



















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 Github<sup>1</sup>.

**Acknowledgement:** We are grateful to the inputs from the reviewers of this journal.

## References

- [1] Aakarshachug, Deep Learning, Introduction Long Short Term Memory. Retrieved (May 2023) from GeeksforGeeks: <https://www.geeksforgeeks.org/deep-learning-introduction-to-long-short-term-memory/>
- [2] BATAVIA PROSPERINDO ASSET MANAGEMENT. Batavia Dana Kas Maximizing Return. Retrieved (May 2023) from Batavia Prosperindo Asset Manajemen: <https://bpam.com/asset-management/files/loads/files/FFS-SDKM.pdf>.
- [3] BENNETT, A., S. *Financial modeling*. MIT press, 2011.
- [4] BODNER, J. *Investments*. New York: McGraw-Hill Education, 2018.
- [5] BURSA EFEK INDONESIA (INDONESIA STOCK EXCHANGE). Informasi Structured Warrant (Structured Warrant Information). Retrieved (September 2022) from idx.co.id: <https://www.idx.co.id/id/data-pasar/structured-warrant-sw/informasi-structured-warrant>.
- [6] FADLY, S. R., 2021. Aktivitas Pasar Modal Indonesia Di Era Pandemi (Indonesian Capital Market Activities in Pandemic Era). Retrieved from Kementerian Keuangan Republik Indonesia (Finance Ministry of Indonesia): <https://www.djkn.kemenkeu.go.id/kpknl-kupang/baca-artikel/13817/Aktivitas-Pasar-Modal-Indonesia-Di-Era-Pandemi.html>.
- [7] FEBRIANTI, W., SIDARTO, K. A., AND SUMARTI, N. Approximate solution for barrier option pricing using adaptive differential evolution with learning parameter. *MENDEL* 28, 2 (2022), 76–82.
- [8] IDZOREK, T. A step-by-step guide to the black-litterman model: Incorporating user-specified confidence levels. In *Forecasting expected returns in the financial markets*. Elsevier, 2007, pp. 17–38.
- [9] MARTIN, R. A., 2018. Black-Litterman Allocation. Retrieved from PyPortfolioOpt: <https://pyportfolioopt.readthedocs.io/en/latest/BlackLitterman.html>.
- [10] MARTIN, R. A., 2018. Post-processing weights. Retrieved from PyPortfolioOpt: <https://pyportfolioopt.readthedocs.io/en/latest/Postprocessing.html>.
- [11] PETUKHINA, E., PAVLOV, Y., HÄRDLE, W. K., AND ZHIVOTOV, N. Robustifying markov. *Journal of Econometrics* (2023).
- [12] ROSS, S. M. *An elementary introduction to mathematical finance*. Cambridge University Press, 2011.
- [13] SUDHAKARAN, M., STEPHAN, A., AND ÖRSKÖL, R. Copula-based black-litterman portfolio optimization. *European Journal of Operational Research* 297, 3 (2022), 1055–1070.
- [14] SANTOS, A., AND TORRENT, H. S. Markowitz technical analysis: Building optimal portfolios by exploiting information in trend-following signals. *Finance Research Letters* 49 (2022), 103063.
- [15] SIMOS, T. E., MOURTAS, S. D., AND KATSIKIS, V. N. Time-varying black-litterman portfolio optimization using a bio-inspired approach and neuronets. *Applied Soft Computing* 112 (2021), 107767.
- [16] STOILOV, T., STOILOVA, K., AND VLADIMIROV, M. Application of modified black-litterman model for active portfolio management. *Expert Systems with Applications* 186 (2021), 115719.
- [17] SUCOR ASSET MANAGEMENT. Sucorinvest Equity Fund. Retrieved (May 2023) from Sucorinvestam: [https://www.sucorinvestam.com/Pdf/FFS\\_SEF.pdf](https://www.sucorinvestam.com/Pdf/FFS_SEF.pdf).
- [18] SUMARTI, N. Simulations of a dynamical portfolio consist of stocks and options for investment during the covid-19 pandemic. In *International Seminar on New Paradigm and Innovation on Natural Sciences and its Application (ISNPINSA)*, Bandung: Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung (2022).
- [19] TAE, J., 2020. Dissecting LSTMs. Retrieved from Github: <https://jaketae.github.io/study/dissecting-lstm>.
- [20] TOPALOGLOU, N., VLADIMIROU, H., AND ZENIOS, S. A. Optimizing international portfolios with options and forwards. *Journal of Banking & Finance* 35, 12 (2011), 3188–3201.

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