Market Basket Analysis with Equivalence Class Transformation Algorithm (ECLAT) For Inventory Management Using Economic Order Quantity (EOQ)

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Abstract

212 Mart is a retail that sells basic needs with guaranteed quality products, prices and a comfortable atmosphere. But over time, new competitors emerged. Therefore, strategies are needed to maintain the Retail business. There are problems in inventory management, namely the occurrence of vacancies or running out of goods which can cause consumers to turn to competitors to look for similar goods and will have an impact on decreasing sales. ECLAT and EOQ can be applied to this problem. ECLAT aims to find the most frequently purchased product combinations together, , while EOQ aims to find the number of goods to be ordered from the supplier so that orders can be made in optimal and economical quantities. The analysis is carried out using a sales transaction data set of 85,038 transactions in the 2021 period. The data was studied using the ECLAT algorithm with a minimum support of 0.1% getting 20 rules with the minimum confidence value of 30%. It is known the most frequently occurring product that

will be used in calculating EOQ are 21 types of products. The results of the implementation of EOQ obtained the number of products to be ordered as many as 536 items for each order.

Keywords
Association Rules, Equivalence Class Transformation Algorithm, Economic Order Quantity, Data Mining, Inventory Management

1. Introduction
212 Mart is a retail that sells basic necessities with guaranteed quality products, prices and a comfortable atmosphere. But over time, new competitors appeared. Therefore, strategies are needed to maintain the Retail business. In this regard, 212 Mart must better understand and explore the various needs and behaviors of consumers, especially in the inventory of goods need to be considered so that the quantity of goods should not be less than what consumers need this causes Out Of Stock so it is necessary to carry out an alternative technique to find out and process information in the form of what types of goods are most often purchased simultaneously at 212 Marts.

212 Mart conducts a very large number of sales transactions. There are ±8,000 types of items available. In a day there are ±1,000 transactions where 212 Mart Pekanbaru have and store a lot of data. However, the existing data is only used as material to analyze goods that sell well to later make promos or events without any further data processing to get new information that is useful for 212 Mart.

One of the right methods in processing large amounts of data is Data Mining. A method that is often used to analyze consumer purchase patterns is shopping cart analysis or Market Basket Analysis (MBA). This method uses the help of the Equivalence Class Transformation Algorithm (ECLAT) to produce Association Rules (association rules) in analyzing the most frequently purchased items simultaneously. The result of the product purchase pattern is in the form of rules (rules) that contain information on product combinations that have a tendency to be purchased simultaneously, so that these rules can later be used as data to calculate the Economic Order Quantity (EOQ) as a proposal for inventory management in maintaining product availability. By maintaining product availability, it can reduce the risk of loss of profit and consumer disappointment with the unavailability of the product.

1.1 Objectives
The objectives obtained based on the above problems are to find out the stock of products that will run out simultaneously using the Equivalence Class Transformation (ECLAT) algorithm and to provide proposed inventory strategies that should be applied based on calculations using the Economic Order Quantity (EOQ).

2. Literature Review
Data mining is the process of finding available data to create a new model, then using it to understand other data patterns that are not available in the available database. In data mining, the process of determining data groups can also be carried out in order to find overall patterns in the available data which will then be carried out other follow-up processes that are useful as support for certain activities and end goals. The purpose of data mining is to find relationships or patterns that may have useful information. From this understanding, a conclusion can be drawn that data mining is a process in finding and recognizing patterns and the process of grouping a large enough amount of data that aims to obtain relationships or patterns that provide benefits (Utomo, et al., 2020).

Association Rules or association rules are one of the techniques or methods in data mining to find relationships or form associative rules between items in a combination of itemsets . In the Association Rule, there is a procedure called Market Basket (Haristyarini and Yustanti, 2021).

$$\text{Support} = \frac{\text{Transaction Number Containing Item A}}{\text{Total Transactions}}$$

support, shows how much the dominance level of an itemset of the entire transaction, It determines whether an itemset is worthy of its trust.

$$\text{Conf}\{A \rightarrow B\} = \frac{f(A \cup B)}{f(A)}$$

Confidence is a measure that shows the relationship between 2 items conditionally (for example, calculating the probability of how often item B is purchased by a customer if the customer purchases item A). Lift is the Probability of items appearing together in a rule divided by the multiplication of the left and right segments of the support, the higher the lift value, the stronger the relationship between items (Nurzani and Tania, 2019).

$$l = \text{Lift}\{A \rightarrow B\} = \frac{f(A \cup B)}{f(A)f(B)}$$

The upgrade value illustrates the following:
1. If the value is <1, then A and B have a low concurrent incidence.
2. If the value is =1, then A and B often appear on the data as expected.
1. 3. If the value is >1, then A and B occur simultaneously on the data more often as.

ECLAT is an association algorithm for finding the most frequently occurring itemsets. Basically, ECLAT performs a search on the database with a vertical layout, if the database is horizontal then the data must first be changed into a vertical form (Evadini, 2022).

Forecasting is an activity of estimating or predicting future events, of course, with the help of preparing a plan in advance, where this plan is made based on the capacity and capability of demand / production that has been carried out in the company (Lusiana and yuliarty, 2020).

The calculation method is the same as a simple moving average given only the weighing coefficient. The determination of the magnitude of the weighing coefficient can be done arbitrarily, but in um the magnitude of the weighing coefficient of the last period of the historical data is twice that of the weighing coefficient of the previous period. Here is the Model of the- weighted moving averages is as follows: (Lusiana and Yuliarty, 2020).

$$\text{WMA} = \frac{\sum D_t \times \text{Weight}}{\sum \text{Weight}}$$

Information:
D_t = Actual data on period t
Weight = Weights given for each month

EOQ is a method used to optimize purchases in terms of purchases that can reduce inventory costs so that the efficiency of material inventory in the company can run well. The use of the EOQ method can help in determining the number of units ordered in order to achieve the minimum possible ordering costs and inventory costs. By using EOQ calculations, the inventory in the warehouse is not too much, but it will also not be too little (Rasminto and Sahid, 2021).

Determination of inventory order frequency, required by the company so that the orders in the warehouse are structured and not messy so that there is no waste in order costs (Solehah, et al., 2021).

3.Methods

Data collection is carried out to collect the information needed in the study. Data collection can be done by making observations, conducting interviews and taking data through documents. This data collection aims to present information according to facts and can be accounted for its truth. In this study, the data collection used was secondary data. In general, secondary data collection is obtained from existing data. The data used is sales transaction data at 212 Mart in 2021. The sales transaction data contains the transaction number, product name, date and quantity, 2021 request data, 2021 order fees storage costs in 2021.

Before processing data with a predetermined method, first raw data in the form of sales transaction data passes through the stages of the Knowledge Discovery in Database (KDD) process. Here are the stages of the Knowledge Discovery in Database (KDD) process:

1. Data Selection: Selection (selection) is carried out to select the data to be used. in this study the data to be processed is divided into two, namely ordinary agent transaction data and stock agent transaction data and choose the attributes needed in data analysis
2. Data Cleaning: Data cleaning is part of preprocessing, which is the process of removing noise and irrelevant data. In this study, cleaning of lost data was carried out, deleting registration items and deleting transactions whose purchases were less than 2 items in one transaction.
3. Data Transformation: Data transformation is the process of changing the shape of data into an appropriate format that aims to make data processing can be carried out and run as it should.

The data that has been processed before, then the data is processed using the ECLAT algorithm with the help of RStudio Software on the data in determining product patterns that are often purchased.

Before calculating the EOQ, the calculation of demand data forecasting for the 2022 period is first carried out. Plotting 2021 request data to determine the right forecasting method. Furthermore, the calculation of forecasting demand data for 2022 is carried out.

The things needed before carrying out the EOQ process are data such as, the number of product demand, data of product ordering cost and data of product storage cost at 212 Mart Jalan HR. Soebrantas. At this stage, the calculation of the number of orders for the next period is carried out, calculating the frequency of orders, calculating the Lead Time.

4. Data Collection

Data collection is carried out by collecting all information or data that has a connection in the research. The data collected at the time of data collection is as follows.

4.1 Data of Sales Transaction at 212 Mart in 2021

Data collection was carried out by obtaining a collection of transactions of 212 Mart Pekanbaru for the 2021 period with a total number of products sold as many as 468,485 transactions in the form of XLSX (Microsoft Office Excel). (Table 1)

Table 1. Data Of Sales Transaction 2021

No.	Code	Stock Name	Member Code	No. Trans	Status	Date	Qty
1	00917564	Daia Softener Pink 900g		2641501000	Nonmember	01/01/2020	1
2	00921422	Hpai Pasta Gigi Herba 120g		2641501000	Nonmember	01/01/2020	1
3	00922170	Bedak M.B.K 13.6g		2717801000	Nonmember	01/01/2020	2
4	00920512	Bagus Spon Mandi		2717801000	Nonmember	01/01/2020	1
5	00921216	Amia Cup 220 Ml		2750801000	Nonmember	01/01/2020	1
6	00005149	Strepsils Vitamin C-1000		2750801000	Nonmember	01/01/2020	1
…	…	…	…	…	…	…	…
468.484	00917595	Sensi Diaper Popok Dewasa L 10	0000002121	7913903620	Member	21/12/2020	1
468.48	00925830	Dr.P Basic Adult	000000212	3272503650	Member	24/12/2020	1

5		L8s	1				

5. Résults and discussion

The data processing uses the ECLAT algorithm to determine the products to be carried out by inventory management by analyzing consumer patterns at 212 Mart Pekanbaru based on association rules from the sales transaction data obtained. After the product names are obtained based on the rules of association with the ECLAT algorithm, the forecasting of 2022 demand data is carried out based on demand data for each type of product based on 2021. Furthermore, conduct inventory management by calculating the Economic Order Quantity (EOQ) method.

5.1 In the Knowledge Discovery in Database (KDD) Process

In the Knowledge Discovery in Database (KDD) process, stages are carried out consisting of selection, preprocessing / cleaning, data transformation. The stages of the KDD process on product transactions are as (Table 2)

Table 2. Data on the Results of the Transformation of 212 Mart Pekanbaru

No.	Product Name
1	Amia Cup 220 Ml,Strepsils Vitamin C-1000,Gery Malkist Coklat 110gr,Vicee Orange Tab,Vicee Rasa Jeruk Tab,Vicee Strawberry 100s
2	Sania 2 Liter,Mila Tepung Terigu 1kg
3	Sania 2 Liter,Danes Coklat Cream 132gr,Wipol Karbol Lemon Reff 240ml
4	Prima 1.5l, Le Mineral 600ml, Saltcheese Crk 200gr, Nabati Sandwich Klapa Lava 50g,Nabati Sandwich Klapa Lava 50g,Pocari Sweat 330 Ml Kaleng,Sh Serba 10 Rb,Sh Serba 10 Rb
5	Tic Tac Rasa Sapi Panggang 90g, Indomie Goreng Jumbo 129g
6	Amia Cup 220 Ml,Teh Pucuk Harum 500ml,Hydro Coco 500ml,Nestle Pure Life 600 Ml,Bear Brand 189ml
…	…
85.037	Gula Premium Psm 1kg, Haan Delima Pudding Coklat 165, Ting Ting Garuda Candy 125gr, Oreo Vanila Summer20 38g, Oreo Double Stuf 147.7g, Oreo Peanut Butter&Choco 133g,Cleo Eco 220ml
85.038	Sunco Minyak Goreng 2ltr, Ting Ting Garuda Candy 125gr

(Source: Data Processing, 2022)

5.2 Association Rule with ECLAT Algorithm

In the calculation process using Rstudio software using a minimum support value of 0.1% and a minimum confidence value of 30%. Here is an example of the syntax used in the application of the ECLAT algorithm using R Studio with the R programming language. (Figure 1) & (Table 3 & 3a)

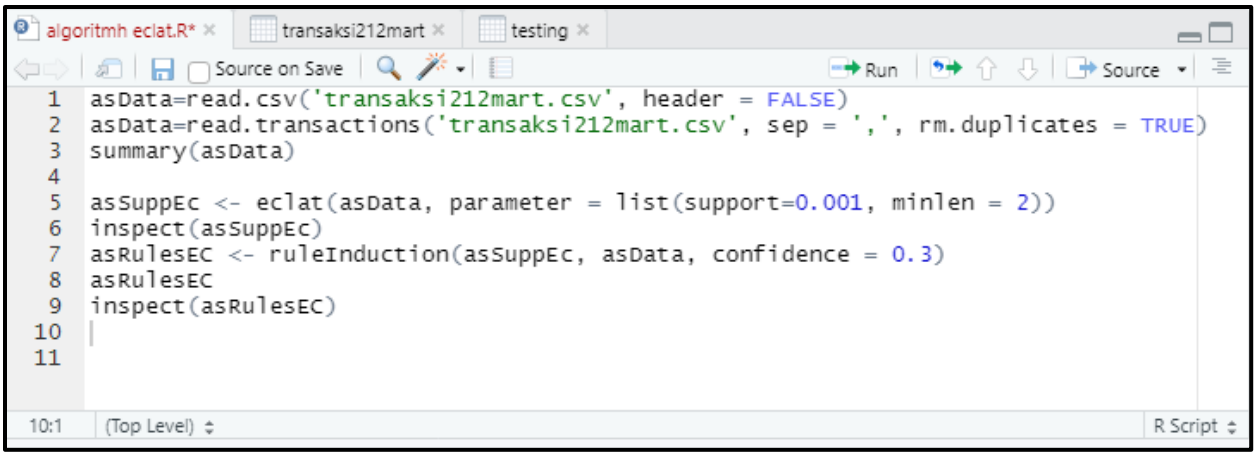

Figure 1. Sintaks R ECLAT Algorithm

Table 3. ECLAT Algorithm Results

No	Rules	Support	Conf	Lift	Itemset
1	Kapal Api Special 165 → Gula Pasir 1kg	0.001065868	0.389	9.25	1
2	Amazing Lime Power 800ml → Minyak Permata 2l	0.001025392	0.319	5.74	2
3	Air Minum Sms Galon → Air Minum Vit Galon	0.001227772	0.302	33.09	3
4	Tricks Biskuit Kentang Original → Tricks Biskuit Kentang BBQ 20g	0.001065868	0.467	185.27	4
5	Tricks Biskuit Kentang BBQ 20g → Tricks Biskuit Kentang Original	0.001065868	0.422	185.27	4
6	Lays Rs Rumput Laut 14g → Chitato Rs Sapi PGG 19 Gr	0.001200788	0.329	77.56	7
7	Alfasa Roti Selai Kecil → Alfasa Roti Tawar Kupas	0.002603956	0.421	27.83	9
8	UHT Indomilk Kids Stroberi 125 → UHT Indomilk Kids Coklat 115ml	0.001740468	0.405	62.63	10
9	Teh Sari Wangi 25 Pcs → Gula Pasir 1kg	0.001969832	0.345	8.22	19
10	Lemonilo Mie Instan Ayam Bwg 7 → Lemonilo Mie Instan Alami Grg	0.002118244	0.386	45.49	22
11	Lemonilo Mie Instan Kari Ayam → Lemonilo Mie Instan Ayam Bwg 7	0.002334116	0.392	71.61	23
12	Lemonilo Mie Instan Ayam Bwg 7 → Lemonilo Mie Instan Kari Ayam	0.002334116	0.426	71.61	23

13	Lemonilo Mie Instan Kari Ayam → Lemonilo Mie Instan Alami GRG	0.002347608	0.394	46.41	24
14	Teh Celup Prendjak 25x2gr → Gula Pasir 1kg	0.002226180	0.340	8.10	28
15	Gula Pasir 1kg, Indomie Kari Ayam 72g → Indomie Goreng Special 80gr	0.001376184	0.445	19.04	71
16	Gula Pasir 1kg, Indomie Goreng Special 80gr → Indomie Kari Ayam 69 Gr	0.001376184	0.445	18.31	71
17	Indomie Kari Ayam 72g, Minyak Permata 2L → Indomie Goreng Special 80gr	0.001092852	0.433	18.52	72

Table 3a. ECLAT Algorithm Results (advanced)

No	Rules	Support	Conf	Lift	Itemset
18	Indomie Goreng Spesial 80gr, Minyak Permata 2L → Indomie Kari Ayam 72g	0.001092852	0.419	17.25	72
19	Indomie Kari Ayam 72g → Indomie Goreng Special 80gr	0.008985671	0.369	15.79	76
20	Indomie Goreng Special 80gr → Indomie Kari Ayam 72g	0.008985671	0.384	15.79	76

5.3 Forecasting with Weighted Moving Average

Before calculating the EOQ, the 2021 request data is first carried out forecasting for the 2022 request data. The forecasting method used is a weighted moving average because it has the lowest MAPE (Mean Absolute Percentage Error) value. (Table 4)

Table 4. Forecasting Results

No	Nama Produk	Total Permintaan(D) 2021	Forcasting Demand 2022
1	Kapal Api Special 165	225	230
2	Gula Pasir 1kg	3,280	3,706
3	Amazing Lime Power 800ml	251	246
4	Minyak Permata 2l	4,256	4,739
5	Air Minum Sms Galon	304	323
6	Air Minum Vit Galon	696	668
7	Tricks Biskuit Kentang Original	191	193
8	Tricks Biskuit Kentang BBQ 20g	210	227
9	Lays RS Rumput Laut 14g	311	328
10	Chitato RS Sapi PGG 19 Gr	364	432
11	Alfasa Roti Selai Kecil	492	677
12	Alfasa Roti Tawar Kupas	1,212	1,191
13	UHT Indomilk Kids Stroberi 125	364	575
14	UHT Indomilk Kids Coklat 115ml	541	557
15	Teh Sari Wangi 25 Pcs	567	576
16	Lemonilo Mie Instan Ayam Bwg 7	449	456
17	Lemonilo Mie Instan Alami GRG	700	720
18	Lemonilo Mie Instan Kari Ayam	479	472

19	Teh Celup Prendjak 25x2gr	547	504
20	Indomie Kari Ayam 72g	2,063	2,104
21	Indomie Goreng Special 80gr	1,996	1,989

5.4 Application of Economic Order Quantity (EOQ)

In calculating EOQ. The data used is the number of settlements carried out in the previous period and forecasting the number of orders in 2021, product order fees and product storage costs at 212 Pekanbaru Mart. (Table 5)

Table 5. Data Of Order Cost for Each Ordering

No.	Product Name	Demand in 2022	Order Cost of Each Ordering (Rp)
1	Kapal Api Special 165	230	244,000
2	Gula Pasir 1kg	3,706	1,500,000
3	Amazing Lime Power 800ml	246	132,000
4	Minyak Permata 2l	4,739	1,200,000
5	Air Minum Sms Galon	323	200,000
6	Air Minum Vit Galon	668	400,000
7	Tricks Biskuit Kentang Original	193	200,000
8	Tricks Biskuit Kentang BBQ 20g	227	200,000
9	Lays RS Rumput Laut 14g	328	234,000
10	Chitato RS Sapi PGG 19 Gr	432	224,000
11	Alfasa Roti Selai Kecil	677	80,000
12	Alfasa Roti Tawar Kupas	1,191	150,000
13	UHT Indomilk Kids Stroberi 125	575	200,000
14	UHT Indomilk Kids Coklat 115ml	557	192,000
15	Teh Sari Wangi 25 Pcs	576	115,000
16	Lemonilo Mie Instan Ayam Bwg 7	456	336,000
17	Lemonilo Mie Instan Alami GRG	720	336,000
18	Lemonilo Mie Instan Kari Ayam	472	336,000
19	Teh Celup Prendjak 25x2gr	504	168,00
20	Indomie Kari Ayam 72g	2,104	438,000
21	Indomie Goreng Special 80gr	1,989	438,000
Total		20,913	20,913

The following is an estimate of the total average storage costs incurred by 212 Mart Pekanbaru in 2021 can be seen in Table 6 below.

Table 6. Holding Cost

No	Information	Holding Cost (H)
1	Werehouse Maintenance	1,500,000
2	Electricity/Year	600,000
Total		1,100,000

Calculation of EOQ value on Kapal Api products

$$EOQ = \sqrt{\frac{2 \times 24{,}000 \times 230}{1{,}100{,}000}} = 10.1 \approx 11 \text{ unit}$$

Calculation of order frequency (F) on Kapal Api products

$$F = \frac{230}{11} = 20.9 \approx 21 \text{ kali}$$

Calculation of the order distance (T) on Kapal Api products

$$T = \frac{365 \text{ Hari}}{21} = 17.38 \approx 17 \text{ Hari}$$

Table 7. Recommendations For Inventory Management

No	Nama Produk	optimal order quantity (EOQ)	Order Frequency (F)	Interval Of Order Time (T)
1	Kapal Api Special 165	11	21	17
2	Gula Pasir 1kg	101	37	10
3	Amazing Lime Power 800ml	8	31	12
4	Minyak Permata 2l	107	45	8
5	Air Minum Sms Galon	11	30	12
6	Air Minum Vit Galon	24	28	13
7	Tricks Biskuit Kentang Original	9	22	17
8	Tricks Biskuit Kentang BBQ 20g	10	23	16
9	Lays RS Rumput Laut 14g	13	26	14
10	Chitato RS Sapi PGG 19 Gr	14	31	12
11	Alfasa Roti Selai Kecil	10	68	5
12	Alfasa Roti Tawar Kupas	19	63	6
13	UHT Indomilk Kids Stroberi 125	16	36	10
14	UHT Indomilk Kids Coklat 115ml	15	38	10
15	Teh Sari Wangi 25 Pcs	11	53	7
16	Lemonilo Mie Instan Ayam Bwg 7	18	26	14
17	Lemonilo Mie Instan Alami GRG	22	33	11
18	Lemonilo Mie Instan Kari Ayam	18	27	14
19	Teh Celup Prendjak 25x2gr	14	36	10
20	Indomie Kari Ayam 72g	43	49	7
21	Indomie Goreng Special 80gr	42	48	8

From the results of the application of EOQ in an effort to optimize product inventory, information can be found regarding the number of products to be ordered (Q), the number of times the product is ordered (F) and the distance of the product order day (T). Products can be ordered economically and optimally. By calculating EOQ, it can also overcome product availability and time management so as to avoid the possible risk of product unavailability or product vacancies that make consumer demand always available. There are few problems with the results of previous EOQ implementations. (Table 7)

6. Conclusion

Based on the results of the process of applying the ECLAT and EOQ Algorithms to the sales transaction data of 212 Mart Pekanbaru, from the results of the ECLAT analysis, 20 rules were obtained with 21 types of products purchased simultaneously, namely Kapal Api Special 165, Granulated Sugar 1kg, Amazing Lime Power 800ml, Gem Oil 2l, Sms Gallon Drinking Water, Vit Gallon Drinking Water, Tricks Original Potato Biscuits, Tricks Potato Biscuits BBQ 20g, Lays RS Seaweed 14g, Chitato RS Sapi PGG 19 Gr, Alfasa Roti Jam Kecil, Alfasa Roti Tawar Peeled, UHT Indomilk Kids Strawberry 125, UHT Indomilk Kids Chocolate 115ml, Teh Sari Wangi 25 Pcs, Lemonilo Mie Instan Ayam Bwg 7, Lemonilo Mie Instan Alami GRG, Lemonilo Mie Instan Kari Ayam, Tehbag

Prendjak 25x2gr, Indomie Curry Ayam 72g, Indomie Goreng Special 80gr which can be used for analysis of the EOQ method. From the results of the EOQ used, it produces the number of goods, the frequency, as well as the recommended ordering distance of items to maintain the availability of goods. One of them is the product with the largest minimum support with a value of 0.008, namely Indomie Kari Ayam 72g, the number of products to be ordered in the next period is 43 units with an order frequency of 49 times and an order distance of 7 days, while indomie Goreng Khusus 80gr amounts to 42 units, 48 times with a distance of 8 days.

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Biography

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