

# Designing Animal Market Layout by Considering Consumer Purchase Behaviors

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## ABSTRACT

Sales transaction data contains rich information and can support company competitiveness. However, this transaction data is initially unstructured and needs to be processed into insight for the company's decision-making. Market Basket Analysis (MBA) is a data mining technique that can be used to study consumer purchasing patterns. This paper presents a case study on using an MBA to obtain consumer buying behaviors where the result of the MBA is then used to design a proposed layout. The animal market governed by Yogyakarta Province, known as Pasty Market, was used as a case study. Pasty Market is an animal trading center with around 30,000 square meters area and 255 sellers that sell various kinds of animals such as songbirds, dove birds, rabbits, cats, dogs, iguanas, turtles, ornamental chickens, and ornamental fish as well as animal food and cage. With this enormous area and number of merchants, the layout of Pasty Market becomes crucial in customer satisfaction. Association rules result in four priority levels in proposed layout planning, where these rules are used to determine the proximity among items in the proposed layout. These four levels of priority, ordered by the confidence value, are (1) "songbirds" and "bird food" (confidence value 91%), (2) "ornamental fish" and "turtles" (confidence value 80-90%), (3) "birdcages" and "songbirds" (confidence value 70-80%), and (4) "cats" and "dog" as well as "birdcages" and "birds" (confidence value 50-70%). Association rules were then used as the basis for determining the proximity value between merchants, where the proximity rules were then used for designing a proposed layout.

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## 1. Introduction

The retail industry faces an abundance of sales transaction data, where transaction data contains essential information that can be used to support the company's competitiveness (Bermudez et al., 2016). However, to get valuable information from the transaction data, the previously unstructured data must be processed first (Kaur & Kang, 2016). For this reason, up until now, not all retail industries have successfully managed their transaction data to improve the company's competitiveness or increase customer satisfaction.

Transaction data representing consumer shopping behavior can be used to formulate layout planning recommendations and promotional strategies (Bermudez et al., 2016). Research conducted by Kaur & Kang, 2016 studying the integration of MBA and 4P strategies in the retail industry. In addition, a study by Panjaitan et al. (2019) used MBA to develop promotional strategies in product

bundling and packaging size changes. Research by [Jain et al. \(2018\)](#); [Kurniawan et al. \(2017\)](#) compiled an MBA-based transaction data processing system as a basis for companies to formulate their strategies. In this study, the MBA results were focused on as a basis for designing the facility layout. Several studies have shown that the layout of a retail outlet plays a vital role in the customer's shopping experience ([Bermudez et al., 2016](#)). In addition, research by [Wahyudi & Anwar \(2022\)](#) stated that product arrangement is essential to customer satisfaction.

Data mining is a technique that converts data into valuable and helpful knowledge for companies. Data mining has various applications in the retail industry, such as customer segmentation, inventory management, churn prediction, and sentiment analysis ([Bermudez et al., 2016](#); [Gupta, M.K., et. al, 2020](#)). Data mining transforms unstructured data into valuable knowledge, employing techniques such as classification, association, prediction, clustering, and outlier analysis ([Kaur & Kang, 2016](#)). This research primarily utilizes the association technique, which explores the relationships between items in customer transactions. A key component of association techniques is affinity analysis, a method that identifies patterns of items often purchased together. Market Basket Analysis (MBA), the focus of this study, is an advanced form of affinity analysis. It leverages association rule mining to analyze the co-occurrence of events within consumer transactions, revealing significant correlations or patterns.

The results of an MBA can be used to formulate strategic plans for marketing, such as promotional policy and layout planning ([Mostafa, 2015](#); [Wahyudi & Anwar, 2022](#)). Insight from an MBA is expected to trigger customers' impulsive or unplanned purchases, as products that customers generally buy in a single purchase are placed adjacently. In addition, the MBA can be used as the basis for formulating the 4P strategy (Products, Price, Place, and Promotion). However, in this study, the results of the MBA are focused on providing recommendations for improvement in the layout (place) aspect ([Kaur & Kang, 2016](#)).

This paper used the animal market governed by Yogyakarta Province, known as Pasty Market, as a case study. Pasty Market has a 30,000 square meters area comprising public facilities and 255 merchants selling various kinds of animals. Public facilities available at Pasty Market are a parking lot, prayer room, toilets, songbird competition arena, culinary center, children's playground, veterinary clinic, and skateboarding hall. In addition, various kinds of animals are sold by 255 merchants, such as songbirds, dove birds, rabbits, cats, dogs, iguanas, turtles, chickens, and ornamental fish. Moreover, Pasty Market also provides a wide range of supplies for keeping animals, such as food and animal cages. [Table 1](#) shows information on the number of sellers for each kind of animal sold in Pasty Market.

With a total of 255 sellers and an area of 30,000 m<sup>2</sup>, the availability of a layout that aligns with the customer buying behavior will lead to customer satisfaction. This research aims to present a case study of the MBA method to get a recommendation for the proposed layout. Previous research on analyzing and using consumer buying behavior in designing product layouts has been performed in various papers. Research by ([Priyanto et al., 2019](#); [Yul & Mulyati, 2022](#); [Wahyudi & Anwar, 2022](#); [Tarigan et al., 2018](#)) use the modern market as a case study, while research by ([Putra et al., 2022](#); [Bermudez et al., 2016](#), [Mostafa, 2015](#); [Rusnandi et al., 2020](#); [Widodo et al., 2021](#); [Qisman et al., 2021](#); [Kurnia & Lestari, 2021](#)) use traditional market/retail as a case study. However, research on integrating consumer buying behavior into layout planning using an animal market as an object has never been performed before. Therefore, this research contributes to presenting a case study that considers customer buying behavior when designing the animal market. This paper also suggests the proposed layout of an animal market based on the Market Basket Analysis (MBA) and Systematic Layout Planning (SLP). [Wahyudi & Anwar \(2022\)](#) combine these two methods, MBA and SLP, to develop the traditional market layout. SLP provides step-by-step guidelines for designing a facility by considering the flow and activity of a facility ([Ali Naqvi et al., 2016](#)).

**Table 1.** The number of sellers for each kind of animal sold in *Pasty Market*

| No. | Seller                     | Code | Number of Kiosk |
|-----|----------------------------|------|-----------------|
| 1   | Birdcage sellers           | A    | 16              |
| 2   | Songbird sellers           | B    | 119             |
| 3   | Dove bird sellers          | C    | 36              |
| 4   | Rabbits sellers            | D    | 5               |
| 5   | Cats sellers               | E    | 6               |
| 6   | Bird feed sellers          | F    | 20              |
| 7   | Dogs sellers               | G    | 6               |
| 8   | Iguana sellers             | H    | 4               |
| 9   | Turtle sellers             | I    | 8               |
| 10  | Ornamental chicken sellers | J    | 9               |
| 11  | Ornamental fish sellers    | K    | 26              |
|     | Total                      |      | 255             |

## 2. Method

This paper aims to utilize transaction data to formulate a proposed layout for traditional markets. The data mining was integrated with the systematic layout planning to formulate the proposed layout. In the methodology, the data mining technique used and the method of formulating the proposed layout will be explained further.

Data mining is a technique used to transform unstructured data into valuable knowledge. Data mining can be classified into five techniques: (1) classification, (2) association, (3) prediction, (4) clustering, and (5) outlier analysis (Kaur & Kang, 2016). This research falls into the association technique category, which examines the relationship between items in customer transactions. Association rule mining is one of the most powerful data mining tools for analyzing large amounts of data by identifying correlations or patterns between objects (Nurmayanti, W. P., et. al, 2021). Market Basket Analysis (MBA) is a data mining technique based on affinity analysis or association rule mining that studies the co-occurrence of events (Nurmayanti, W. P., et. al, 2021).

Systematic Layout Planning (SLP) is a systematic procedure for designing facilities that require comprehensive information about the facilities' flows, procedures, and activities. SLP consists of 7 (seven) steps consisting of (1) determining plant capacity, (2) analysis of operations, (3) material flows, (4) relationship between departments, (5) spatial requirements, (6) layout alternatives, and (7) selected layout (Ali Naqvi et al., 2016). In Step 2 and Step 4, the activity relationship chart (ARC) and activity relationship diagram (ARD) method will determine the relationship between departments. In this study, the Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) are essential tools used to optimize the market layout based on consumer behavior insights derived from Market Basket Analysis (MBA). The ARC is used to systematically represent and quantify the degree of proximity between different sellers based on customer purchasing patterns.

Paper Nurmayanti, W. P., et. al, (2021) explained the terminology used in MBA: (a) items (products), (b) support, (c) confidence, (d) lift, and (e) desired outcome. Items are objects that will be seen for their association. The group of items is called the item set (or set of products). The support of a product or the support of a set of products is the proportion of transactions that contain the product or set of products compared to all products. For example, in the historical data, there are 100 transactions, of which 50 customers bought Product A, 40 bought Product B, and 25 bought Product A and Product B simultaneously. Based on this illustration, the Support of Product A is 50%, the Support of Product B is 40%, and the Support of Product A and Product B is 25%.

Confidence is the conditional probability that if a customer buys Product A, they will also purchase Product B (Nurmayanti, W. P., et. al, 2021). In the example above, out of 50 customers who bought Product A, 25 customers also bought Product B. So, the Confidence of Product A and Product B is  $25/50 = 50\%$ . This means that if someone buys Product A, there is a 50% chance that they will

also purchase Product B. Lift answers that if a customer buys Product A, by what percentage does the probability of purchasing Product B increase. A lift value greater than 1 indicates that the presence of Product A can increase the likelihood of Product B in the transaction. Conversely, a lift value less than 1 suggests that the presence of Product A decreases the probability of Product B in the transaction. The desired outcome is determining the rules used in decision-making; for example, the rules chosen can be a rule with a lift value of more than one and rules with the greatest confidence.

In this study, the MBA was performed using the Apriori Algorithm. Among all data mining methods, the Apriori algorithm is among the best methods for association rules mining (Dhanabhakym & Punithavalli, 2011). Apriori algorithm applies selection criteria to the number of possible association rules. Much previous research on MBA used the Apriori algorithm, such as (Nurmayanti et al., 2021, Qisman et al., 2021, and Panjaitan et al., 2019).

Data mining consists of a series of processes that start with business understanding, data understanding, data preparation, modeling, evaluation, and deployment. Business understanding is the phase of determining the objectives of the data mining project from a business point of view. Data understanding is the data collection phase and continues with data preparation, consisting of data selection, cleaning, integration, and transformation. The following process is selecting a model or analysis technique and evaluating and deploying the results. In this study, data was collected using the interview method directly with Pasty Market's buyers. Fifty purchase transaction data was obtained from one month of observation shown in Table 2.

**Table 2.** Transaction data

| Transactions No. | Item purchased                        |
|------------------|---------------------------------------|
| 1                | Bird cage, songbird, dove bird        |
| 2                | Bird cage, songbird, dove bird        |
| 3                | Dove bird, rabbit, ornamental chicken |
| ...              | ...                                   |
| 50               | Bird feed, songbird                   |

### 3. Results and Discussion

Each sales transaction represents a consumer behavior pattern showing a combination of items purchased simultaneously. In this study, the results of the MBA are only used to propose re-layout planning. Based on the data collected, the frequency of the itemset is sought, starting from the selection of the first itemset (1 item in a set), the second itemset (2 items combinations), and the third itemset (3 items combinations). The number of transaction frequencies in the itemset must be greater than or equal to the minimum support. Itemset whose number of transactions does not reach the minimum support will not be continued to calculate the combination of two item sets. This study used a minimum support value of 10% and a minimum confidence value of 50%.

In conducting the MBA, determining appropriate minimum support and confidence values is crucial for extracting meaningful patterns from transaction data. In this study, the minimum support value was set at 10%, which was chosen to ensure that only items that appear in at least 10% of the transactions are considered. This threshold helps to focus on items that are more commonly purchased, avoiding the noise created by rarely bought items and ensuring a significant level of prevalence in the dataset. In addition, the minimum confidence value was set at 50%, representing a balance between reliability and the quantity of rules generated. This value implies that for a rule to be considered, the likelihood of the consequent item being purchased when the antecedent item is purchased must be at least 50%. This threshold was selected to ensure that the associations identified are sufficiently strong to suggest a probable relationship, yet not so high as to miss potentially interesting but less obvious associations. These thresholds were chosen based on a combination of statistical analysis and domain expertise, with an aim to capture a broad yet relevant set of associations that can inform meaningful

layout decisions. Adjusting these values could lead to different insights, which is a consideration for future research to explore the sensitivity of layout recommendations to these parameters.

Table 3 presents the support value of one item set. All items have a support value above 10%, which means that the calculation for these items can be continued in the second item set. Item code B (songbirds) and item code F (bird feed) are the items with the largest purchase of over 40%. This means that both items are favorite items for Pasty market visitors. Table 4 shows the rules of two-item sets, combining two items in a single purchase. Four rules meet the minimum support value of 10% and confidence value of 50%. Of the four rules, the rule "if buy B, then buy F" has the largest confidence value of 91%, which means that if a customer buys product B (songbirds) then 91% of the customers will buy item B (bird feed). Table 5 indicates the rules that meet the minimum support of 10% and confidence value of 50%. There is one rule that meets the minimum support value of 10% and confidence value of 50%, which is if a consumer buys product A (birdcage) and B (songbird), then he/she will buy product F (bird feed). This rule has a confidence value of 57%, meaning that more than half of those buying products A and B will buy product F.

**Table 3.** One item set with a minimum support of 10%

| Rules | Number of transactions | Support |
|-------|------------------------|---------|
| Buy A | 14                     | 28%     |
| Buy B | 23                     | 46%     |
| Buy C | 18                     | 36%     |
| Buy D | 8                      | 16%     |
| Buy E | 5                      | 10%     |
| Buy F | 25                     | 50%     |
| Buy G | 5                      | 10%     |
| Buy H | 3                      | 6%      |
| Buy I | 5                      | 10%     |
| Buy J | 8                      | 16%     |
| Buy K | 7                      | 14%     |

**Table 4.** Two item sets with minimum support of 10% and confidence value of 50%

| Rules               | Number of transactions | Support | Confidence |
|---------------------|------------------------|---------|------------|
| If buy A then buy B | 10                     | 20%     | 71%        |
| If buy A then buy C | 7                      | 14%     | 50%        |
| If buy A then buy F | 9                      | 18%     | 64%        |
| If buy B then buy F | 21                     | 42%     | 91%        |

**Table 5.** Three item sets with minimum support of 10% and confidence value of 50%

| Rules                       | Number of transactions | Support | Confidence |
|-----------------------------|------------------------|---------|------------|
| If buy A & buy B then buy F | 8                      | 16%     | 57%        |

The MBA outputs were then used for an activity relationship chart (ARC). The higher the confidence value, the more critical the closeness of items. A confidence value of 50% was set as the minimum value considered in the relationship rules. Fig. 1 shows the ARC formulated based on the confidence value.

| Sellers |                     | A   | B   | C   | D   | E   | F   | G   | H   | I   | J   | K   |
|---------|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A       | Birdcages           |     | I 3 | O 4 | U 5 | U 5 | O 4 | U 5 | U 5 | U 5 | U 5 | U 5 |
| B       | Songbirds           | I 3 |     | U 5 | U 5 | U 5 | A 1 | U 5 | U 5 | U 5 | U 5 | U 5 |
| C       | Dovebirds           | O 4 | U 5 |     | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 |
| D       | Rabbits             | U 5 | U 5 | U 5 |     | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 |
| E       | Cats                | U 5 | U 5 | U 5 | U 5 |     | U 5 | O 4 | U 5 | U 5 | U 5 | U 5 |
| F       | Bird feeds          | O 4 | A 1 | U 5 | U 5 | U 5 |     | U 5 | U 5 | U 5 | U 5 | U 5 |
| G       | Dogs                | U 5 | U 5 | U 5 | U 5 | O 4 | U 5 |     | U 5 | U 5 | U 5 | U 5 |
| H       | Iguanas             | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 |     | U 5 | U 5 | U 5 |
| I       | Turtles             | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 |     | U 5 | E 2 |
| J       | Ornamental chickens | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 |     | U 5 |
| K       | Ornamental fish     | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | U 5 | E 2 | U 5 |     |

| Closeness Rating |                      | Code | Reason (Confidence value) |
|------------------|----------------------|------|---------------------------|
| A                | Absolutely necessary | 1    | 90-100%                   |
| E                | Especially important | 2    | 80-90%                    |
| I                | Important and core   | 3    | 70-80%                    |
| O                | Ordinary             | 4    | 50-70%                    |
| U                | Unimportant          | 5    | <50%                      |

Fig.1. Activity relationship chart (ARC) based on confidence values

The activity relationship diagram (ARD), as shown in Fig. 2, indicates the degree of proximity between items. “Songbirds” and “bird food” sellers, with a degree of closeness of four lines indicating that the two sellers absolutely need to be close together. “Ornamental fish” and “turtle” sellers are marked with three lines, which means it is very important to be close because both are aquatic animals. “Birdcage” and “songbirds” sellers are marked with two lines, which means it is important to be located closely. “Birdcages” and “bird food,” “birdcages” and “bird feeders,” and “dogs” and “cats” are marked with a single line, which means it is important enough to be placed adjacently. Items that do not have a relationship mean it is not important to be placed closely. The location of items with U symbols can be based on the current layout.

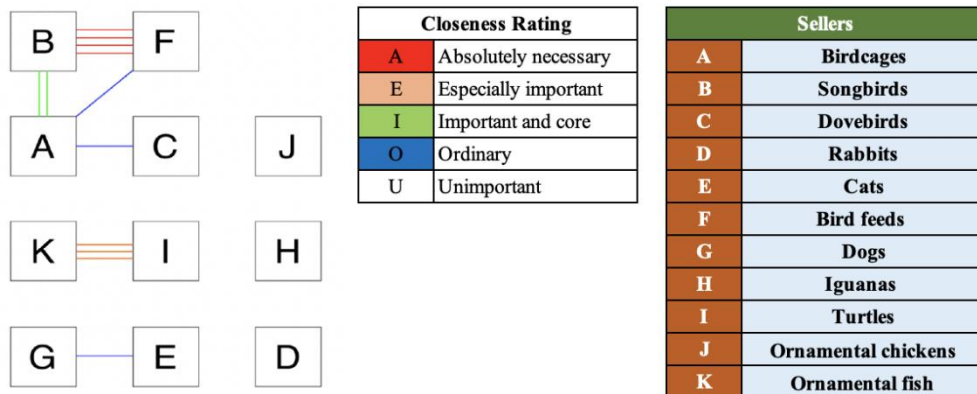


Fig. 2. Activity relationship diagram (ARD) based on confidence values

The MBA and ARC-ARD indicate that there was an opportunity to improve the layout of Pasty's animal market to increase customer transactions. This section presents an alternative layout for Pasty's animal market by considering two association rules from a combination of three item sets. The two rules are "if visitors buy birdcages and songbirds, then they buy bird food" and "if visitors buy birdcages and dove birds, then they buy bird food." As mentioned in the previous paragraph, the facility layout design also considers the four priority levels of item placement. Based on these

considerations, the initial and the proposed layout of the animal market Pasty are shown in Fig. 3 and Fig. 4, respectively.



Fig. 3. Initial layout

The differences between the initial layout and the proposed layout are significant, with some changes in seller placement. The changes in the proposed layout are as follows:

- Most “bird food” sellers were not relocated (16 sellers remained, and four sellers were shifted into a row with “dove birds” and “songbirds”). As a result of interviews with *Pasty Market* managers, most visitors come to look for “bird food.”
- Sellers of “songbirds” were located close to the “bird competition” arena because the location was often used as a gathering place for “songbird” lovers.
- “Ornamental fish” was the merchant that attracted many visitors. “Ornamental fish” were placed adjacent to “turtles,” which were still one type of aquatic animal. On the other hand, “ornamental fish” are placed far away from poultry animals.
- Other areas were placed according to the degree of proximity.



Fig. 4. Proposed layout

Despite the significant insights derived from this study, there are several limitations that should be considered for future research. The Market Basket Analysis (MBA) utilized in this study depends on the quality of the collected transaction data. Any inaccuracy or incompleteness in the data can potentially skew the results. Moreover, the current study only utilized data from a single time period. Consumer behavior can vary due to seasonal changes, which were not captured in this research.

Therefore, future research can be conducted by integrating MBA and SLP using different case studies. The important note that should be taken when utilizing an MBA to determine the proximity level for SLP is that the researcher should ensure that the data collected is sufficient and captures the population.

#### 4. Conclusion

Based on the processing of transaction data using MBA, the following facility layout recommendations were identified as having the highest priority (absolutely important) with a confidence value of 91%: "Songbird" stands should be located next to "Bird Food" stands. The second priority (very important) with a confidence level of 80-90%: "Ornamental fish" vendors were placed near "Turtle" vendors. The third priority (important) with a confidence of 70-80%: "Bird Cages" kiosks were placed near "Songbirds" kiosks. The fourth priority (moderately important) with a confidence of 50-70%: "bird cages" were located next to "bird food" vendors, "cats" next to "dog" kiosks, and "bird cages" next to "songbirds" kiosks. Based on the insights gained from the results of the MBA calculations, recommendations for the market layout were given.

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