



Analysis of Optimization Strategy and Consumer Behavior using Game Theory and Markov Chain on Marketplace Competition.

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Abstract

Indonesia is one of the largest e-commerce markets, resulting in increasingly intense competition among marketplaces. This situation highlights the need to identify effective competitive strategies and understand consumer loyalty to maintain marketplace competitiveness. This study aims to determine optimal marketplace strategies using game theory, analyze marketplace loyalty using Markov chains, and examine consumer behavior among active students at UNNES and IPMAFA. Data were collected through questionnaires from 250 students selected using the Slovin formula and analyzed using SPSS and POM-QM. Seven attributes were examined: product diversity, price, shipping costs, discount vouchers, feature completeness, payment methods, and product reviews. The results show that the game values for Shopee vs. TikTok Shop (Tokopedia), TikTok Shop vs. Lazada, and Shopee vs. Lazada are 70.59, 84, and 135.14, respectively, with discount vouchers, product reviews, and price emerging as the dominant strategies. The Markov chain results indicate transition probabilities of 48.52% for Shopee, 39.50% for TikTok Shop and Tokopedia, and 11.98% for Lazada. The novelty of this study lies in integrating game theory and Markov chains to identify competitive strategies and predict marketplace loyalty. Discount vouchers are the most preferred attribute influencing purchasing decisions. Therefore, marketplaces should maintain their competitive advantages, particularly through effective promotional strategies, while continuously adapting to consumer preferences to reduce customer switching and strengthen loyalty.

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1. Introduction

Data from the We Are Social shows that in 2025, there will be 212 million internet users in Indonesia out of a total population of 285 million in 2024 [1]. The increase in the number of internet users will certainly also impact the growth in the number of marketplace users. A marketplace is a platform that serves as an intermediary between sellers and buyers to conduct online transactions. Based on [2], the three most accessed marketplaces by users in Indonesia are Shopee, Tokopedia, and Lazada. On the other hand, internet users also access social media. Tiktok ranks fourth as the most used social media [1]. With these advantages, TikTok has partnered with Tokopedia by providing the TikTok Shop [3]. The data shows that the trend of online shopping is growing very rapidly in Indonesia. Therefore, these marketplaces are competing fiercely to maintain their existence. An optimal strategy can help a marketplace win the market competition. To determine the optimal strategy, the strategy can be analyzed by utilizing one of the operation research through game theory [4], [5], [6], [7], [8], [9]. Game theory is one of the decision-making methods that combines mathematical theory and economic theory [4]. The main objective of game theory is to find the optimal strategy for players in the game [4].

Game theory uses pure strategies and mixed strategies [7], [10], [11]. First, the problem is solved using pure strategies to find the saddle point [10], [11]. If the pure strategy does not yield a saddle point, then the solution is carried out using a mixed strategy [10]. The steps to be taken in this strategy are to reduce the rows and columns using the principle of dominance, then find the saddle point as done in the pure strategy [10]. If the saddle point is still not obtained, then the game value is calculated using one of the alternative methods, namely linear programming [10], [11].

The variety of marketplaces allows users to access the various available marketplaces. This certainly impacts user loyalty and allows for brand (marketplace) switching. This marketplace migration can be analyzed using the Markov chain method [5], [12]. Markov chain have a special property of probability that involves how to process will evolve in the future depending only on the current state of the process and not on the past [10]. The Markov chain method is applied by calculating its transition probabilities over a specific time period.

In choosing and using the desired product, there is a behavior of consumers who are influenced by certain factors such as psychological factors and other external factors to consider buying the product [13]. This action is referred to as consumer behavior, which is the way consumers choose, buy, and use products or services to meet their needs or desires [14]. This consumer behavior analysis is needed to find out what factors influence consumers in considering buying a product. In this research, data will be collected from respondents who are active students of Universitas Negeri Semarang and Institut Pesantren Mathaliu'ul Falah. Students from both universities were chosen to conduct an analysis of consumer behavior in making purchasing decisions. After conducting preliminary data collection, it was found that the three marketplaces with the most users are Shopee, Tokopedia or Tiktok Shop, and Lazada.

Based on the background that has been described, several problem formulations in this research: First, how can the optimal strategy against marketplace competition be formulated using game theory? Second, what is the percentage of user loyalty for each marketplace using Markov chain? Then, how is the consumer behavior analysis of active students of Universitas Negeri Semarang and Institut Pesantren Mathaliu'ul Falah? This research analyzed optimal strategies using game theory, user loyalty with Markov chain, and provides a dashboard that presents data visualization results from the analysis of consumer behavior of students at Universitas Negeri Semarang and Institut Pesantren Mathaliu'ul Falah.

2. Method

2.1. Research Population and Research Sample

The population of this study is the active students from Universitas Negeri Semarang dan Institut Pesantren Mathaliu'ul Falah who access the marketplace. This study uses the stratified random sampling technique. To determine the sample size, the Slovin formula is used. Here is the formula to determine the total sample from each university.

$$n = \frac{N}{1 + Ne^2},$$

where N : total population, n : number of sampel, and e : error. Because of the number of students in each faculty is different, then a proportional calculation is used. Here is the formula.

$$n_i = \frac{N_i}{N} n,$$

where N_i : total population of the i -th stratum and n_i : number of samples of the i -th stratum.

2.2. Research Variables

The variables in this study are the attributes of the Shopee, Tiktok Shop (Tokopedia), and Lazada. Here are the attribute variables in this study.

Table 1. Attribute Variables

Game Attributes	Variables		
	Shopee	Tiktok Shop (Tokopedia)	Lazada
Product Diversity	X_1	Y_1	Z_1
Price	X_2	Y_2	Z_2

Shipping Costs	X_3	Y_3	Z_3
Discount			
Vouchers	X_4	Y_4	Z_4
Feature			
Completeness	X_5	Y_5	Z_5
Payment Methods	X_6	Y_6	Z_6
Product reviews	X_7	Y_7	Z_7

2.3. Data and Data Sources

The data that used in this research is primary data obtained from questionnaires. The questionnaire in this study is presented in the form of a form through Google Forms. Two questionnaires were distributed to collect data for game theory and Markov chain calculations. The first questionnaire is preliminary questionnaire to collect data on the three most used marketplaces, marketplace marketing strategies, and understand the factors influencing users purchasing decisions. The second one is a research questionnaire to collect data on user preferences in making marketplace selection decisions.

2.4. Game Theory

Data analysis with game theory is used to determine the game value of each marketplace and to identify the strategies that are the strengths of those marketplaces. Each game in game theory has two players, namely the row player and the column player [10], [11], [15]. Each player will gain and lose based on the strategies they use, where the row player maximizes gains while the column player minimizes losses [15], [16]. The profit or loss can be determined by looking at the pay-off values of each player's strategy [15], [17]. Here is the pay-off matrix.

Table 2. Pay-off Matrix

	Y_1	Y_2	$\dots$	Y_n
X_1	A_{11}	A_{12}	$\dots$	A_{1n}
X_2	A_{21}	A_{22}	$\dots$	A_{2n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
X_m	A_{m1}	A_{m2}	$\dots$	A_{mn}

where P_1 : row player; P_2 : column player; X_i : strategy of player 1, $i = 1, 2, 3, \dots, m$; Y_j : strategy of player 2, $j = 1, 2, 3, \dots, n$; a_{ij} : pay-off value, $i = 1, 2, 3, \dots, m$ and $j = 1, 2, 3, \dots, n$.

Based on the table 2, the minimum value is taken for the strategy of each row player. Meanwhile, the strategy of each column player is taken as the maximum value. After that, the row player must choose a strategy whose minimum pay-off is the largest, while the column player must choose a strategy whose maximum pay-off is the smallest [10], [11]. When the maximin value equals the minimax, then that point is a saddle point [10], [11]. When the saddle point is reached, the game can be solved with a pure strategy. However, when the saddle point is not reached, the game cannot be solved with pure strategies. Therefore, according to [11], to achieve the equilibrium point, a mixed strategy is used. A game with a mixed strategy is a game where the strategy used by each player is a combination of various different strategies [7]. A mixed strategy game is a game where the strategy used by each player is a combination of various different strategies [7]. If both players have more than two strategies, then the dominance technique can be applied [18]. If a saddle point is obtained, the game can be continued with a solution using pure strategies. If a saddle point is still not found, then it is necessary to use another alternative solution, one of which is linear programming. Every game with mixed strategies can be solved by transforming it into a linear programming problem [10].

The row player (P_1) is the player who maximizes profit. So, the optimal strategy for P_1 is the choice that corresponds to the maximin price for the mixed strategy.

$$\max_{x_i} \left\{ \min \left(\sum_{i=1}^m a_{i1}x_i, \sum_{i=1}^m a_{i2}x_i, \dots, \sum_{i=1}^m a_{in}x_i \right) \right\}$$

where $\sum_{i=1}^m x_i = 1$ and $x_i \geq 0$ for all $i = 1, 2, \dots, m$. Let,

$$V = \min \left(\sum_{i=1}^m a_{i1}x_i, \sum_{i=1}^m a_{i2}x_i, \dots, \sum_{i=1}^m a_{in}x_i \right) \quad (1)$$

then, (1) can be written as $\max f_0 = V$. We have

$$\sum_{i=1}^m a_{ij}x_i \geq V, j = 1, 2, \dots, n$$

where $\sum_{i=1}^m x_i = 1$ and $x_i \geq 0$ for all $i = 1, 2, \dots, m$; V = game value [11]. Let $V > 0$, then $\frac{\sum_{i=1}^m a_{ij}x_i}{V} \geq 1, j = 1, 2, \dots, n$.

Therefore, $\frac{\sum_{i=1}^m x_i}{V} (\sum_{i=1}^m a_{ij}) \geq 1, x_i \geq 0$, for all i . Because of $\sum_{i=1}^m x_i = 1$, then $\frac{\sum_{i=1}^m x_i}{V} = \frac{1}{V}$. Let $\frac{x_i}{V}$ denoted as X_i where $i = 1, 2, \dots, m$. Because of $\max V = \min \frac{1}{V} = \min (X_1 + X_2 + \dots + X_m)$, then the general form of the linear program for the row player is as follows.

Minimize $f_0 = X_1 + X_2 + \dots + X_m$

Constraint,

$$a_{11}X_1 + a_{21}X_2 + \dots + a_{m1}X_m \geq 1$$

$$a_{12}X_1 + a_{22}X_2 + \dots + a_{m2}X_m \geq 1$$

$\vdots$

$$a_{1n}X_1 + a_{2n}X_2 + \dots + a_{mn}X_m \geq 1$$

where $f_0 = \frac{1}{V}$ and $\frac{x_i}{V} = X_i; X_i \geq 0; i = 1, 2, \dots, m$ [11]

The column player (P_2) is the player who minimizes loses. So, the optimal strategy for P_2 is the choice that corresponds to the minimax price for the mixed strategy.

$$\min_{y_j} \left\{ \max \left(\sum_{j=1}^n a_{1j}y_j, \sum_{j=1}^n a_{2j}y_j, \dots, \sum_{j=1}^n a_{mj}y_j \right) \right\}$$

where $\sum_{j=1}^n y_j = 1$ and $y_j \geq 0$ for all $j = 1, 2, \dots, n$. Let,

$$V = \max \left(\sum_{j=1}^n a_{1j}y_j, \sum_{j=1}^n a_{2j}y_j, \dots, \sum_{j=1}^n a_{mj}y_j \right) \quad (2)$$

then, (2) can be written as $\min g_0 = V$. We have

$$\sum_{j=1}^n a_{ij}y_j \leq V, i = 1, 2, \dots, m$$

where $\sum_{j=1}^n y_j = 1$ and $y_j \geq 0$ for all $j = 1, 2, \dots, n$; $V = \text{game value}$ [11]. Let $V > 0$, then $\frac{\sum_{j=1}^n a_{ij}y_j}{V} \leq 1, i = 1, 2, \dots, m$.

Therefore $\frac{\sum_{j=1}^n y_j}{V} (\sum_{j=1}^n a_{ij}) \leq 1$, for all $i = 1, 2, \dots, m$. Because of $\sum_{j=1}^n y_j = 1$, then $\frac{\sum_{j=1}^n y_j}{V} = \frac{1}{V}$. Let $\frac{y_j}{V}$ denoted as Y_j where $j = 1, 2, \dots, n$. Since $\min V = \max \frac{1}{V} = \min(Y_1 + Y_2 + \dots + Y_n)$, the general form of the linear program for the column player is as follows.

Maximize $g_0 = Y_1 + Y_2 + \dots + Y_n$

Constraint,

$$a_{11}Y_1 + a_{12}Y_2 + \dots + a_{1n}Y_n \leq 1$$

$$a_{21}Y_1 + a_{22}Y_2 + \dots + a_{2n}Y_n \leq 1$$

$\vdots$

$$a_{m1}Y_1 + a_{m2}Y_2 + \dots + a_{mn}Y_n \leq 1$$

where $g_0 = \frac{1}{V}$ and $\frac{y_j}{V} = Y_j; y_j \geq 0; j = 1, 2, \dots, n$ [11].

2.5. Markov Chain

Markov chain is a method that can be used to estimate future parameters or variables by considering and studying the current parameters or variables [19]. Based on [10], [20], here is the process in Markov chain modeling.

1. Define the state.

The state i of a discrete time Markov chain is observed after each transition, where the possible states are $i = 0, 1, \dots, M$ [10].

2. Construct the transition probability matrix.

A matrix whose elements are the transition probability values from one state to another state, or to the same state within a certain system, is called a transition probability matrix. The r -step transition probability can be expressed in matrix form as

$$P^{(r)} = \begin{pmatrix} p_{00}^{(r)} & p_{01}^{(r)} & \dots & p_{0M}^{(r)} \\ p_{10}^{(r)} & p_{11}^{(r)} & \dots & p_{1M}^{(r)} \\ \vdots & \vdots & \dots & \vdots \\ p_{M0}^{(r)} & p_{M1}^{(r)} & \dots & p_{MM}^{(r)} \end{pmatrix}$$

3. Determining the steady state probability.

The steady state probability is defined as $\lim_{n \rightarrow \infty} p_{cd}^{(r)} = \pi_d > 0$, where π_d uniquely satisfy the following steady state equations [10].

$$\pi_d = \sum_{c=0}^M \pi_c p_{cd} \quad (3)$$

for $d = 0, 1, \dots, M$ and $\sum_{d=0}^M \pi_d = 1$. The π_d is called the steady state probability of the Markov chain. If (3) is expressed in matrix form, then the equation can be expressed as

$$\pi = \pi P^{(r)}$$

where $\pi = (\pi_0, \pi_1, \dots, \pi_M)$.

2.6. Research Flow Diagram

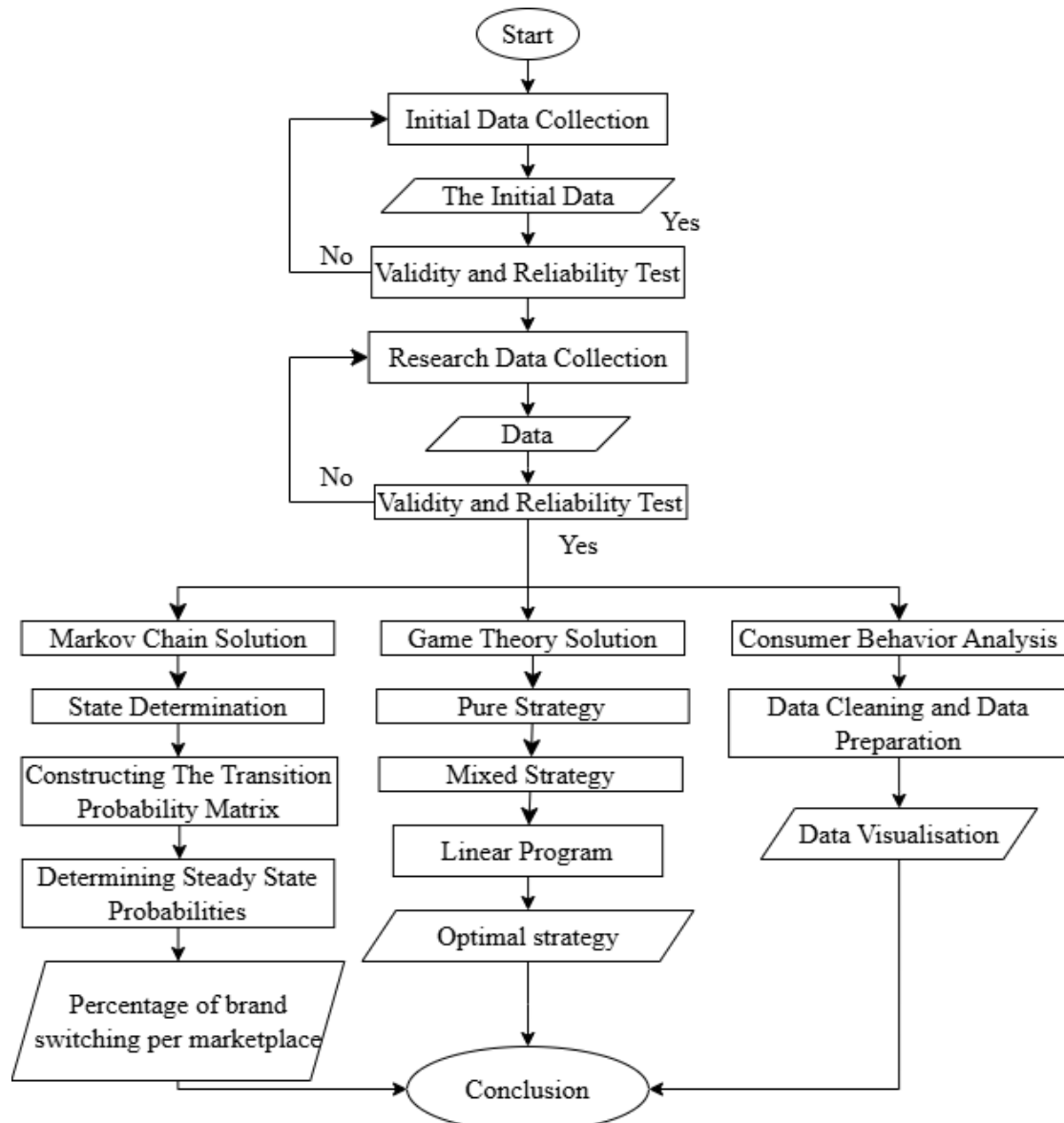


Figure 1. Research Flow Diagram

3. Results and discussions

3.1. Research Sample

The number of respondents in the preliminary questionnaire was assumed to be close to the normal distribution based on the central limit theorem that a normal approximation to the sample mean will generally be good if $n \geq 30$ [21]. So, the preliminary questionnaire obtained 108 respondents who used the marketplace and 2 respondents that did not use the marketplace. The sample calculation of research questionnaires on Universitas Negeri Semarang using the Slovin method is as follows.

$$n = \frac{52.352}{1 + (52.352)(0,1)^2} = \frac{52.352}{524,52} = 99,80935$$

Form this calculation, the sample of active students of Universitas Negeri Semarang was 100 respondents. While the sample calculation for Institut Pesantren Mathali'ul Falah is as follows.

$$n = \frac{1.730}{1 + (1.730)(0,1)^2} = \frac{52.352}{18,3} = 94,53551913$$

Form this calculation, the sample of active students of Institut Pesantren Mathali'ul Falah was 100 respondents. So, the minimum total number of respondents of research questionnaire are 200 respondents. After obtaining the total sample for each college, the number of samples for each faculty was determined by proportional calculation. In this study, 250 respondents filled out the research questionnaire who were active students of Universitas Negeri Semarang and Institut Pesantren Mathali'ul Falah.

3.2. Validity and Reliability Test

In this study, validity and reliability tests were carried out on preliminary questionnaires and research questionnaires that had been filled out by respondents. The data in the preliminary questionnaire used a likert scale

while the data in the research questionnaire used a nominal scale. Data was tested for validity using Pearson correlation. The formula of correlation Product Moment is as follows.

$$r_{vw} = \frac{n(\sum VW) - (\sum V)(\sum W)}{\sqrt{[n(\sum V^2) - (\sum V)^2][n(\sum W^2) - (\sum W)^2]}}$$

where r_{vw} : correlation coefficient, n : number of samples, V : variable score of V (strategy), and W : variable score of W (strategy). The data on the questionnaire is said to be valid if r_{hitung} (r_{vw}) is greater than r_{table} with a significance value of 10% [22]. Then to test the reliability of data with a likert scale and a nominal scale, the Cronbach's Alpha technique was used. Here is the formula.

$$r_{au} = \left[\frac{k}{k-1} \right] \left[1 - \frac{\sum \sigma_b^2}{\sigma_f^2} \right]$$

where r_{au} : reliability coefficient, k : number of strategies, $\sum \sigma_b^2$: total variance of items (each strategy), and σ_f^2 : total variance.

The preliminary questionnaire was filled out by 108 respondents. As shown in Table 3, the validity test results for each user preference factor in choosing a marketplace are valid.

Table 3. Validity of The Initial Data

Strategy/Atributes	r Value	r Table	Conclusion
Product Diversity	0,667	0,1591	Valid
Price	0,663	0,1591	Valid
Shipping Costs	0,643	0,1591	Valid
Discount Vouchers	0,613	0,1591	Valid
Feature Completeness	0,624	0,1591	Valid
Payment Methods	0,722	0,1591	Valid
Product reviews	0,638	0,1591	Valid

The reliability test was conducted using Cronbach's alpha. The reliability test result for the initial data is declared reliable and has a value of Cronbach's alpha value that fell into the high reliability because the value was between 0,70-0,90 [23]. The reliability test results are shown in Table 4.

Table 4. Reliability of The Initial Data

Strategy/Atributes	α	Conclusion
Product Diversity	0,734	Reliable
Price	0,735	Reliable
Shipping Costs	0,744	Reliable
Discount Vouchers	0,747	Reliable
Feature Completeness	0,765	Reliable
Payment Methods	0,721	Reliable
Product reviews	0,742	Reliable

In addition, the research questionnaire was filled out by 250 respondents. The results of the validity and reliability tests on the research questionnaire data also stated that the data were valid and reliable.

3.3. Game Theory Solution

3.3.1. Pure Strategy

The solution using a pure strategy is carried out by finding the smallest (minimum) value in each row and the largest (maximum) value in each column. Then the smallest value from each row is taken as the maximum value (maximin) and the largest value from each column is taken as the minimum value (minimax) [10], [11].

Table 5. Solution of Pure Strategy of Shopee and Tiktok Shop (Tokopedia)

		Tiktok Shop (Tokopedia)							Maximin
		Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	
Shopee	X_1	112	-12	26	-12	104	80	20	-12
	X_2	84	48	18	-22	108	106	36	-22
	X_3	66	42	78	-4	90	86	36	-4
	X_4	94	86	90	82	100	96	70	70
	X_5	36	-6	24	-20	106	84	34	-20
	X_6	44	12	8	-2	62	76	26	-2

	X_7	42	24	58	-16	78	86	74	-16
Minimax		112	86	90	82	108	106	74	

The steady state is not obtained in the pure strategy of Shopee and Tiktok Shop (Tokopedia) competition. So, based on [11], the solution of this competition is continued with a mixed strategy.

Table 6. Solution of Pure Strategy of Tiktok Shop (Tokopedia) and Lazada

		Lazada							Maximin
		Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	
Tiktok Shop (Tokopedia)	Y_1	126	56	90	60	144	122	106	56
	Y_2	112	96	110	58	152	132	120	58
	Y_3	108	70	98	48	108	128	94	48
	Y_4	122	98	128	84	132	126	108	84
	Y_5	78	36	88	48	104	104	76	36
	Y_6	74	46	90	48	82	126	88	46
	Y_7	108	74	96	72	114	134	128	72
Minimax		126	98	128	84	152	134	128	

The saddle point in the competition between Tiktok Shop (Tokopedia) and Lazada is 84.

Table 7. Solution of Pure Strategy of Shopee and Lazada

		Lazada							Maximin
		Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	
Shopee	X_1	154	92	126	98	164	140	134	92
	X_2	154	148	154	110	144	152	132	110
	X_3	140	112	120	98	146	142	124	98
	X_4	168	130	158	142	164	148	164	130
	X_5	136	90	118	84	162	142	150	84
	X_6	116	94	102	90	136	162	138	90
	X_7	144	106	136	100	146	150	166	100
Minimax		168	148	158	142	164	162	166	

The steady state is not obtained in the pure strategy of Shopee and Lazada competition. So, the solution of this competition is continued with a mixed strategy [11].

3.3.2. Mixed Strategy

The solution using a mixed strategy is carried out by principle of dominance [18]. If a row dominates another row or a column dominates another column, then the dominated row and column are eliminated [10]. Then determine the maximin and minimax values with pure strategy.

The reduction for Shopee and Tiktok Shop (Tokopedia) competition is reducing rows X_2, X_3, X_6, X_1, X_5 and reducing columns Y_1, Y_2, Y_3, Y_5 , and Y_6 . Then, the pay-off matrix after row and column elimination is as follows.

Table 8. Solution of Mixed Strategy of Shopee and Tiktok Shop (Tokopedia)

Shop	Tiktok Shop (Tokopedia)		Maximin
	Y_4	Y_7	
	X_4	82 70	
ee			70

	X_7	-16	74	-16
Minimax		82	74	

Since the saddle point has not been obtained, the competition between Shopee and Tiktok Shop (Tokopedia) can't be solved with a dominance strategy. Therefore, according to [10], the game theory solution is continued with the linear program simplex method.

The reduction for Shopee and Lazada competition is reducing rows X_1, X_3, X_5, X_6, X_7 and reducing columns Z_1, Z_3, Z_6 , dan Z_7 .

Table 9. Solution of Mixed Strategy of Shopee and Lazada

Shopee	Lazada			Maximin
		Z_2	Z_4	
	X_2	148	110	110
	X_4	130	142	130
Minimax		148	142	

Since the saddle point has not been obtained, the competition between Shopee and Lazada can't be solved with a dominance strategy. Therefore, according to [10], the game theory solution is continued with the linear program simplex method.

3.3.3. Linear Program

The first step in solving game theory using a linear program is to modify the pay-off matrix. The elements of the pay-off matrix must be non-negative numbers [10]. Therefore, the previous pay-off matrix that contains negative numbers must be modified by adding the smallest negative element with a constant k [10].

1. Shopee and Tiktok Shop (Tokopedia) competition

a. Row Player (Shopee)

Since in the pay off matrix of Shopee and Tiktok Shop (Tokopedia) competition there is a negative number -22, then the elements in the pay-off matrix must be added with a constant $k = 22$. Then the results of solving the linear program on row player using the POM-QM application are as follows.

Table 10. Optimal Solution of Shopee as a Row Player

Minimize	X_1	X_2	X_3	X_4	X_5	X_6	X_7		RHS	Dual
	1	1	1	1	1	1	1			
Constraint 1	134	106	88	116	58	66	64	$\geq$	1	0
Constraint 2	10	70	64	108	16	34	46	$\geq$	1	0
Constraint 3	48	40	100	112	46	30	80	$\geq$	1	0
Constraint 4	10	0	18	104	2	20	6	$\geq$	1	-0,0004
Constraint 5	126	130	112	122	128	84	100	$\geq$	1	0
Constraint 6	102	128	108	118	106	98	108	$\geq$	1	0
Constraint 7	42	58	58	92	56	48	96	$\geq$	1	-0,0104
Solution	0	0	0	0,0095	0	0	0,0013		0,0108	

Based on the results of the simplex method, to get the game value of the competition between Shopee and Tiktok Shop (Tokopedia), the following calculations are carried out.

$$f_0 = \frac{1}{V} = 0,0108$$

$$V = \frac{1}{f_0} = \frac{1}{0,0108} = 92,59$$

$$x_4 = 0,0095 \times 92,59 = 0,88$$

$$x_7 = 0,0013 \times 92,59 = 0,12$$

Then V is minus by constant of k added during the modification of the *pay-off* which is $k = 22$. So, the value of $V = 92,59 - 22 = 70,59$. Since the value of $x_4 = 0,88$ and $x_7 = 0,12$, the optimal strategy of the Shopee are discount voucher and product review strategies. So, the games value of the row player is 70,59 with strategies 4 and 7, which are discount vouchers (0,88) and product reviews (0,12).

b. Column Player (Tiktok Shop and Tokopedia)

The results of solving the linear program on column player using the POM-QM application are as follows.

Table 11. Optimal Solution of Tiktok Shop (Tokopedia) as a Column Player

Maximize	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7		RHS	Dual
	1	1	1	1	1	1	1			

Constraint 1	134	10	48	10	126	102	42	$\leq$	1	0
Constraint 2	106	70	40	0	130	128	58	$\leq$	1	0
Constraint 3	88	64	100	18	112	108	58	$\leq$	1	0
Constraint 4	116	108	112	104	122	118	92	$\leq$	1	0,0095
Constraint 5	58	16	46	2	128	106	56	$\leq$	1	0
Constraint 6	66	34	30	20	84	98	48	$\leq$	1	0
Constraint 7	64	46	80	6	100	108	96	$\leq$	1	0,0013
Solution	0	0	0	0,0004	0	0	0,0104		0,0108	

Based on the results of the simplex method, to get the game value of the competition between Shopee and Tiktok Shop (Tokopedia), the following calculations are carried out.

$$g_0 = \frac{1}{V} = 0,0108$$

$$V = \frac{1}{g_0} = \frac{1}{0,0108} = 92,59$$

$$y_4 = 0,0004 \times 92,59 = 0,037$$

$$y_7 = 0,0104 \times 92,59 = 0,96$$

Then V is minus by constant of k added during the modification of the *pay-off* which is $k = 22$. So, the value of is $V = 92,59 - 22 = 70,59$. Since the value of $y_4 = 0,037$ and $y_7 = 0,96$, the optimal strategy of the Tiktok Shop (Tokopedia) are discount voucher and product review strategies. So, the games value of the column player is 70,59 with strategies 4 and 7, which are discount vouchers (0,37) and product reviews (0,96).

2. Shopee and Lazada competition.

a. Row Player (Shopee)

The results of solving the linear program on row player using the POM-QM application are as follows.

Table 12. Optimal Solution of Shopee as a Row Player

Minimize	X_1	X_2	X_3	X_4	X_5	X_6	X_7		RHS	Dual
	1	1	1	1	1	1	1			
Constraint 1	154	154	140	168	136	116	144	$\geq$	1	0
Constraint 2	92	148	112	130	90	94	106	$\geq$	1	-0,0048
Constraint 3	126	154	120	158	118	102	136	$\geq$	1	0
Constraint 4	98	110	98	142	84	90	100	$\geq$	1	-0,0027
Constraint 5	164	144	146	164	162	136	146	$\geq$	1	0
Constraint 6	140	152	142	148	142	162	150	$\geq$	1	0
Constraint 7	134	132	124	164	150	138	166	$\geq$	1	0
Solution	0	0,0018	0	0,0057	0	0	0		0,0074	

Based on the results of the simplex method, to get the game value of the competition between Shopee and Lazada, the following calculations are carried out.

$$f_0 = \frac{1}{V} = 0,0074$$

$$V = \frac{1}{f_0} = \frac{1}{0,0074} = 135,14$$

$$x_2 = 0,0018 \times 135,14 = 0,24$$

$$x_4 = 0,0057 \times 135,14 = 0,77$$

Since the value of $x_2 = 0,24$ and $x_4 = 0,77$, the optimal strategy of the Shopee are price and discount voucher strategies. So, the games value of the row player is 135,14 with strategies 2 and 4, which are price (0,24) and discount voucher (0,77).

b. Column Player (Lazada)

The results of solving the linear program on column player using the POM-QM application are as follows.

Table 13. Optimal Solution of Lazada as a Column Player

Maximize	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7		RHS	Dual
	1	1	1	1	1	1	1			
Constraint 1	154	92	126	98	164	140	134	$\leq$	1	0
Constraint 2	154	148	154	110	144	152	132	$\leq$	1	0,0018
Constraint 3	140	112	120	98	146	142	124	$\leq$	1	0
Constraint 4	168	130	158	142	164	148	164	$\leq$	1	0,0057
Constraint 5	136	90	118	84	162	142	150	$\leq$	1	0

Constraint 6	116	94	102	90	136	162	138	$\leq$	1	0
Constraint 7	144	106	136	100	146	150	166	$\leq$	1	0
Solution	0	0,0048	0	0,0027	0	0	0		0,0074	

$$g_0 = \frac{1}{V} = 0,0074$$

$$V = \frac{1}{g_0} = \frac{1}{0,0074} = 135,14$$

$$z_2 = 0,0048 \times 135,14 = 0,65$$

$$z_4 = 0,0027 \times 135,14 = 0,36$$

Since the value of $z_2 = 0,65$ and $z_4 = 0,36$, the optimal strategy of the Lazada are price and discount voucher strategies. So, the games value of the column player is 135,14 with strategies 2 and 4, which are price (0,65) and discount voucher (0,36).

3.4. Markov Chain Solution

1. Define the state.

The state in this research is the marketplaces. From the results of the preliminary questionnaire, the top three marketplaces are Shopee, Tiktok Shop (Tokopedia), and Lazada.

Table 14. State Marketplace

State i	Marketplace Brand
State 0	Shopee
State 1	Tiktok Shop and Tokopedia
State 2	Lazada

2. Transition probability matrix

Based on the results of the research questionnaire that has been distributed to 250 respondents, the table below is a recapitulation of the values obtained.

Table 15. Markov Chain Data Recapitulation

	Shopee	Tiktok Shop and Tokopedia	Lazada	Total Users
Shopee	26	150	32	208
Tiktok Shop and Tokopedia	27	4	4	35
Lazada	7	0	0	7
			Total	250

After the data recapitulation from the Markov chain is obtained, the data is made into a transition probability matrix, by dividing each item by the number of users. The transition probability matrix is as follows.

Table 16. Transition Probability Matrix

	Shopee	Tiktok Shop and Tokopedia	Lazada	Total
Shopee	0,1250	0,7212	0,1538	1
Tiktok Shop and Tokopedia	0,7714	0,1143	0,1143	1
Lazada	1	0	0	1

3. Steady state probability

The next step is to determine the steady state probability in a transition probability matrix.

$$(\pi_0 \quad \pi_1 \quad \pi_2) = (\pi_0 \quad \pi_1 \quad \pi_2) \begin{pmatrix} 0,1250 & 0,7212 & 0,1538 \\ 0,7714 & 0,1143 & 0,1143 \\ 1 & 0 & 0 \end{pmatrix}$$

then,

$$\pi_0 = 0,125\pi_0 + 0,7714\pi_1 + \pi_2 \Leftrightarrow 0,8750\pi_0 - 0,7714\pi_1 - \pi_2 = 0$$

$$\pi_1 = 0,7212\pi_0 + 0,1143\pi_1 \Leftrightarrow -0,7212\pi_0 + 0,8857\pi_1 = 0$$

$$\pi_2 = 0,1538\pi_0 + 0,1143\pi_1 \Leftrightarrow -0,1538\pi_0 - 0,1143\pi_1 + \pi_2 = 0$$

and

$$\pi_0 + \pi_1 + \pi_2 = 1$$

then we have the following equation

$$0,8750\pi_0 - 0,7714\pi_1 - \pi_2 = 0 \quad (4)$$

$$-0,7212\pi_0 + 0,8857\pi_1 = 0 \quad (5)$$

$$-0,1538\pi_0 - 0,1143\pi_1 + \pi_2 = 0 \quad (6)$$

$$\pi_0 + \pi_1 + \pi_2 = 1 \quad (7)$$

To obtain the steady state probability, the (4), (5), and (6) equation can be expressed as

$$(\pi_0 \ \pi_1 \ \pi_2) \begin{pmatrix} 0,875 & -0,7212 & -0,1538 \\ 0,7714 & 0,8857 & -0,1143 \\ -1 & 0 & 1 \end{pmatrix} = (0 \ 0 \ 0).$$

Since the matrix multiplication is equal to zero matrix, so, the (4) equation is replaced by (7). Then,

$$\begin{aligned} (\pi_0 \ \pi_1 \ \pi_2) \begin{pmatrix} 1 & -0,7212 & -0,1538 \\ 1 & 0,8857 & -0,1143 \\ 1 & 0 & 1 \end{pmatrix} &= (1 \ 0 \ 0) \\ \Leftrightarrow (\pi_0 \ \pi_1 \ \pi_2) &= (1 \ 0 \ 0) \begin{pmatrix} 1 & -0,7212 & -0,1538 \\ 1 & 0,8857 & -0,1143 \\ 1 & 0 & 1 \end{pmatrix}^{-1} \\ \Leftrightarrow (\pi_0 \ \pi_1 \ \pi_2) &= (1 \ 0 \ 0) \begin{pmatrix} 0,4852 & 0,3951 & 0,1198 \\ -0,6104 & 0,6320 & -0,0216 \\ -0,4852 & -0,3951 & 0,8802 \end{pmatrix} \\ \Leftrightarrow (\pi_0 \ \pi_1 \ \pi_2) &= (0,4852 \ 0,3951 \ 0,1198) \end{aligned}$$

Thus, the steady state probability is

Table 17. Steady State Probability

Variable	Marketplace	Steady State Probability
π_0	Shopee	0,4852
π_1	Tiktok Shop and Tokopedia	0,3951
π_2	Lazada	0,1198

The steady state probabilities can also be generated from transition probabilities over a period of time. A probability is said to reach a steady state if the transition probability produces the same value continuously. The calculation of the transition probability using POM-QM is obtained as follows.

Table 18. Transition Probability at Time Period

Period	Shopee	Tiktok Shop and Tokopedia	Lazada
1	0,24	0,616	0,144
2	0,6492	0,2435	0,1073
3	0,3763	0,496	0,1277
4	0,5574	0,3281	0,1146
5	0,4373	0,4394	0,1232
6	0,5169	0,3656	0,1175
7	0,4641	0,4145	0,1213
⋮	⋮	⋮	⋮
20	0,4853	0,3949	0,1198
21	0,4851	0,3951	0,1198
22	0,4852	0,395	0,1198
23	0,4852	0,395	0,1198
24	0,4852	0,395	0,1198

Based on table 18, it can be seen that one year ahead after the current period, Shopee has decreased users quite drastically, from 83,2% to 24%. Entering the 2nd period, Shopee users began to increase again to 64%, then decreased again in the 3rd period. The number of Shopee users from period to period is unstable because it increases and decreases alternately every period until period 21. However, in the 22nd period onwards, the number of Shopee users began to stabilize at a value of 48,52%. Meanwhile, Tiktok Shop (Tokopedia) has increased to 61,6% where these users are users who initially chose Tiktok Shop (Tokopedia) and users from other marketplaces who switch to the Tiktok Shop (Tokopedia). However, after the 1st period, Tiktok Shop (Tokopedia) decreased drastically to 24,32%. Then it increased again in the 3rd period, but the number of users decreased again in the 4th period. The number of Tiktok Shop (Tokopedia) users from period to period is unstable because it increases and decreases alternately every period. However, in the 22nd period onwards, the number of Tiktok Shop (Tokopedia) users began to stabilize at a value of 39,5%. In contrasted with Lazada, the number of Lazada users is relatively stable at 11%. In the 22nd period onwards, the number of Lazada users reached a steady state of 11,98%. Therefore, it can be concluded that the transition probability reaches a steady state during the 22nd period where 48,52% of users (loyal users and users switching from other marketplaces) will use Shopee as the main marketplace, 39,5% use Tiktok Shop and Tokopedia, and 11,98% use Lazada.

3.5. Consumer Behavior Analysis

Datasets that have been processed in data cleaning and data preparation through Google Colab, then visualized in a dashboard through Looker Studio. The following is the visualization dashboard.



Figure 2. Marketing Performance Dashboard

The dashboard can be accessed through <https://lookerstudio.google.com/reporting/0f845b81-edc7-4541-bf0d-64158e51473f>.

Based on the dashboard, analysis of consumer behavior among active students of Universitas Negeri Semarang and students of Institut Pesantren Mathali'ul Falah revealed that out of a total of 250 respondents, only 12.5% of users continued using Shopee and 11.4% continued using Tiktok Shop and Tokopedia. As many as 72.1% of Shopee users switched to Tiktok Shop (Tokopedia), 77.1% of Tiktok Shop (Tokopedia) users switched to Shopee, 11.4% of Tiktok Shop (Tokopedia) users switched to Lazada, 15.4% of Shopee users switched to Lazada, and 100% of Lazada users switched to Shopee. Here, a fairly unique incident occurs where it is possible to exchange users between these

marketplaces. From the dashboard, we can also know that the strategy most chosen by users before making a purchase decision on the three marketplaces is a discount voucher. So, the possibility of switching brands by users can occur because the dominant strategy of the three marketplaces is the same. If a marketplace has problems or a decline in its superior strategy, then users may move to other marketplaces that offer the same strategy. From the previous Markov chain results, it was found that in the first period, the number of Tiktok Shop (Tokopedia) users increased drastically from 14% to 61.6% because many Shopee users switched to Tiktok Shop (Tokopedia). This happens because the strategies most chosen by users from both marketplaces are relatively the same, such as excelling in discount voucher strategies, pricing, and product reviews. So, if one of the marketplaces encounters an issue, users will easily switch to the other marketplace. Therefore, both marketplaces must compete with each other on those strategies to maintain their existence. So, each marketplace must maintain the strategy that becomes its advantage according to calculations using game theory.

4. Conclusion

Based on the research results obtained, it can be concluded that Shopee's optimal strategies are discount vouchers (0,88) and product reviews (0,12). Tiktok Shop (Tokopedia)'s optimal strategy is discount vouchers (0,037) and product reviews (0,96). The game value generated by both is 70,59. Then the optimal strategy of Tiktok Shop (Tokopedia) and Lazada is price. The game value in their competition is 84. In Shopee and Lazada competition, Shopee's optimal strategy is price (0,24) and discount vouchers (0,77). Lazada's optimal strategy is price (0,65) and discount voucher (0,36). The game value generated by both is 135,14. The percentage of marketplace user loyalty based on calculations using Markov chain obtained that the percentage of Shopee's transition probability is 48,52%, Tiktok Shop and Tokopedia is 39,5%, and Lazada is 11,98%. Analysis of consumer behavior among active students of Universitas Negeri Semarang and students of Institut Pesantren Mathali'ul Falah revealed that there is a possibility of switching users from one marketplace to another. If the initial marketplace used has problems or a decrease in its superior strategy, then there is a possibility that users move from one marketplace to another because the three marketplaces have relatively the same superior strategy, which is a discount voucher strategy. So, if one of the marketplaces encounters an issue, users will easily switch to the other marketplace. Therefore, the marketplaces must compete with each other on those strategies to maintain their existence. Each marketplace must maintain the strategy that becomes its advantage according to calculations using game theory.

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