of the popular data visualization tool in python. Using sunburst chart of plotly,

the system portrays the association between antecedents and consequents. The system also generates different graphs which gives idea about the revenue generated by the items , frequent items purchased, and the most productive day of the month.

B. Workflow Of The Proposed System

The proposed system’s workflow can be understood by looking at how the various system participants carry out their duties one by one. The process starts by the store owner uploading the transactional dataset on to the platform. After the data is uploaded, the system goes through data preparation steps to prepare the dataset for additional processing. Once the data is processed, it is fed to the apriori algorithm which will generate the association rules. These rules are visualized using plotly library in python that provides with interactive visualizations and helps in capturing the most associated products. Once the rules are visualized, the store owner can take a glance over the graphs and make decisions that will be profitable for the store. This proposed approach gives the store owner useful insights into the buying habits of customers by implementing this methodical workflow. This will in return increase sales and improve customer satisfaction by optimising product positioning, implementing targeted marketing campaigns, and making data-informed decisions. This technique of market basket analysis has proven to be beneficial for the business and has been applied in various industries to enhance growth of their business.

IV. RESULTS AND DISCUSSION

To conduct this market basket analysis, we utilized a comprehensive dataset consisting of monthly transactional data from the grocery store. The dataset encompassed a sample size of over 10,000 data points, providing a substantial foundation for the analysis.

A. Analysis Of Frequent Itemsets

Figure(3) depicts the frequent itemsets(antecedents and consequents) with the help of minimum support value. Support, confidence, and lift values are the measures used in market basket analysis to quantify the strength of associations between items. Support quantifies how often a dataset’s itemsets occur. It displays the percentage of transactions that include a specific itemset.

$$\text{Support}(A) = \frac{\text{Number of transactions containing itemset } A}{\text{Total number of transactions}}$$

By calculating the conditional probability of the consequent given the antecedent, confidence quantifies the dependability or certainty of a rule. It shows how likely it is that after the antecedent has been acquired, the consequent will also be bought.

$$\text{Confidence}(A \rightarrow B) = \frac{\text{Support}(A, B)}{\text{Support}(A)}$$

Lift calculates the degree of association between the antecedent and the consequent while taking into account the likelihood that the latter would be purchased without taking the former into account. When compared to its individual likelihood, it shows how much more likely the consequent is to be purchased when the antecedent is present.

$$\text{Lift}(A \rightarrow B) = \frac{\text{Support}(A, B)}{\text{Support}(A) \times \text{Support}(B)}$$

The consequent items are the items which are purchased along with the antecedent items. They depict an IF-THEN relationship where the IF component is known as the antecedent. The THEN component is known as the consequent.

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction
0	(Mocan Veggie Burger Patty 600Gms)	(Burger Bun)	0.004176	0.011746	0.002088	0.500000	42.566667	0.002039	1.976507
1	(Burger Bun)	(Mocan Veggie Burger Patty 300Gms)	0.011746	0.004176	0.002088	0.177778	42.566667	0.002039	1.211137
2	(Shreenath Iceberg Lettuce)	(Burger Bun)	0.014618	0.011746	0.002088	0.142857	12.161905	0.001917	1.152963
3	(Burger Bun)	(Shreenath Iceberg Lettuce)	0.011746	0.014618	0.002088	0.177778	12.161905	0.001917	1.198438
4	(Carry Bag Small)	(Dilly Wafer Rolls)	0.038371	0.026103	0.003915	0.102041	3.909184	0.002914	1.084567
5	(Dilly Wafer Rolls)	(Carry Bag Small)	0.026103	0.038371	0.003915	0.150000	3.909184	0.002914	1.131328
6	(Carry Bag Small)	(Fruit & Vegetables)	0.038371	0.038893	0.003132	0.081633	2.988891	0.001640	1.046538
7	(Fruit & Vegetables)	(Carry Bag Small)	0.038893	0.038371	0.003132	0.060537	2.988891	0.001640	1.046539
8	(Rampee Corn Crackers 150 gm)	(Carry Bag Small)	0.013573	0.038371	0.002610	0.192308	5.011774	0.002088	1.190888

Figure (3):Output of Frequent Itemsets

In this research with the help of Market Basket Analysis, the association of the frequently purchased items is calculated and shown in the figure(3).

B. Discussion of Association Rules

The association rules derived from the frequent item sets were analysed and interpreted by the system. It concentrated on finding the most associated and significant rules, with a focus on those that have strong confidence and support values. These guidelines have implications for streamlining several elements of grocery store operations and provide insightful information about consumer purchase patterns. Utilized a Sunburst chart from the Plotly library to graphically show the associations. A hierarchical visualisation known as a sunburst chart shows the association rules in a circular layout.



Figure (4): Graphical Representation of Association

The Sunburst chart makes it possible to investigate connections between items. The outermost ring of the chart represents the antecedent items, and the inner ring indicate the consequent items. Figure(5) gives a more detailed view upon the selection of a single parent item. As shown in the figure(5), the inner ring item "PB Anar" is significantly related to a number of the

outer ring items. Items like "Shreenath Broccoli," "Shreenath Iceberg Lettuce," "Fruit Vegetables," and "Fanta/Orange/Pet 250 ML-24" are among them. The prominent placement of 'PB Anar' next to these products shows a significant connection and potential customer preferences for purchasing these products together.

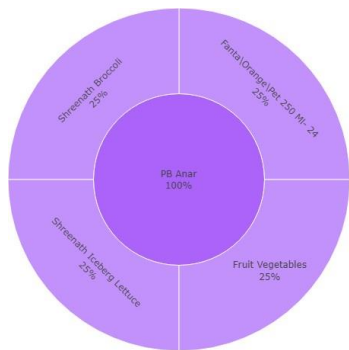


Figure (5): Graphical Representation of Association

This chart offers a simple and visual representation of the association rules, highlighting the connections between the market basket analysis's antecedents and consequents. It makes it simple for the store owner to identify the products that are most frequently related with one another and helps to comprehend the patterns and trends in consumer purchasing behaviour.

C. Additional Graphs

Additional graphs were included in the system to give the owner a greater understanding about various store-related factors. The transaction data from the month of March was used to create these graphs.

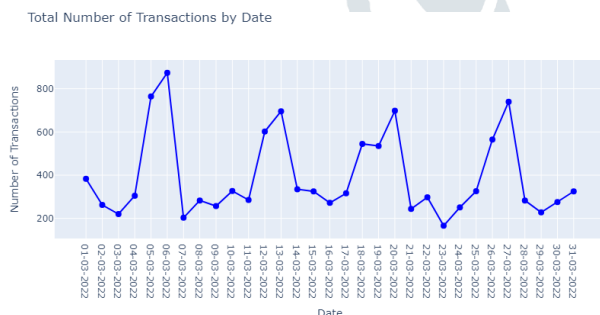


Figure (6): Graphical Representation Of Total Number Of Transactions By Date

In the above graph, it was noted that 06/03/2022 had the most transactions. A total of more than 800 transactions were observed on that day. The above information can help store owner to identify which days or times have a large amount of transactions and which ones are slower. By analyzing this, effective resource allocation can be achieved by scheduling employees during busy times or planning promotions to boost sales during slower times using the information provided.

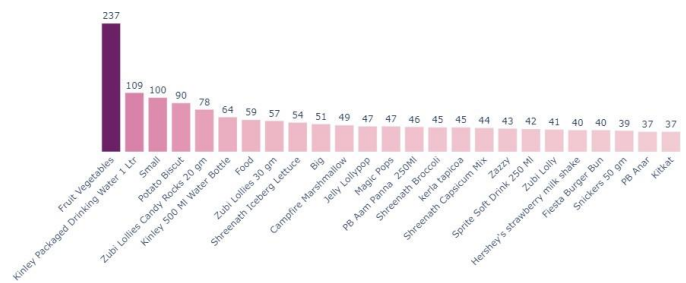


Figure (7): Graphical Representation Of Most Frequent Items Of The Month

With a count of 237, figure(7) reveals that fruits and vegetables were the most frequently purchased goods this month. The store owners can use this information to identify the most popular products and ensure that they have enough inventory to meet demand spikes.

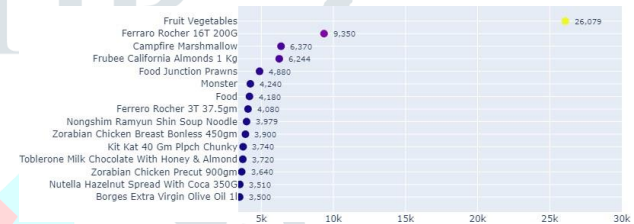


Figure (8): Graphical Representation Of Most Revenue Generated Products In This Month

According to figure(8), fruits and vegetables brought in the most money of Rs.26,079 followed by Ferraro Rocher and Campfire Marshmallow. By concentrating on stocking and marketing particular products, store owner can make sure that customers can easily access them. This can improve inventory management and guarantee that well-liked products are always in stock. To increase their visibility and draw in more customers, they can devote more resources to marketing and advertising these goods. In order to increase sales, they can also make appealing offers and incentives by taking advantage of how well-liked certain products are. Store owners can suggest complimentary or more expensive items to consumers who frequently purchase these products in order to raise the average transaction value.

V. CONCLUSION

In this study, the objective was to conduct a market basket analysis of a grocery store located in Pune using the Apriori algorithm to identify associations and relationships between frequently purchased items by customers. Generation of association rules based on the frequent itemsets, using a dataset consisting of over 10,000 data points, revealed the relationships and associations between items. Store owners

could optimise their product positioning, cross-selling tactics, and product bundling offers by knowing which items were frequently purchased in combination. Using this information, they were able to enhance sales by proposing related products or coming up with appealing package deals. Products that were regularly bought together could be placed strategically close to one another to entice buyers to buy them all in one trip. This boosted overall sales performance, raised the possibility of spontaneous purchases, and increased consumer convenience. To fulfil client demand, they made sure that popular items are constantly in stock while changing the stock levels of less often bought items. Store operators can increase operational effectiveness and cut expenses by preventing stockouts and minimising surplus inventory.

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