



# Investing in Mutual Funds Before and During the Covid-19 Pandemic: An Analysis using Markov Chain

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## ABSTRACT

Indonesian people's interest in stocks and mutual funds is still low compared to other investment instruments. This study aims to evaluate the performance of mutual funds in Indonesia before and during the COVID-19 pandemic. Markov chain is used to assess the performance of each type of mutual fund because of its accuracy and suitability for data showing volatility. The results showed that all types of mutual funds experienced an increase with a probability of more than 50% in the long term. Money market mutual funds, both Islamic and conventional, have the highest probability of increasing by more than 90%. The first passage time can indicate how much price volatility is, wherein in this study, stock mutual funds and sharia stock mutual funds have high volatility. Before conducting further technical analysis, the Markov chain can be used to choose the type of mutual fund that is anticipated to increase.

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## 1. INTRODUCTION

A survey from the Bank of Indonesia showed that stocks and mutual funds are the investment instruments with the slightest public interest in the last four years. This condition may occur because investing in stocks and mutual funds carries a greater risk than other instruments. During the COVID-19 pandemic, investors tend to choose low-risk investments, such as gold, to maintain investment values (Sulistiwati et al., 2021; Yousaf et al., 2021; Yuliana & Robiyanto, 2021).

Risk can be defined as a negative return on investment. Statistically, risk can be described by the standard deviation of price. The higher the price fluctuation, the greater the risk faced by investors (Mangram, 2013), whereas the greater the risk, the greater the return (Philavong & Phomvongsa, 2021). On this basis, investors must be able to calculate the risk and return to maximize profits. Several techniques can be used to predict the price, such as fundamental, technical, psychological analysis, and Markov chain (Oseghale &

Michael, 2020; Sariyer et al., 2018).

Several studies using the Markov chain showed that the Markov chain is an effective technique for evaluating and predicting the price behaviour of investment instruments. Wu (2021) conducted a study using Markov chains to evaluate stock prices showing that Markov chains have an average accuracy of 99.155%. Uzun & Kiral (2017) use the Markov chain to predict gold prices, where the study showed that gold in the long term has a higher probability of increasing than falling. In addition, Filip & Rogala (2021) used the Markov chain to evaluate the performance of mutual funds in Poland. The study showed that the long-term performance of mutual funds with small managed funds is more likely to increase than mutual funds with large managed funds.

This study aims to evaluate the performance of mutual funds using data before and during the Covid-19 Pandemic. The Markov chain is used as an evaluation technique because of its effectiveness in predicting the volatility of the price of

investment instruments.

**2. RESEARCH METHODS**

A stochastic process can be said to be a Markov chain when the process meets the following properties (Equation 1):

$$P\{X_{t+1} = j | X_0 = k_0, X_1 = k_1, \dots, X_{t+1} = k_{t-1}, X_t = i\} = P\{X_{t+1} = j | X_t = i\} \tag{1}$$

Where  $t = 0, 1, \dots$  and so for the sequence  $i, j, k_0, k_1, \dots, kt+1$

Markovian properties can be defined as the conditional probability of a state in the future ( $t + 1$ ) which only depends on the current state (Hillier & Lieberman, 2001). Suppose a Markov chain ( $X_{t+1} = j | P(X_t = i) = P_{ij}$  with infinite state space,  $t = 0, 1, 2, \dots$ .  $P_{ij}$  can be said to be a one-step transition probability from state  $i$  to the previous time to state  $j$  at the current time. Suppose  $s$  is the number of states; then the transition probability can be described as an  $s \times s$  matrix as follows:

$$P = \begin{bmatrix} p_{11} & p_{12} & \dots & p_{1s} \\ p_{21} & p_{22} & \dots & p_{2s} \\ \vdots & \vdots & & \vdots \\ p_{s1} & p_{s2} & \dots & p_{ss} \end{bmatrix} \tag{2}$$

The study used data on the closing prices of each mutual fund from March 1, 2017, to March 1, 2022. The period ( $t$ ) used in this study is in a month. The closing price of the mutual fund is obtained from Bareksa (<https://www.bareksa.com>). There are eight types of mutual funds: Stock, Fixed Income, Balanced, Money Market, Sharia Stock, Sharia Fixed Income, Sharia Balanced, and Sharia Money Market Mutual Funds.

Data processing begins by calculating the difference between the closing price of the  $t+1$  period and the previous period ( $t$ ). The data are grouped into four states: *drastically up (DU)*, *up (U)*, *down (D)*, and *drastically down (DD)*, as research by Fitriyanto & Lestari (2018). A state is classified as DU if there is an increase by more than the average increase. On the other hand, the state is categorized as DD if there is more than the average decrease. The results are then used to calculate the frequency of state transitions, one-step transition probabilities,  $n$ -step transition probabilities, steady-state probabilities, and first passage time.

**3. RESULTS AND DISCUSSION**

Table 1 and Table 2 show the closing price of each mutual fund. The data for stock, fixed income, balanced, and money market mutual

funds are depicted in Table 1. At the same time, the data for stock sharia, fixed income sharia, balance sharia, and money market sharia mutual funds are shown in Table 2.

**Table 1.** The Closing Price of the Mutual Funds

Date	Stock	Fixed income	Balance	Money market
	5251.47	2787.60	2884.28	1232.25
March 01, 2017	5474.30	2847.89	2959.65	1236.85
– March 01, 2022	5451.63	2863.54	2962.38	1241.34
	5528.29	2881.48	2984.56	1244.51
	...	...	...	...
	4557.69	3493.14	3111.73	1430.23
	4474.09	3490.38	3084.66	1433.25
	4582.00	3501.41	3133.81	1434.56

**Table 2.** The Closing Price of the Mutual Funds

Date	Stock sharia	Fixed income sharia	Balance sharia	Money market sharia
	2111.16	2610.63	3272.69	1195.86
March 01, 2017	2229.26	2665.44	3360.68	1199.56
– March 01, 2022	2200.62	2680.90	3378.48	1209.00
	2240.93	2698.68	3376.11	1206.37
	...	...	...	...
	1333.76	3199.74	3288.21	1373.41
	1311.21	3198.08	3260.42	1376.57
	1329.15	3207.69	3293.45	1378.77

Table 3 depicts the state transition and state transition probability matrix. The order of the state from top to bottom and left to right is DU, U, D, and DD, respectively. Let's take the stock mutual fund as an example of state categorization. The closing price on 01/03/18 is 2787.60, while the closing price on 01/04/18 is 2847.89. The change between 01/03 and 01/04 is 21.08. The average increase for the 60 periods (01/03/18 – 01/03/22) is 31.10, and the average decrease is -30.08. Based on the calculation, the transition from 01/03/17 to 01/04/17 can be categorized as *Up (U)* because the increase was less than the average increase.

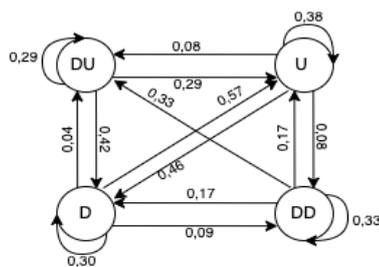
A transition probability matrix can be converted into a transition probability diagram. Because of the page limitation, this paper only depicts three types of mutual funds: stock, fixed income, and balanced mutual funds. Fig. 1, Fig. 2, and Fig. 3 show a transition probability diagram for stock, fixed income, and balanced mutual funds.

The most significant probability for stock mutual funds will be in the transition from D to U, with more than 57% probability (Fig. 1). It means that if this month's state is Down, there is a probability of 57% that the state will increase in the next month. In addition, if this month's state increases, the next month's state will go down with more than a 46% probability. On the fixed-income

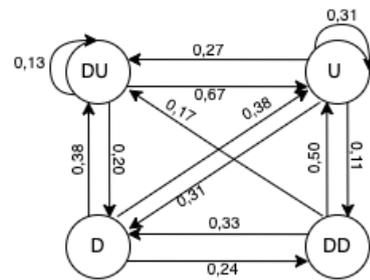
mutual funds (Fig. 2), the highest transition probability will be a transition from DU to U at around 67%, followed by a transition from DD to U with a 50% probability. On the other hand, balanced mutual funds (Fig. 3) show that the highest transition probability is D to U, with more than 70% probability. It indicates that if the state in month  $n$  is Down, there will be more than a 70% probability that in month  $n+1$ , the state is Up. The three mutual funds show the same behaviour, with a transition to U being the highest transition probability.

**Table 3.** State Transition Probability Matrix

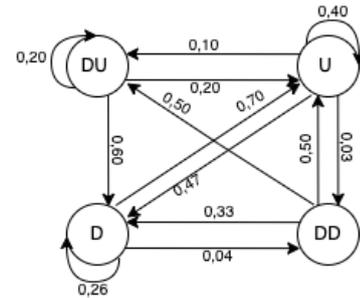
Mutual fund	State transition	State transition probability matrix		
Stock	$\begin{bmatrix} 2 & 2 & 3 & 0 \\ 2 & 9 & 11 & 2 \\ 1 & 13 & 7 & 2 \\ 2 & 1 & 1 & 2 \end{bmatrix}$	$\begin{bmatrix} 0,29 & 0,29 & 0,42 & 0,00 \\ 0,08 & 0,38 & 0,46 & 0,08 \\ 0,04 & 0,57 & 0,30 & 0,09 \\ 0,33 & 0,17 & 0,17 & 0,33 \end{bmatrix}$		
	Stock sharia	$\begin{bmatrix} 1 & 2 & 3 & 0 \\ 2 & 5 & 13 & 0 \\ 2 & 13 & 9 & 4 \\ 1 & 1 & 2 & 2 \end{bmatrix}$	$\begin{bmatrix} 0,17 & 0,33 & 0,50 & 0,00 \\ 0,10 & 0,25 & 0,65 & 0,00 \\ 0,07 & 0,46 & 0,32 & 0,14 \\ 0,17 & 0,17 & 0,33 & 0,33 \end{bmatrix}$	
		Fixed income	$\begin{bmatrix} 2 & 10 & 3 & 0 \\ 7 & 8 & 8 & 3 \\ 5 & 5 & 0 & 3 \\ 1 & 3 & 2 & 0 \end{bmatrix}$	$\begin{bmatrix} 0,13 & 0,67 & 0,20 & 0,00 \\ 0,27 & 0,31 & 0,31 & 0,11 \\ 0,38 & 0,38 & 0,00 & 0,24 \\ 0,17 & 0,50 & 0,33 & 0,00 \end{bmatrix}$
			Fixed income sharia	$\begin{bmatrix} 3 & 8 & 4 & 0 \\ 7 & 11 & 7 & 2 \\ 4 & 6 & 2 & 2 \\ 1 & 2 & 1 & 0 \end{bmatrix}$
Balance				$\begin{bmatrix} 1 & 1 & 3 & 0 \\ 3 & 12 & 14 & 1 \\ 0 & 16 & 6 & 1 \\ 1 & 1 & 0 & 0 \end{bmatrix}$
	Balance d sharia			$\begin{bmatrix} 1 & 2 & 1 & 0 \\ 1 & 9 & 14 & 3 \\ 1 & 14 & 5 & 2 \\ 1 & 3 & 1 & 2 \end{bmatrix}$
		Money market		$\begin{bmatrix} 5 & 7 & 0 & 1 \\ 8 & 31 & 1 & 0 \\ 0 & 1 & 5 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}$
			Money market sharia	$\begin{bmatrix} 3 & 8 & 1 & 1 \\ 10 & 30 & 2 & 0 \\ 0 & 4 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$



**Fig. 1.** State Probability Diagram (Stock Mutual Funds)



**Fig. 2.** State Probability Diagram (Fixed Income)



**Fig. 3.** State Probability Diagram (Balance Mutual Funds)

**3.1 N-step probability matrix**

The  $n$ -step transition matrix determines the change of states after the  $n$  periods. In addition, this concept is also used to calculate the probability at a steady state. The calculation results are shown in Table 4. Each type of mutual fund has  $n$  different periods to reach a steady state. Equity mutual funds, fixed-income mutual funds, and mixed funds went into a steady state in the ninth period.

Table 5 shows the steady-state probabilities for all types of mutual funds. All kinds of mutual funds in the long term will increase. Money market sharia becomes the type of mutual fund with the highest probability of increasing by more than 90% in the long term. On the other hand, stock sharia becomes the type of stock with the most negligible probability of increasing at around 55%.

**3.2 First Passage Time**

First passage time can determine the average number of transitions required from state  $i$  to state  $j$  for the first time. In this study, the first passage time can be interpreted as how long an investor can keep his investment until the instrument moves from the state up to the state down. Table 6 shows the calculation of the first passage time.

In this study, mean first passage time provides information on how long the transition from state  $i$  to  $j$ . For stock mutual funds, it takes 2,33 months to transition from Drastic Up (DU) to Down (D). Investor in stock mutual funds can hold

their investment for 2,33 months before the state turns *Down*.

**Table 4.** N-Step Probability Matrix

Mutual funds	N-step probability matrix				
Stock	$P^6 =$	0.11	0.42	0.37	0.10
		0.11	0.42	0.37	0.10
		0.11	0.42	0.37	0.10
		0.11	0.42	0.37	0.10
Stock sharia	$P^8 =$	0.10	0.35	0.45	0.10
		0.10	0.35	0.45	0.10
		0.10	0.35	0.45	0.10
		0.10	0.35	0.45	0.10
Fixed income	$P^6 =$	0.25	0.43	0.22	0.10
		0.25	0.43	0.22	0.10
		0.25	0.43	0.22	0.10
		0.25	0.43	0.22	0.10
Fixed income sharia	$P^4 =$	0.25	0.45	0.23	0.07
		0.25	0.45	0.23	0.07
		0.25	0.45	0.23	0.07
		0.25	0.45	0.23	0.07
Balance	$P^6 =$	0.08	0.50	0.39	0.03
		0.08	0.50	0.39	0.03
		0.08	0.50	0.39	0.03
		0.08	0.50	0.39	0.03
Balanced sharia	$P^9 =$	0.07	0.46	0.35	0.12
		0.07	0.46	0.35	0.12
		0.07	0.46	0.35	0.12
		0.07	0.46	0.35	0.12
Money Market	$P^{34} =$	0.23	0.67	0.08	0.02
		0.23	0.67	0.08	0.02
		0.23	0.67	0.08	0.02
		0.23	0.67	0.08	0.02
Money market sharia	$P^6 =$	0.22	0.70	0.07	0.01
		0.22	0.70	0.07	0.01
		0.22	0.70	0.07	0.01
		0.22	0.70	0.07	0.01

**Table 5.** Steady-State Probability

Mutual funds	Drastic up	Steady State		
		Up	Down	Drastic down
Stock	0.11	0.42	0.37	0.10
Sharia stock	0.10	0.35	0.45	0.10
Fixed income	0.25	0.43	0.22	0.10
Sharia fixed income	0.25	0.45	0.23	0.07
Money market	0.23	0.67	0.08	0.02
Sharia money market	0.22	0.70	0.07	0.01
Balance	0.08	0.50	0.39	0.03
Sharia balance	0.07	0.46	0.35	0.12

**Table 6.** First Passage Time

Mutual funds	First Passage Time			
Stock	0	2.60	2.33	14.21
	10,32	0	2.34	12.87
	10,67	2.01	0	12.78
	6,75	3.30	3.25	0
Sharia Stock	0	2.68	1.83	14.87
	10.71	0	1.57	14.62
	10.82	2.47	0	13.04
	9.58	3.40	2.35	0
Fixed income	0	1.63	3.85	10.06
	3,52	0	3.50	9.07
	3,24	2.08	0	8.36
	3,84	1.96	3.39	0
Sharia fixed income	0	1.97	3.80	14.93
	3.78	0	3.83	13.96
	3.69	2.16	0	13.13
	3.81	2.03	3.87	0
Balance	0	2.36	1.78	29.50
	12.97	0	2.12	28.49
	14.00	1.48	0	28.17
	4.48	2.18	2.96	0
Sharia balanced	0	1.88	2.80	11.64
	18.72	0	2.20	10.25
	18.63	1.65	0	10.42
	16.36	2.10	3.28	0
Money Market	0	1.75	55.75	53.25
	5.75	0	54	59
	11.75	6	0	65
	6.75	1	55	0
Sharia money market	0	1.6	12,6	53,6
	4.4	0	14	58
	5.4	1	0	59
	6.4	2	1	0

### 3.4 Discussion

All mutual funds will increase in the long term based on the steady-state probability. Stock and sharia stock mutual funds will likely increase by 53.% (11% in DU + 42% in U) and 45 %, respectively. These results align with research conducted by [Aprilianti et al. \(2022\)](#) using the Sharpe and Treynor method. The research found that the performance of conventional and sharia equity mutual funds is increasing during the COVID-19 pandemic. Fixed and sharia fixed-income mutual funds will likely increase by 68 % and 70%, respectively. These results align with research conducted by [Handayani et al. \(2019\)](#), which states that sharia fixed-income mutual funds are more stable than conventional fixed-income mutual funds because, with lower risk, the returns obtained are not much different.

Balanced and sharia-balanced mutual funds have a probability of increasing by 58% and 53%, respectively. These results align with research conducted by [Purbowisanti \(2020\)](#), which states that sharia-balanced mutual funds have a much greater risk potential than

conventional mixed mutual funds, as indicated by a higher level of volatility. Money market and sharia money market mutual funds are likely to increase by 90% and 92%, respectively. Unlike other mutual fund products, money market/islamic money market mutual funds have the lowest probability of going down drastically down. This result is in line with research conducted by Putri & Wijaya (2022), which states that money market mutual funds are the only mutual fund products that never lose money and have positive performance for both conventional and sharia money markets mutual funds.

Fig. 4 compares the performance of eight types of mutual funds. Based on the first passage time, it shows that stock and sharia stock mutual funds have high volatility, as indicated by the small value in the first passage time. Meanwhile, conventional and sharia fixed income and money market mutual funds have low volatility, as indicated by their sizeable first passage time values.

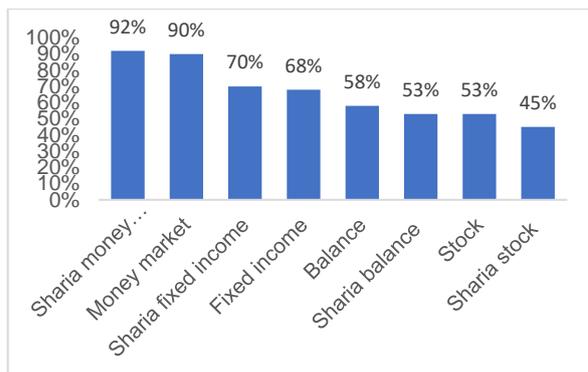


Fig. 4. Performance of Mutual Funds

This study only incorporates the probability of increasing every type of mutual fund. This study does not consider the profitability of every kind of mutual fund. As shown in Fig. 4, stock and sharia stock have the most negligible probability of an increase in the long term. Stock and sharia stock become the mutual with the highest risk compared to other types of mutual funds because, in a stock mutual fund, more than 80% of the investment portfolio is in stock.

#### 4. CONCLUSION

Based on the  $n$ -step matrix, all types of mutual funds have increased in the long term. All kinds of mutual funds are likely to rise by more than 50%, except for the sharia stock mutual fund. Money market mutual funds, both Islamic and conventional, have the highest probability of increasing by more than 90%. The first passage time can indicate how much price volatility is, wherein in this study, stock mutual funds and

sharia stock mutual funds have high volatility. Before conducting further technical analysis, the Markov chain can be used to choose the type of mutual fund that is anticipated to increase. A detailed study can then be conducted in the kind of mutual fund selected from the Markov chain analysis. Future research can be performed on analyzing other types of investment, such as gold and stock, by incorporating the event of the Covid-19 pandemic.

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