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DEVELOPMENT OF EXPECTED MONETARY VALUE USING BINOMIAL STATE PRICE IN DETERMINING STOCK INVESTMENT DECISIONS

Giovanny Theotista[1*], Margareta Febe[2], Yvone Marshelly[3]

[1] *Data Science Study Program, Faculty of Technology and Design, Bunda Mulia University*
[2,3] *Accounting Study Program, Faculty of Social and Humaniora, Bunda Mulia University*
Lodan Raya Street no. 2, Jakarta-14430, Indonesia.

*Corresponding author's e-mail: * **giovannytheotista@gmail.com***

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ABSTRACT

Stock investment is an investment opportunity. This stock investment carries relatively high risk and therefore requires additional analysis to minimize losses and maximize profits. Expected Monetary Value (EMV) is a simple modeling method for estimating the value of an investment that will provide the greatest future return. The expected monetary value (EMV) method involves multiplying the total value of each scenario by the probability of that scenario occurring. However this method has weaknesses in terms of how many cases occur what is the value of each case and what is the probability of each case occurring. Binomial State Price is a method commonly used to calculate stock options and real options but includes the step of modeling the value of an investment in many situations and opportunities that arise in the future. In this paper, our objective is to develop the EMV method with the binomial state pricing model to determine the investment that offers the most favorable payoff. In short, we can develop the expected monetary value (EMV) method and the binomial state pricing model. It was found that this model always recommends stocks which have high dividens.

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1. INTRODUCTION

Financial freedom is the state in which a person has enough money to meet their basic needs. Having financial freedom enables individuals to make life decisions without worrying about financial constraints [1]. As a consequence of the desire to achieve financial freedom, those who start investing sooner are better prepared for financial freedom and can live without worrying about financial constraints in the future. One approach to achieving financial freedom is investing in stocks.

Stocks are also called equity securities. Equity securities represent a share of ownership of the corporation. Holders of equity securities are entitled to the earnings of the corporation when those earnings are distributed in the form of dividends; they are also entitled to a proportional share of the remaining equity in case of liquidation [2]. Dividend payments provide additional benefits to investors along with capital gains. We cannot expect dividends because not all companies pay dividends. Dividend policy is the decision whether the profits earned by the company are distributed to investors as dividends or retained in the form of retained earnings to finance future investments [3].

Stock investments are not without risk. The investor must be known that risk is very closely related to profit and loss, like two sides of a coin. In investing, we often hear the phrase "high risk, high return". The greater the risk, the greater the potential profit or loss. Conversely, low risk tends to reduce the chances of profit or loss. Risk cannot be avoided, but it can be minimized with good and proper planning [4]. The investors should manage financial risk using a variety of strategies and products. It is important to understand how these products and strategies work to reduce risk within the context of the investor's risk tolerance and objectives. Careful calculations should be made to minimize the risk of losses incurred. One of the options is to use Expected Monetary Value (EMV). This is a simple way to calculate the investment with the highest profit potential.

Expected Monetary Value (EMV) method consists of maximizing the sum of payoff of each situation multiplied by the probability of that situation occurring. However, this method has weaknesses in terms of the number of situations that occur, payoff of each situation, and the probability of each situation occurring. Article [5] consider that EMV is usually combined with decision tree methods to select the alternative that is considered the most appropriate. One of the financial models used to model the value of investments (especially stocks and real options) over the next few timesteps is the binomial state price. Binomial state price allows you to calculate possible future situations, payoff of each situation, and calculate the probability of that situation occurring.

It is interesting to develop the expected monetary value (EMV) method and the binomial state pricing model. In other words, by using the binomial state price, we expect the decision to be made using the expected monetary value (EMV) without knowing the upfront payment. Obtained payoffs (the payoffs in this study are obtained solely from modeling stock prices and dividends without the use of other tools such as taxes, investment costs, etc.), the number of payoffs that occur, and the likelihood of each payoff. In addition, by using multiple stock prices from companies that are members of LQ45 because according to [6], LQ45 is considered a good choice of stock, the combined expected monetary value (EMV) method and the binomial state pricing model are simulated in decision making.

2. RESEARCH METHODS

Article [7] discusses the application of expected monetary value (EMV) using decision tree in project decision making. We utilize the model from [8] and [9] to represent expected monetary value (EMV). Assume that there are several alternatives with payoff in each option and the probability that this payoff will occur, the expected monetary value (EMV) for each alternative can be determined. Expected cost or average cost is the long-run average cost of a decision. The EMV for an alternative is the sum of all possible outcomes for each alternative multiplied by the probability that the outcome will occur. Mathematically it can be written:

$$EMV(i) = \sum_{j=1}^{n} X_{ij} \times P(X_{ij}) \tag{1}$$

where

X_{ij} = payoff for possibility j in alternative choice i

$P(X_{ij})$ = probability of occurrence X_{ij}

n = the number of possible different payoffs

The following table are 10 company stocks and their dividends which are members of the Indonesian stocks exchange LQ45 taken throughout 2021 (247 exchange days) from the Yahoo Finance website [10]–[19] which was launched on December 15, 2022.

Table 1. Company Name and Closing Price

Company Name	Sector	Closing Prices		
		04/01/2021	…	30/12/2021
PT. United Tractors	Industrial	26650	…	22150
PT. Telekomunikasi Indonesia	Infrastructur	3490	…	4040
PT. Semen Indonesia	Basic Materials	12575	…	7250
PT. Perusahaan Gas Negara	Energy	1540	…	1375
PT. Kalbe Farma Tbk	Health	1475	…	1615
PT. Japfa Comfeed Indonesia	Consumer Non-Cyclicals	1485	…	1720
PT. Indofood Sukses Makmur	Consumer Non-Cyclicals	6825	…	6325
PT. Erajaya Swasembada	Consumer Cyclicals	484	…	600
PT. Elang Mahkota Teknologi	Technology	1540	…	2280
PT. Bank Syariah Indonesia	Fincancial	2360	…	1780

Table 2. Dividend Received

Company Name	dividend distribution date (1)	dividend value (1)	dividend distribution date (2)	dividend value (2)
PT. United Tractors	20/04/2021	473	07/10/2021	335
PT. Telekomunikasi Indonesia	09/06/2021	168	-	-
PT. Semen Indonesia	08/04/2021	188	-	-
PT. Perusahaan Gas Negara	-	-	-	-
PT. Kalbe Farma Tbk	08/06/2021	28	-	-
PT. Japfa Comfeed Indonesia	26/04/2021	40	-	-
PT. Indofood Sukses Makmur	07/09/2021	278	-	-
PT. Erajaya Swasembada	07/06/2021	14	-	-
PT. Elang Mahkota Teknologi	-	-	-	-
PT. Bank Syariah Indonesia	-	-	-	-

***Data source**: Yahoo Finance,* accessed on 15 December 2022.

2.1 Lognormal Stock Return

Let S_t represent the stock price at time t and Δt denote the time change. The definition of stock return is approximated by the natural logarithm of the stock price ratio, that is

$$R_{t+\Delta t,t} = \ln \frac{S_{t+\Delta t}}{S_t} \tag{2}$$

This lognormal stock return have advantages which is not owned by classic stock return definition that is fulfills the additive nature, namely:

$$R_{N,0} = \ln \frac{S_N}{S_0} = \ln \left(\frac{S_N}{S_{N-1}} \frac{S_{N-1}}{S_{N-2}} \dots \frac{S_1}{S_0} \right) = \ln \frac{S_N}{S_{N-1}} + \ln \frac{S_{N-1}}{S_{N-2}} + \dots + \ln \frac{S_1}{S_0} = \sum_{i=1}^{N} \hat{R}_{i,i-1} \tag{3}$$

The definition of stock price return that is approximated by the natural logarithm of the stock price ratio has uncertainty because it changes over time is modeled as

$$\frac{(S(t+\Delta t) - S(t))}{S(t)} = \mu \Delta t + \sigma \sqrt{\Delta t} Z \tag{4}$$

where:

μ is the average classic daily return (drift),

σ is the daily classic volatility of returns (volatility),

$Z \sim N(0,1)$.

Using the central limit theorem, we obtained

$$\ln \frac{S(t)}{S(0)} \sim N\left(\mu - \frac{1}{2}\sigma^2, \sigma^2 t\right)$$

Assuming that the distribution of stock returns has a lognormal distribution

$$R_{t+\Delta t,t} = \ln \frac{S(t+\Delta t)}{S(t)} \sim N(\bar{\mu}, \bar{\sigma}^2)$$

where:

$\bar{\mu}$ is the average lognormal daily return (drift),

$\bar{\sigma}$ is the daily volatility lognormal of returns (volatility),

As the consequences by equating the results of the central limit theorem and assuming stock returns are lognormally distributed, we get the drift parameter $\mu = \frac{1}{\Delta t}\left(\bar{\mu} + \frac{1}{2}\bar{\sigma}^2\right)$ and the volatility of stock prices $\sigma = \frac{\bar{\sigma}}{\sqrt{\Delta t}}$.

2.2 Binomial Cox, Ross, and Rubinstein (CRR) Model

We utilize the model from [20] and [21] to represent binomial CRR Model. First, suppose that the time interval $[0, T]$ is divided into N equal sub-intervals of length to be the dividing point $0 = t_0 < t_1 < \cdots < t_N = T$ where $t_j = j\Delta t$ $(j = 1, \ldots, N), \Delta t = \frac{T}{N}$ and $S_j = S(t_j)$ is the stock's price at time t. Suppose that

1. In the time interval Δt, stock price can move up or down $S \to S\,u$ or $S \to S\,d$ with $0 < d < u$.
2. Opportunity for the stock price to rise $P(up) = p$
3. The expected stock price return is the same as the risk-free interest rate r_f.
4. Without reducing the generality that if a stock price S increases by a factor of increase u and then decreases by a factor of decrease d, then the value must return to S, which means $ud = 1$.

It was found that for each sub-intervals Δt

$$u = e^{\sigma\sqrt{\Delta t}} \tag{5}$$

$$d = e^{-\sigma\sqrt{\Delta t}} \tag{6}$$

$$p = \frac{\left(e^{r_f \Delta t} - d\right)}{u - d} \tag{7}$$

Suppose the stock price at t_0 is S_0, then the stock price at $t_1 = 1.\Delta t$ is $S_0 u$ or $S_0 d$. Then, when $t_2 = 2.\Delta t$ is one of $S_0 u^2, S_0 ud$ or $S_0 d^2$. By continuing these steps, it is found that at t_j the stock price that will occur is

$$S_{ij} = S_0 u^i d^j, \quad i = 0,1, \ldots, j \tag{8}$$

where S_{ij} denote the stock price at time t_j having experienced i instances of increase and $j - i$ instances of decrease in price, calculated since $t_0 = 0$.

2.3 Binomial State Price

We utilize the model from [22] and [23] to represent binomial state price. Consider that the value of 1 goldbar increases to u with the probability $p = q_u u$, the probability of stock price can increase is the result of multiplying the discount factor of the price can increase q_u by the increase factor u, and can move down to d with probability $1 - p = q_d d$, where the probability of stock price can decrease is the result of multiplying the discount factor of the price can decrease q_d by the decrease factor d. So we can write

$$1 = q_u u + q_d d \Leftrightarrow S_0 = q_u u S_0 + q_d d S_0$$

This method is closely related to the linear principle: if the initial value can increase in one period with the increase factor u and decrease in the period with the decrease factor d, thus becoming the value of 1$ in the next period. then let it be $(1 + r_f)$.

$$1 = q_u R + q_d R \tag{9}$$

with $R = \left(1 + r_f\right) \cong e^{r_f}$. So, equating the above two equations, we get

$$q_u = \frac{R-\bar{d}}{R(\bar{u}-\bar{d})} = \frac{e^{r_f}-\bar{d}}{e^{r_f}(\bar{u}-\bar{d})} \tag{10}$$

$$q_d = \frac{\bar{u}-R}{R(\bar{u}-\bar{d})} = \frac{\bar{u}-e^{r_f}}{e^{r_f}(\bar{u}-\bar{d})} \tag{11}$$

The model for 1 period is shown in the following **Figure 1**.

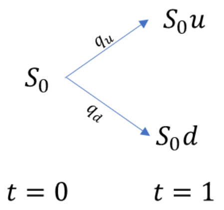

Figure 1. Binomial tree 1 period

In the multi-period model, the time interval $T = 1$ with $\Delta t = \frac{T}{N}$ where N is the total timesteps, the increase factor u, the decrease factor d, and $R = e^{r_f \Delta t}$. The model of multi-period in time interval T is shown in the following **Figure 2**.

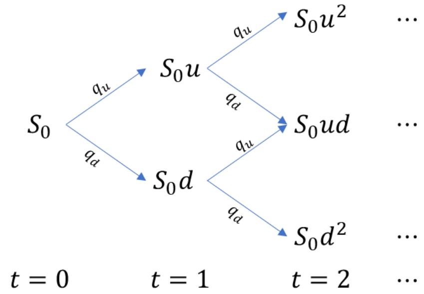

Figure 2. Binomial tree multi-period

The number of paths to reach the nodes to the period timesteps t dan j are the nodes that show the number of price down with $j = 0,1,2, \dots, t$ is $\binom{t}{j}$.

2.3 Relation Between Binomial CRR Model and Binomial State Price

We follow **[23]** to find the relation between binomial CRR model and binomial state price. Consider that by multiplying the state price by 1 plus risk-free interest rate (r_f), R, it produces a risk neutral price which is commonly used to calculate the option value as in the binomial CRR model. It can be formulated:

$$p = q_u R \tag{12}$$

and

$$1 - p = q_d R \tag{13}$$

The formulation above demonstrates that the risk-neutral price represents the probability distribution of states, provided their sum is equal to 1.

Note that the binomial state price with an increase factor u has a discount factor q_u and a decrease factor d has a discount factor q_d, but are not probability to increase or decrease. Therefore, we are looking for the relationship between the discount factor in the binomial state price and the probability of an increase or decrease in binomial CRR.

$$p + (1 - p) = q_u R + q_d R = \frac{R-d}{R \times (u-d)} R + \frac{u-R}{R \times (u-d)} R = 1 \tag{14}$$

Furthermore, this leads to a fundamental aspect in the equivalence of calculating options with risk-neutral price and state price. Suppose an asset provides a payoff of X_u, where this payoff is greater than the invested capital, and a payoff of X_d, where this payoff is smaller than the invested capital, one period after an investment in the one-period binomial model. At time $t = 0$, the value of the asset can be obtained using the state price as $q_u X_u + q_d X_d$, and simultaneously, when calculating the asset's value using risk-neutral price, we obtain:

$$\frac{pX_u + (1-p)X_d}{R} = \frac{expected\ asset\ using\ state\ price}{R}$$
$$= q_u X_u + q_d X_d \tag{15}$$

From **Equations (14)** and **Equation (15)**, it can be concluded that: calculating options using the state price or CRR model will produce the same value. In other words, calculating options using the usual binomial CRR model will produce the same value using the binomial state price.

2.4 Development of Expected Monetary Value Using Binomial State Price

First, we use the increase factor u and the decrease factor d of the share price according to the CRR binomial which examined in **[20]** that is $u = e^{\sigma\sqrt{\Delta t}}$ and $d = e^{-\sigma\sqrt{\Delta t}}$.

Suppose that payoff for the possibility of increasing / decreasing with the binomial model in the next period is the initial price of the stock S_0, can be up to uS_0 or down to dS_0 minus the initial share price plus dividends (if any) which are assumed to be a percentage, D, of the share price in that period. Therefore, the probability payoff of j in the next 1 period is

$$X_u = u^1 d^0 S_0 - S_o + D u^1 d^0 S_0 = S_0(u^1 d^0 (1 + D) - 1) \tag{16}$$
$$X_d = u^0 d^1 S_0 - S_o + D u^0 d^1 S_0 = S_0(u^0 d^1 (1 + D) - 1) \tag{17}$$

Consequently, model for 1 period stock price movements is shown in the following **Figure 3**.

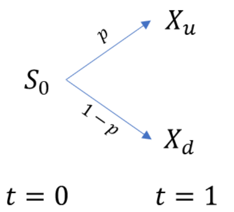

Figure 3. Binomial tree 1 period of expected monetary value

We follow **[23]**, that is, using the relationship between binomial state price and binomial CRR model, and it turns out that the probability of increase in 1 period is

$$p = \frac{R-d}{R \times (u-d)} R = \frac{R-d}{u-d} \tag{18}$$

and

$$(1 - p) = \frac{u-R}{R \times (u-d)} R = \frac{u-R}{u-d} \tag{19}$$

where R is equal to 1 plus the interest rate $(1 + r_f) \cong e^{r_f}$ such that $p = \frac{e^{r_f} - d}{u-d}$.

Suppose that someone invests I in a stock, then he will have I/S_0 shares such that the EMV value for alternative i using the binomial model in the next 1 period is

$$EMV(i) = \frac{I}{S_0}(p \times X_u + (1 - p) \times X_d) \tag{20}$$
$$= \frac{I}{S_0}\left(\frac{R-d}{u-d}(uS_0(1 + D) - S_o) + \frac{u-R}{u-d}(dS_0(1 + D) - S_o)\right) \tag{21}$$

Therefore, for the multi-period model in time interval T = 1, which leads to $\Delta t = \frac{T}{n}$, where n is the number of time steps, the payoff at timesteps t and the number of price increases j is as follows

$$X_{t,j} = S_0 u^j d^{t-j}(1+D) - S_0 = S_0\left(u^j d^{t-j}(1+D) - 1\right) \tag{22}$$

We have stock price movements in multi-period model which has also been discussed in article [24] and [25] is shown in the following Figure 4.

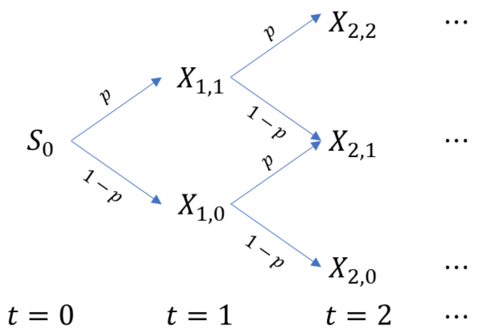

Figure 4. Binomial tree multi-period of expected monetary value

Notice that the number of paths to reach the nodes to the timesteps t and j is the node that shows the number of increasing prices with $j = 0,1,2,\ldots,t$ is $\binom{t}{j}$. As the consequences, the probability at timesteps t and the number of price increases j is as follows:

$$p(t,j) = \binom{t}{j}(p)^j(1-p)^{t-j} \tag{23}$$

The EMV value for an alternative i with the binomial state price model in the timestep t period is as follows:

$$EMV(i) = \frac{I}{S_{0,i}}\left(\binom{t}{t}(p)^t X_{i,t,t} + \binom{t}{t-1}(p)^{t-1}\left((1-p)\right)^1 X_{i,t,t-1} + \cdots + \binom{t}{0}(1-p)^t X_{i,t,0}\right) \tag{24}$$

$$= \frac{I}{S_{0,i}}\left(\binom{t}{t}(p_i)^t S_{0,i}(u_i^t d_i^0(1+D_i)-1) + \binom{t}{t-1}(p_i)^{t-1}\left((1-p_i)\right)^1 S_{0,i}(u_i^{t-1}d_i^1(1+D_i)-1) + \right.$$

$$\left. \ldots + \binom{t}{0}(1-p_i)^t S_{0,i}(u_i^0 d_i^t(1+D_i)-1)\right) \tag{25}$$

$$= \frac{I}{S_{0,i}} S_{0,i}\left((1+D_i)\sum_{j=0}^{t}\binom{t}{j}(p_i u_i)^j\left((1-p_i)d_i\right)^{t-j} - \sum_{j=0}^{t}\binom{t}{j}(p_i)^j\left((1-p_i)\right)^{t-j}(1)\right) \tag{26}$$

$$= I\left((1+D_i)\sum_{j=0}^{t}\binom{t}{j}(p_i u_i)^j\left((1-p_i)d_i\right)^{t-j} - \sum_{j=0}^{t}\binom{t}{j}(p_i)^j\left((1-p_i)\right)^{t-j}\right) \tag{27}$$

$$= I\left((1+D_i)\sum_{j=0}^{t}\binom{t}{j}(p_i u_i)^j\left((1-p_i)d_i\right)^{t-j} - 1\right) \tag{28}$$

As the result, in making decisions using EMV with the development of a binomial state price model can be written as:

$$Max\left(EMV(i)\right) = \max\left(I\left((1+D_i)\sum_{j=0}^{t}\binom{t}{j}(p_i \times u_i)^j\left((1-p_i)\times d_i\right)^{t-j} - 1\right)\right) \tag{29}$$

3. RESULTS AND DISCUSSION

This section describes algorithm of decision making using Expected Monetary Value which has been developed with binomial state price and then we perform numerical simulation using the stock data listed in LQ45.

3.1 Algorithm of Decision Making Using Expected Monetary Value Which Has Been Developed With Binomial State Price

As the result of development of expected monetary value using binomial state price, we have algorithm EMV calculation method:

1. Determine the amount of capital, I.
2. Select the number of stocks to be used.
3. Calculate the dividend rate D_i for each selected stock.
4. Choose an investment period T, then determine the number of sub-interval time periods, N.
5. Determine the risk-free interest rate r_f.
6. Calculate μ_i, which is the drift, and σ_i, which is the volatility of each stock price i .
7. Calculate increase factor u_i and decrease factor d_i for each stock price i in 1 period.
8. Calculate the probability of increase, p_i with **Equation (18)**, and decrease, $(1 - p_i)$ with **Equation (19)**, for each stock price i in 1 period.
9. Calculate Expected Mean Value of each stock which has been developed with binomial state price, $EMV(i)$ with **Equation (28)**.
10. Determine the best EMV of all stocks used with **Equation (29)**.

3.2 Numerical Simulation of Decision Making Using Expected Monetary Value Which Has Been Developed With Binomial State Price

We perform decision making simulation to visualize and also to confirm the findings in the previous section. First, we assumed that an investor has Rp. 1 billion. Next, a decision-making simulation will be given using data on **Table 1**. The closing price for each stock at date 4 January 2021 automatically be selected as our initial stock price.

Next, we must conclude percentage dividends received for each stock at 2021. Dividends received for each stock in 2021 are shown on **Table 2**. Assume that the percentage of dividends D is the total amount of dividends received at several time divided by the initial price of the stock $D = \frac{\sum D_j'}{S_0}$, then the dividends of each company are presented in the following table:

Table 3. Dividend Percentage

Company Name	Percentage Dividends
PT. United Tractors	3,03%
PT. Telekomunikasi Indonesia	4,81%
PT. Semen Indonesia	1,50%
PT. Perusahaan Gas Negara	0,00%
PT. Kalbe Farma Tbk	1,90%
PT. Japfa Comfeed Indonesia	2,69%
PT. Indofood Sukses Makmur	4,07%
PT. Erajaya Swasembada	2,89%
PT. Elang Mahkota Teknologi	0,00%
PT. Bank Syariah Indonesia	0,00%

The investment simulation will be carried out for 1 year (assuming 247 exchange days) which means there will be 247 steps forward ($t = 247$) from the last price and r_f follows the latest Bank Indonesia rate (December 2022), which is 5.25% per year. Furthermore, the computation will be performed in MATLAB 2019b, following the algorithm described in the previous section.

First, our computation is to find drift and volatility by previously calculating the lognormal returns and sigma for each stock which is presented in this following table:

Table 4. Drift and Volatility

Company Name	μ	σ
PT. United Tractors	0,06086	0,38118

PT. Telekomunikasi Indonesia	0,04970	0,28413
PT. Semen Indonesia	0,03957	0,38648
PT. Perusahaan Gas Negara	0,07744	0,41149
PT. Kalbe Farma Tbk	0,06394	0,34104
PT. Japfa Comfeed Indonesia	0,10355	0,43402
PT. Indofood Sukses Makmur	0,02537	0,24587
PT. Erajaya Swasembada	0,11957	0,46015
PT. Elang Mahkota Teknologi	0,16080	0,52111
PT. Bank Syariah Indonesia	0,15829	0,59376

Next, our computation is to calculate increase factor u_i and decrease factor d_i for each stock price i and also probability of increase, p_i, and decrease, $(1-p_i)$, for each stock price i in 1 period which is presented in this following table:

Table 5. Increase and Decrease Factor With Each Probabilities

Company Name	u	d	p	$1-p$
PT. United Tractors	1,02455	0,97604	0,49832	0,50168
PT. Telekomunikasi Indonesia	1,01824	0,98208	0,50136	0,49864
PT. Semen Indonesia	1,02490	0,97571	0,49817	0,50183
PT. Perusahaan Gas Negara	1,02653	0,97416	0,49751	0,50249
PT. Kalbe Farma Tbk	1,02194	0,97853	0,49947	0,50053
PT. Japfa Comfeed Indonesia	1,02800	0,97276	0,49694	0,50306
PT. Indofood Sukses Makmur	1,01577	0,98448	0,50288	0,49712
PT. Erajaya Swasembada	1,02971	0,97115	0,49631	0,50369
PT. Elang Mahkota Teknologi	1,03371	0,96739	0,49492	0,50508
PT. Bank Syariah Indonesia	1,03850	0,96292	0,49337	0,50663

Futhermore, we calculate Expected Mean Value of each stock which has been developed with binomial state price, EMV(i). As the result, we have emv for each stock in this following table:

Table 6. Expected Monetary value of each stocks

Company Name	EMV
PT. United Tractors	85.835.810
PT. Telekomunikasi Indonesia	**104.595.275**
PT. Semen Indonesia	69.711.101
PT. Perusahaan Gas Negara	53.902.562
PT. Kalbe Farma Tbk	73.926.711
PT. Japfa Comfeed Indonesia	82.252.541
PT. Indofood Sukses Makmur	96.796.396
PT. Erajaya Swasembada	84.360.346
PT. Elang Mahkota Teknologi	53.902.562
PT. Bank Syariah Indonesia	53.902.562

Thus, based on the results of the EMV calculation, it was found that PT. Telekomunikasi Indonesia is the most recommended stock for investment and PT. State Gas Company, PT. Elang Mahkota Teknologi, and PT. Bank Syariah Indonesia is the least recommended stock for investing.

4. CONCLUSIONS

We could develop the Expected Monetary Value (EMV) method using a binomial state price approach, constrained exclusively resembling by daily stock prices and dividends provided over the given time interval T. It was found that this model always recommends stocks which have high dividends. Calculations with

EMV on the development results with the state binomial price model still needed to be improved by adding tools such as taxes, capital costs, third-party funds, etc., to improve the decision results.

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