COVID-19 AND POLITICAL CRISIS EFFECTS ON RISK MINIMISING PORTFOLIO FOR MALAYSIA'S STOCK MARKETS USING MEAN-CVAR OPTIMIZATION MODEL

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1. Introduction

This research focuses on the effects of the coronavirus disease 2019 (CoVid-19) pandemic and political crisis, onto Malaysia's (portfolio) stock markets. CoVid-19's emergence as a pandemic has caused significant impacts on society, corporations, and institutions across the world in many ways. The pandemic has also influencing financial markets and the global economy. This is due to the strict curfews, travel restrictions and border crossing limitations. Throughout the pandemic, Malaysia has also gone through a constitutional crisis that worsen the affects on the stock markets.

Modern Portfolio Theory (MPT) is pioneered by Harry Markowitz (1952) model that uses variance to measure risk. Since Markowitz's work on the theory, optimization has been at the heart of all work relating to portfolio selections. Various mean-risk models are introduced as the results of the Markowitz's nobel-prize-winning work (refer Roman and Mitra (2009)). On top of this, various applications of mean-risk models motivated from MPT are being studied recently (see Abdul Razak et al. (2019), Maasar et al. (2016), Maasar et al. (2020), Maasar et al. (2021) for examples).

The mean-CVaR model used in this study is also formulated in Roman and Mitra (2009). Consider the future returns of the assets are random variables denoted by $R_1 \dots R_n$. A portfolio is denoted by $x = (x_1, \dots, x_n)$ where x_j is the fraction of the capital invested in asset $j, j = 1, \dots, n$. The entries in $(x_1, \dots, x_n)$ are also called as the portfolio weights, one of the required investment decisions. The weights must fulfil a set of constraints that construct a set X of feasible decision vectors to represent a portfolio (Roman and Mitra, 2009). The brief of formulation for a mean-CVaR is presented in Section 2.

2. Methodology

Conditional value-at-risk (CVaR) is utilised as the risk measure for this study. We present here the formulation of CVaR, followed by the construction of the mean-CVaR optimisation model used in this study.

2.1. *CVaR computation model*

Following notation in (Roman and Mitra, 2009), Let R_x denote the random return of a portfolio x over a given holding period and $A\% = \alpha \in (0, 1)$ a percentage which represents a sample of "worst cases" for the outcomes of R_x (usually $\alpha = 0.01 = 1\%$ or $\alpha = 0.05 = 5\%$). The CVaR at level α of R_x is defined as:

$$CVaR_\alpha(R_x) = -\frac{1}{\alpha}\{E(R_x 1_{\{R_x q^\alpha(R_x)\}}) - q^\alpha(R_x)[P(R_x \leq q^\alpha(R_x)) - \alpha]\} \tag{1}$$

where

$$1_{\{\text{Relation}\}} = \begin{cases} 1, & \text{if the relation is true;} \\ 0, & \text{if the relation is false.} \end{cases}$$

Hence, $R_x 1_{\{R_x q^{\alpha}(R_x)\}}$ is obtained from R_x by considering only the outcomes below the upper $\alpha-$quantile (refer Roman and Mitra (2009) for details on upper quantiles).

Random returns are frequently defined in practical applications by their realizations under multiple scenarios; consequently, a portfolio return R_x is a discrete random variable. Calculating and optimizing CVaR is even easier in this case: the two (convex) optimization issues (refer Roman and Mitra (2009) become linear programming problems. Indeed, for instanceR_x now has S possible outcomes $r_{1x}, \dots, r_{Sx}$ with probabilities $p1, \dots, p_S$, with $r_{ix} = \sum_{j=1}^{n} x_j r_{ij}, \forall i \in \{1, \dots, S\}$, where r_{ij} is the return of asset j under scenario i. Finally, we write our formulation of $CVaR$ in Equation (1) as a function of x and v;

$$F_{\alpha}(x, v) = \frac{1}{\alpha} \sum_{i=1}^{S} p_i [v - r_{ix}]^+ - v = \frac{1}{\alpha} \sum_{i=1}^{S} p_i [v - \sum_{j=1}^{n} x_j r_{ij}]^+ - v \tag{2}$$

2.2. *Mean-CVaR Model*

The formation of the mean-CVaR optimisation model considers the following notation:

x_j = fraction of money invested in asset j;
r_{ij} = return of asset j under scenario $i, i = 1, \dots, S$;
μ_j = expected rate of return of asset $j, j = 1, \dots, n$.

In addition to the decision variables $x_1, \dots, x_n$ indicating portfolio weights, there are $S + 1$ decision variables in the formulation of the mean-CVaR model. The variable v indicates the portfolio return distribution's negative $\alpha-$quantile. The other S decision variables represent the magnitude of the negative deviations of the portfolio return from the $\alpha-$quantile, for every scenario $i \in \{1, \dots, S\}$:

$$y_i = \begin{cases} -v - \sum_{j=1}^{n} x_j r_{ij}, & \text{if } \sum_{j=1}^{n} x_j r_{ij} \leq -v; \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

Thus, the algebraic formulation of the mean-CVaR model is given as:

$$\begin{aligned} & \min v + \tfrac{1}{\alpha S} \textstyle\sum_{i=1}^{S} y_i \\ & \text{subject to:} \\ & -v - \textstyle\sum_{j=1}^{n} x_j r_{ij} \leq y_i, \forall i \in \{1, \dots, S\} \\ & y_i \geq 0, \forall i \in \{1, \dots, S\} \\ & -v - \textstyle\sum_{j=1}^{n} \mu_j x_j \geq d; x \in X. \end{aligned} \tag{4}$$

Note here that d is the pre-determined level of return set by the computer or investor.

3. Results

Scenarios of returns of assets in the top 30 market are simulated to represent carefully the two different time frames. One is the time frame before the CoVid-19 and political issues hit Malaysia. The other one is the time frame with the two unfortunate incidents. For both of the time frames, 10 samples of which each consists of 100 scenarios (of each assets) are used to construct 10 in sample portfolios under different levels of pre-determined (target) return, d. The target returns are set at $d_1 = 0.85\%$ to represent the low target return, $d_2 = 1.5\%$ (medium target), and $d_3 = 2\%$ (high target).

The parameters are run using the mean-CVaR optimisation model shown in Equation 4 with $\alpha = 0.05$. Ten in samples portfolios show a consistent outcome where the risk measure in terms of $CVaR_{0.05}$ are higher during the time frame when the pandemic and political issue hit Malaysia. We name D-portfolios as portfolios constructed during the pandemic and political issues, and B-portfolios for portfolio constructed using scenarios before that. Table 1 exhibit the first two examples from the ten in sample portfolio's obtained.

Table 1: Risk values for the first two in-sample portfolios in terms of standard deviation and $CVaR_{0.05}$

In-sample	Target return %	Standard deviation B-portfolio %	Standard deviation D-portfolio %	$CVaR_{0.05}$ B-portfolio %	$CVaR_{0.05}$ D-portfolio %
	0.85	2.60	2.67	3.77	3.82
1	1.50	3.24	3.46	3.69	4.18
	2.00	4.38	4.35	4.69	6.45
	0.85	2.51	2.66	3.65	3.74
2	1.50	3.30	3.56	3.67	4.10
	2.00	4.47	4.26	4.84	6.27

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In sample portfolios for both B-portfolios and D-portfolios are validated by using the out-of-sample analysis (backtesting). We found two important findings as to validate the in-sample results; 1. Targeted returns always met for every backtesting; 2. Risk values in terms of $CVaR_{0.05}$ and standard deviation repeats the behaviour of the values of the in-sample portfolios (in terms of having higher values in D-portfolios, mainly for $CVaR_{0.05}$). The extract of these out-of-samples results are shown in Table 2.

Table 2: Realized returns and risk values for the first two out-of-sample analyses

In-sample	Target return %	Realized returns B-portfolio %	Realized returns D-portfolio %	Standard deviation B-portfolio %	Standard deviation D-portfolio %	$CVaR_{0.05}$ B-portfolio	$CVaR_{0.05}$ D-portfolio
	0.85	0.99	0.93	2.63	2.72	3.77	3.82
1	1.50	1.46	1.61	3.24	3.42	3.69	4.18
	2.00	2.03	2.20	4.34	4.38	4.69	6.44
	0.85	0.91	0.92	2.55	2.70	3.65	3.74
2	1.50	1.48	1.62	3.29	3.52	3.67	4.09
	2.00	2.06	2.17	4.42	4.29	4.84	6.27

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4. Conclusion

Many industries in Malaysia are negatively impacted by the COVID-19 outbreak as well as the political crisis that has been going on about the same time in the years of 2020-2022. As a direct result of these occurrences, the stock markets in Malaysia are impacted. The goal of portfolio optimization is to either maximise the expected value of return while minimising the amount of risk taken on or to decrease the amount of risk taken on while maximising the expected value of return. When it comes to tackling challenges involving minimizing risk of a portfolio, mean-risk models are one of the strategies that can be used. Because of this, several risk measures have been developed in order to optimise a portfolio by making use of mean-risk models. This research construct the risk minimizing portfolio of Malaysia's stock markets using mean-CVaR model. These portfolios are carefully constructed to represent the two different time frames (stated in Section 3) and named as B-portfolios and D-portfolios. Out-of-sample analyses are done to validate the outcome we claimed during the portfolio construction. Altogether, this research managed to mainly conclude that the CoVid-19 pandemic and political issues that hit Malaysia in 2020-2022 has significantly affect the risk levels of financial assets.

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