

Table 2: Prior, views, and posterior stocks' return.

Stock	Confidence Level
ADRO	0.05
ASII	0.05
BBRI	0.01
BBTN	0.01
BMRI	0.01
BUMI	0.02
EXCL	0.03
MFIN	0.05
PGAS	0.03
TLKM	0.03

Table 3: Optimal stock portfolio (May 2022).

Stock	Portion
ADRO	14.150%
ASII	9.451%
BBRI	1.305%
BBTN	11.332%
BMRI	12.571%
BUMI	3.141%
EXCL	8.581%
MFIN	5.244%
PGAS	19.899%
TLKM	2.326%

- Returns obtained from simulation are dependent on adjustment frequency; the more often adjustment is done, the higher expected return will be obtained. It may happen because investors could avoid bigger losses by doing portfolio adjustments.
- Portfolio construction using Markowitz with Black-Litterman shows a stable portfolio, it is indicated by net worth growing smoothly as shown in Figure 3.
- Simulated portfolios show better performance, i.e., the returns were higher than the actual return of the mutual funds reported by Sucor Asset Management [17], which was -6.20%.

3.4 Portfolio of Call and Put Structured Warrants

Due to the non-existence of put structured warrants in Indonesia until this research was done, we experimentally designed the fiction put warrants that were similar to offered call warrants. By using historical data, we could obtain the upward factor and its probability for each stock. Then we calculated a fair price for each warrant using the Binomial CRR method, especially for put warrants, the initial fair prices functioned as offered prices. Table 5 shows the offering price for each warrant (call and put), which 7th letter shows warrant type (C for call and P for put).

Fair prices were determined every month, following the adjustment period. Figure 4 and Figure 5 show the movement of warrant fair prices since they were listed till the last trading date.

According to the figures above, we may spot that the fair prices are decreasing as it was close to the

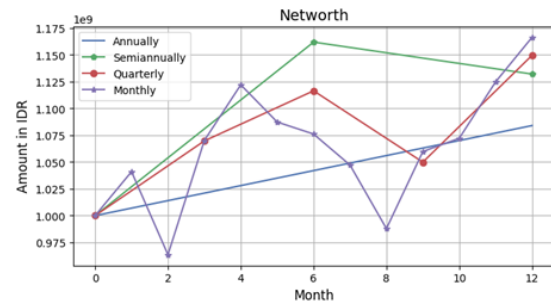


Figure 3: Net worth of stocks portfolio for each scheme.

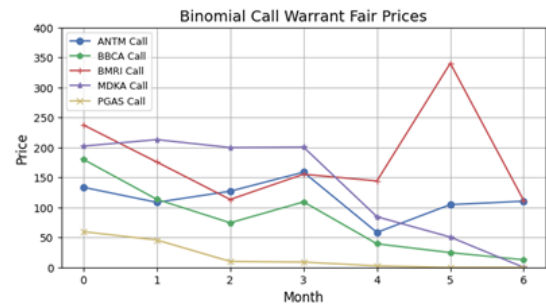


Figure 4: Call warrant fair prices.

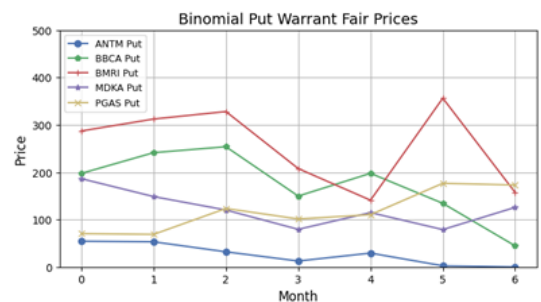


Figure 5: Put warrant fair prices.

exercise date. Theoretically, call warrant and put warrant prices contrast each other because, at the exercise date, only one of them would be exercised. As the figures show when it was closer to the exercise date, one of them would be approaching zero. For example, on May 5, 2023 (month 6 in graphs) which was close to the exercise date (May 10, 2023), MKDADRCK3A and PGASDRCK3A had fair prices equal to zero, but the put warrants (MDKADRPK3A and PGASDRPK3A) had fair prices IDR 125.81 and IDR 172.96 respectively.

After we get the fair prices for each period, we will construct a structured warrant portfolio with monthly adjustments starting on November 10, 2022. The last adjustment was held on April 5, 2023, then on May 5, 2023 (the last trading date), we did not buy any warrants, instead, we just decided whether to sell them or hold them till the exercise date. So, on May 5, 2023, we would calculate the predicted settlement value when exercising warrants, if the predicted settlement was higher than the trading prices then we would sell them immediately otherwise we would hold them for exercise.

Table 4: Optimal stock portfolio simulation results.

Adjustment Frequency	Ending Balance	Gain	Annual Return
Annually	IDR 1,084,102,346	IDR 84,102,346	8.4102%
Biannually	IDR 1,132,147,024	IDR 132,147,024	13.2147%
Quarterly	IDR 1,149,678,892	IDR 149,678,892	14.9679%
Monthly	IDR 1,166,505,435	IDR 166,505,435	16.6505%
Sucorinvest Equity Fund	IDR 938,000,000	-IDR 62,000,000	-6.20%

Table 5: Optimal stock portfolio simulation results.

Structured Warrant	Offering Price	Structured Warrant	Offering Price
ANTMDRCK3A	IDR 196	ANTMDRPK3A	IDR 54.35
BBCADRCK3A	IDR 550	BBCADRPK3A	IDR 197.55
BMRIDRCK3A	IDR 645	BMRIDRPK3A	IDR 287.10
MDKADRCK3A	IDR 300	MDKADRPK3A	IDR 186.42
PGASDRCK3A	IDR 116	PGASDRPK3A	IDR 70.37

Table 6: Optimal structured warrant portfolio (November 2022).

Warrant	Raw Return	Scaled Return	Uniform	Price Ratio
ANTMDRCK3A	1.6578%	0.0000%	20%	14.7875%
BBCADRCK3A	25.3180%	25.7986%	20%	17.0181%
BMRIDRCK3A	17.5761%	17.3570%	20%	0.0000%
MDKADRCK3A	34.4157%	35.7186%	20%	40.1222%
PGASDRCK3A	21.0325%	21.1258%	20%	28.0722%
ANTMDRPK3A	73.3850%	82.7523%	20%	17.1930%
BBCADRPK3A	3.8458%	1.0112%	20%	39.5764%
BMRIDRPK3A	2.9855%	0.0000%	20%	26.9680%
MDKADRPK3A	16.3347%	15.6915%	20%	0.0000%
PGASDRPK3A	3.4491%	0.5449%	20%	16.2626%

Table 7: Predicted settlement value for each structured warrant.

Call Warrant	Settlement	Put Warrant	Settlement
ANTMDRCK3A	IDR 91.40	ANTMDRPK3A	IDR 0.00
BBCADRCK3A	IDR 0.00	BBCADRPK3A	IDR 38.05
BMRIDRCK3A	IDR 0.00	BMRIDRPK3A	IDR 43.00
MDKADRCK3A	IDR 0.00	MDKADRPK3A	IDR 179.89
PGASDRCK3A	IDR 0.00	PGASDRPK3A	IDR 174.29

Using the Binomial CRR method for valuation and four allocation methods, we could obtain each warrant proportion in the portfolio. Expected returns and price ratios were used to determine the proportions as formula (16), (17), and (18). The proportion of each warrant for the first period (November 2022) is shown in Table 6.

The portfolios were adjusted every month until April 2023, then on May 5, 2023, we predicted the settlement value for each warrant using the Binomial CRR method. Table 7 shows the predicted settlement value per share for each structured warrant, where if the call warrant has a non-zero predicted settlement, then the put warrant predicted settlement is zero, and vice versa.

Table 8 shows the selling price for each warrant on May 5, 2023, for the call warrant we were using real price in the market, meanwhile for the put warrant we were using fair price at that date. We compared these prices to predicted settlements to decide whether we hold those warrants or just sell them.

Table 9 shows real settlement for each warrant,

Table 8: Structured warrant selling prices on May 5, 2023.

Call Warrant	Sell Price	Put Warrant	Sell Price
ANTMDRCK3A	IDR 108	ANTMDRPK3A	IDR 0
BBCADRCK3A	IDR 86	BBCADRPK3A	IDR 44
BMRIDRCK3A	IDR 122	BMRIDRPK3A	IDR 157
MDKADRCK3A	IDR 2	MDKADRPK3A	IDR 125
PGASDRCK3A	IDR 3	PGASDRPK3A	IDR 172

where these were obtained on May 10, 2023 (exercise date). If we compare these values to the predicted ones, they are not significantly different except for MDKADRPK3A. Anyway, the decision to sell ANTMDRCK3A, BBCADRCK3A, BMRIDRCK3A, MDKADRCK3A, PGASDRCK3A, BBCADRPK3A, BMRIDRPK3A and to hold MDKADRPK3A was accurate. Although there was inaccuracy in holding PGASDRPK3A (real settlement is lower than selling price), it was tolerable due to the slight difference between predicted settlement, selling price, and real settlement.

After the simulation was done for each method until the exercise date (May 10, 2023), we could calculate the ending balance of structured warrant portfolios where all schemes were using the same initial balance, i.e., IDR 100,000,000. To compare the performances, we could also calculate the gain and return as shown in Table 10 for call warrant portfolios and Table 11 for put warrant portfolios.

Some discussions based on the results of the optimal structured warrant portfolio are the following.

Table 9: Real settlement value for each structured warrant.

Call Warrant	Real Settlement	Put Warrant	Real Settlement
ANTMDRCK3A	IDR 98.00	ANTMDRPK3A	IDR 0.00
BBCADRCK3A	IDR 0.00	BBCADRPK3A	IDR 43.33
BMRIDRCK3A	IDR 0.00	BMRIDRPK3A	IDR 66.67
MDKADRCK3A	IDR 0.00	MDKADRPK3A	IDR 212.00
PGASDRCK3A	IDR 0.00	PGASDRPK3A	IDR 170.00

Table 10: Ending balance, gain, and return of call structured warrant portfolios.

Call Warrant	Raw Return	Scaled Return	Uniform	Price Ratio
Balance	IDR 3,314,343	IDR 3,248,316	IDR 14,291,206	IDR 43,649,036
Gain	-IDR 96,685,657	-IDR 96,751,684	-IDR 85,708,794	-IDR 56,350,064
Return	-96.6857%	-96.7517%	-85.7088%	-56.3510%

Table 11: Ending balance, gain, and return of put structured warrant portfolios.

Put Warrant	Raw Return	Scaled Return	Uniform	Price Ratio
Balance	IDR 4,624,899	IDR 5,501,177	IDR 91,106,297	IDR 615,846,109
Gain	-IDR 95,375,101	-IDR 94,498,823	-IDR 8,893,703	IDR 515,846,109
Return	-95.3751%	-94.4988%	-8.8937%	515.8461%

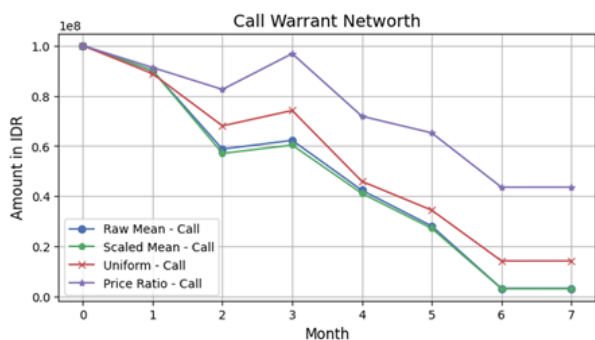


Figure 6: Net worth of call structured warrant portfolio for each scheme.

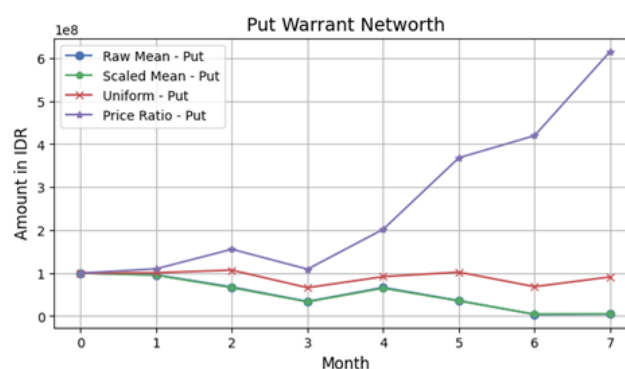


Figure 7: Net worth of put structured warrant portfolio for each scheme.

- Returns obtained from call warrant portfolios are all-negative, this makes sense because most of the underlying stock prices were decreasing and were less than the exercise price. Only one warrant could be exercised, i.e., ANTMDRCK3A with a settlement value of IDR 98, which was much lower than its offering price (IDR 196). Besides that, the exercise prices were too high, so the probability of exercising the warrants was very low. Thus, we could state that the offering prices were too high for such warrants. Net worth movement of call warrant portfolios is shown in Figure 6.
- Returns obtained from put warrant portfolios are majorly negative except the one using the Price Ratio method. It means the Price Ratio method is dominating among other methods as it is the only one that results in a very high return (515.8461%). Anyway, this method also shows much better performance in call warrant portfolios when others resulted in loss of more than 80%, this method only resulted in 56% loss. Net worth movement of put warrant portfolios is shown in Figure 7.
- Put warrant portfolio could produce such high re-

turn as we were using fair prices though real prices in the market may be different. So, with the assumption that all trading prices are fair, a high return can be obtained.

- Structured warrant may be an alternative for investment, especially for a special portfolio with a high expected return target. In addition, this could be interesting when put warrant exists in the Indonesian market and it may be broadly traded in the future.

4 Conclusion

Having researched this topic, we have some conclusions. Constructed stock portfolios using Markowitz with Black-Litterman model showed decent performances where the annual returns were 8.41% for annual adjustment, 13.21% for biannual adjustment, 14.97% for quarterly adjustment, and 16.65% for monthly adjustment. These returns are much higher than the assumed risk-free rate return of 4%. Adjustment frequency affects portfolio expected return, the more of-

ten adjustment is done, the higher expected return obtained as adjustment prevents bigger losses from happening. In the simulation, returns of constructed portfolios are much higher than the mutual fund return that we referred to, i.e., -6.2%.

The performance of the call structured warrant portfolio was not good enough, even with the best method (Price Ratio) in this research, we got the return was -56.35%. This happened because the exercise prices were too high and most of the underlying stocks did not reach those borders. Meanwhile, put structured warrant portfolio was the opposite, where it showed the possibility of gaining profit as with the best method (Price Ratio), we obtained a return of more than 500%. This happened as we were using fair prices though the reality might be different. Therefore, it is important to choose proper warrants that result in an appropriate return. In the future, structured warrants may become popular in the Indonesian stock market with better performance.

The supplementary material accompanying this article contains the code and data needed are publicly available at Github¹.

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¹<https://github.com/corneliusfj/Stock-and-Structure-d-Warrant-Portfolio-Optimization>