ESTIMATION OF TAIL-RELATED RISK MEASURES USING EXTREME VALUE APPROACH

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ABSTRACT

The preceding empirical studies has attested that price volatility in both financial and commodity market has a substantial effect on a firm's earnings capability due to the rationale of the escalating level of uncertainties has the tendency to inhibit producers to increase the volume of production, which turned out the stagnation in economic activities (Alom, Ward & Hu, 2012). The presence of extreme occasion risk will trigger intensified volatility rate in the stock market, which may possibly cause investors to lose their trading book value as a result of hostile market movements or so-called as market risk. Henceforth, risk management has played a crucial role in identifying, measuring and controlling risks through a systematic approach. In this study, we will focus on financial risks on the asset level. This research aims to study how the risk measures value at risk and expected shortfall can be estimated by augmenting variations of AR(1)-GARCH(1,1)-type models with the peak over threshold model from extreme value theory. The researchers adopt the daily closing price for crude palm oil futures (FCPO) and share counters of Felda Global Ventures (FGV) Holding Berhad and Genting plantation Berhad from 1st January 2015 until 7th February 2019 which comprises of 1,000 observations. The performance of each model will be evaluated through back testing the estimates on a few financial data sets which specialized in the palm oil industry. In this paper, we two stages EVT-GARCH approach (McNeil & Frey, 2000) is implemented, coupled with findings that all of the models are performing inferiorly with low p-values.

Key words: Extreme value theory; Risk management; Value-at-Risk (VAR)

INTRODUCTION

As one of the prominent economic growth driver, the palm oil industry in Malaysia accounts for 31.4% of world production outputs as well as 44% of the global exports which is equivalent to 5 percent of the country's export value (World Bank, 2017). The upbeat prospect of the palm oil industry has been seizing the international market valuation of US$65.73 billion in the year 2015 coupled with the forecasted annual compounded growth rate of 7.2%, has gained intentness from diverse stakeholders specifically stock investors. From the perspective of measurement for capital gains, the plantation industry subsumes two premier indexes which are FTSE Bursa Malaysia Palm Oil Plantation and FTSE Bursa Malaysia Asian Palm Oil Plantation Index (MYR & USD), wherein their monthly performances were recorded as 11.17% and 7.69% respectively as at 31 January 2019, which outperformed other index series (FTSE Monthly Report, January 2019). Nevertheless, appertaining to the annual returns for FTSE Bursa Malaysia Palm Oil Plantation, the year 2018 turned up to be the worst performing time throughout the last decades with the suffering loss of 23.8 percent (FTSE Russell Factsheet, 28 February 2019). This is in line with the track of contemporary global market occurrences wherein mostly triggered by political risks which are prompted a greater volatility, as evidenced by the yearly volatility predictor of 23.11% for FTSE Bursa Malaysia KLCI Index (V-Lab, 2019).

In the contemporary practice, an exorbitant price that plantation firms have to forfeit towards their eco-harmful deeds, which is best illustrated through the incident of suspension of international certification of Malaysia second largest palm oil supplier, IOI Corporation Bhd in March 2016 which has triggered three gigantic food and consumer products manufacturer (i.e. Unilever, Mars Co. & Kellogg Co.) to cease their sales contract with IOI, causing it to suffer severely impairments in term of its reputation (The Straits Time, 2016). Additionally, previous researches have validated that companies with the positive press announcement on their environment-friendly initiatives are inclined to experiencing substantial share price increment, and conversely firms that are revealed being unaccountable on the environmental issues (e.g. pollution, illegal deforestation, open burning, and etc.) would grapple with share price tumbling (Flammer, 2012). Henceforth, investors are deliberated to manage their portfolio risk particularly in the presence of intensified volatility rate in a financial market, which might induce losses on their trading book value due to the reason of the adverse market movement, or so-called as market risk. Furthermore, policymaker should also scrutinise the risk management issue as the price volatility could possibly deteriorate the development and productivity of the nation's economy as a whole. Moreover, the researchers intend to explore on the relatively rare yet worth to explore topics i.e. extreme value theory that is typically used to estimate the distributional probability of financial returns under the *extreme* events, at which this study takes account of 1,000 observations with the interval of 1st January 2015 until 7th February 2019.

LITERATURE REVIEWS

The preceding empirical studies has attested that environmental corporate social responsibilities (CSR) has the capability to generate noble competitive resources for firms. The findings have authenticated that companies with the positive press announcement on their environment-friendly initiatives are predisposed to experiencing a substantial share price increment, contra-wise, firm that is revealed being unaccountable on the environmental issues (e.g. pollution, illegal deforestation, open burning, and etc.) would grapple with price tumbling. The arguments have been postulated by prior researches that with the incorporation of ecological value into the firms' philosophy ought to be motivated by both external and internal moderators (Flammer, 2012).

ANTECEDENTS OF SHARE PRICE MOVEMENT FOR LISTED PLANTATION INDUSTRY PLAYERS

The preeminent factor that influences the performance of Bursa Malaysia Plantation Index is the share price of constituents (Lee et al, 2016), particularly the top five constituents i.e. FGV Holdings, Boustead Plantations, Jaya Tiasa Holdings, Sime Darby Plantation and TDM Berhad, which carries the weight of 54.73 percent. FTSE Bursa Malaysia Palm Oil Plantation Index constitutes the public listed companies (PLCs) wherein under the EMAS index, with a substantial proportion of its earnings (i.e. equal or more than 30%) is generated from palm oil industry (FTSE Russell Factsheet, 28 February 2019). Meanwhile, the empirical studies have evidenced the commodity (i.e. CPO) price is reflected in the fluctuations of the stock prices (Nordin, Nordin & Ismail, 2014). As a sustainable crop, Rahman et. al. (2013a) has abridged the antecedents that would significantly influence CPO price are supply and demand for palm oil, the price and demand of other vegetable oils, weather patterns, import policies of importing countries and alteration in taxation policy and import duty.

An extensive body of anecdotal shreds of evidence has demonstrated the empirical results appear to be inconclusive, and most of the preceding empirical researches are indicating mixed results (Barnett & Salomon, 2012) for the interlinkage between environmental responsible initiatives and firms' financial performance. The imposition of product certification (e.g. ISO 14001 & RSPO) could possibly bring less impact on carbon footprint, as well as diminish the increasing pressures from the external stakeholders (e.g. non-governmental organizations (NGOs), communities, governments, media, and other institutions) on the companies' ecological footprints (Garriga & Mele, 2004). This is consistent with the stakeholders theory which states that various parties have diverse interests towards the business organizations, as the literature indicates that the firms that engage in corporate social responsibility (CSR) activities may possibly meet the expectations by the non- shareholder constituencies which in turn will decrease a firm's risk premium (Brown and Forster, 2012; Branco and Rodrigues, 2007). Two prominent international environmental management certification bodies are ISO 14000 family of standard and Roundtable on Sustainability Palm oil. ISO 14001 is an international standard that furnishes a concrete instrument, in turn to assist diverse companies to manage their environmental requirements. ISO 14001 prioritizes on providing a framework that could be effectively adhered to set up the management procedures and processes. The pursuing certification on environment management is regarded as a systematic approach to address environmental risk exposures, managing environmental obligations and thus improving business performance (Ong et al., 2016). Apart from this, the initiative to establish the RSPO (2015) is to promote the production and use of sustainable palm oil for people, planet and prosperity through the mutual agreement among various stakeholders including oil palm growers, palm oil processors and traders, consumer goods manufacturers, environmental NGOs, social NGOs, banks/investors, and retailers (About sustainable palm oil, 2019).

The previous studies reveal that firms with superior financial performance have a greater propensity to be proactively in pursuit of accreditation (Heras-Saizarbitoria, Landin & Molina-Azorin, 2011; Ong et al., 2016). On the other hands, firms with poor financial performance are less probable to involve in environmental initiatives due to lack of resources (Margolis & Walsh, 2003; Orlitzky, Schmidt & Rynes, 2003). Henceforth, Bansal and Roth (2000) has inferred three preeminent driving forces which are pressures from stakeholder particularly international customers, commercial opportunities and contractual obligations that propel firms to invest in ecological footprint management. Alam, Er, and Begum (2015) posits several challenges that are encountered by palm oil plantation industry player in Malaysia. Amongst them including deficit in land-labour ratio, competition for market share, increasing of aging tree population, loss of biodiversity, plant infection, susceptible to forest fires and emission of greenhouse gases, deforestation, sustainability practices for better productivity and the impact on local community from the perspective of economic and social. Regardless of its pivotal economic contribution, the palm oil sector is disapprovingly tie in with the controversy of environmental sustainability. Henceforth, it is eminent for the investors and policymaker to further contemplate on the spill-over effect of the global commodity market and the share price performance of the plantation firms listed in Kuala Lumpur Stock Exchange (KLSE). Figure 1 lists down the top twelve largest palm oil planter and refiners in Malaysia.

Table 1: Major crude palm oil producers and planted acreage in Malaysia

No.	Company	Production (metric tonnes)	Oil palm planted area (hectares)
1	Felda Global Ventures Holdings Berhad	3,091,262	730,557
2	Sime Darby Berhad	2,442.418	603.264
5	Wilmar Group	1,517,472	240,958
6	Kuala Lumpur Kepong Berhad	1,060,442	211,574
7	IOI Corporation Berhad	697,334	179,271
8	Cargill Worldwide Group	399,866	50,972
9	Genting Plantations Berhad	359,643	134,828
10	Ta Ann Holdings Berhad	171,482	41,141
11	Hap Seng Plantations Holdings Berhad	163,849	35,532
12	Jaya Tiasa Holdings Berhad	82,000	69,064

Source: Palm Oil Analytics (2017). Essential Palm Oil Statistics.

SHARE PRICE VOLATITY

The preceding empirical studies have attested that price volatility in both financial and commodity market has a substantial effect on a firm's earnings capability due to the reasoning of the escalating level of uncertainties has a tendency to inhibit producers to increase the volume of production, which turn out the stagnation in economic activities (Alom, Ward & Hu, 2012). Hence, the exhibition of volatility and the likelihood of negative outcome on CPO prices have conjured the plantation firms to undertake hedging strategy i.e. derivative instruments to mitigate the volatility effect of subsequently the occurrence of extreme or rare events. The conventional assumption of normality in stock returns has theoretically reformed with the demonstration of empirical evidences signify the fat-tailed distribution is prevalence in estimating returns, wherein the idiosyncrasy linked with the heightening magnitude as well recurrence. The explicit distributional assumption is violating with the normality assumption which typically widely adopted in well-established financial theories such as CAPM and Black-Scholes Option Pricing Model, whereas it further denotes the fallen apart of the mean-variance analysis in the estimation (Gettinby et al., 2004)

For the terrain of share price returns, the empirical finding reveals that daily share yields range averagely two orders of magnitude (Mantegna & Stanley, 1995). Additionally, Johansen and Sornette (1998) conjectures that market crashes should be classified as the outlier instead of the fat-tailed financial phenomenon. The disputes ascend while computation of stock returns by applying the stable laws which indicating the property of infinite variance (i.e. prohibition of volatility in financial risks estimation with the exception of higher order moments), whereas the empirical evidences have been unveiled that stock returns mostly tied with finite variance. Scaling laws demonstrates fat tails yet allowed for supplementary properties in case of absence of the scale, whereas Extreme value theory (EVT) is used to delineate and measuring probabilistic behaviour of abnormally huge losses. In pursuant of generating eloquent scaling approximation, the range of variation should be sufficiently broad (Focardi & Fabozzi, 2003). Although conventional methodologies on parametric and non-parametric perform well in the empirical distribution estimation, but it turns out to be an inferior estimator when dealing with rare occasions (Fernandez, 2003).

In finance, VaR is extensively espoused to solve the puzzle on the greatest amount of loss that might be suffering throughout a period of time, on condition of giving confidence level. The evolution of VaR was initiated by J.P. Morgan two decades ago, along with triple essential refinements to make VaR modeling much more rigorous in estimating and modelling risk measures (Karmakar, 2013). The first amelioration is relatively convenient and non-parametric methods, historical simulation (HS) wherein the empirical distribution of return is estimated through the application of archival price movement with the conjecture that historical trend will repeat by itself, or known as constant volatility whereas it turns out to be not effective in measuring extreme quantiles as the estimator is susceptible to high variance (McNeil & Frey, 2000). In other respect, econometric models of volatility dynamics exhibiting present volatility background with the postulation of conditional normality, which predisposes to underestimate the magnitude of risk due to the rationale of the methodology is incapacitated to accommodate real financial data that occasionally experiencing extreme scenarios. Thereon, extreme value theory (EVT), a sound statistical theory for an asymptotic behaviour of extreme observations of random variables in exceptional events has gained limelight to extrapolate tail-related risk measures (McNeil & Frey, 2000).

SOURCE OF DATA

For the source of data, the researchers adopt the daily closing price for crude palm oil futures (FCPO) and share counters of Felda Global Ventures (FGV) Holding Berhad and Genting Plantation Berhad which were derived from investing.com, a worldwide financial platform which offering both fundamental and technical analysis as well as financial tools about the global financial markets (About Investing.com). The period under this study was from 1st January 2015 until 7th February 2019 which comprises of 1,000 observations. Recognition as an environmental sustainable organisation is compelling for the palm oil industry player. Therefore, the researchers select FGV Holdings Bhd and Genting Plantation Berhad as the sample for the PLCs due to the rationale of their momentous membership from Roundtable on Sustainable Palm Oil (RSPO), International Sustainability & Carbon Certification (ISCC), Malaysian Sustainable Palm Oil (MSPO) as well as ISO 14001:2015 certification. Furthermore, Kumar, Acharya and Suresh (2014) has attested commodity market experiences is greatly affected by external antecedents, subsequently inducing a greater degree of price instability as evidenced by the average monthly volatility rate of 15.3% over the past five years (FTSE Russell Factsheet, 28 February 2019).

METHODOLOGY

Denoting by$S_t, t \in \mathbb{Z}$, the daily closing price of an asset at day t and the loss (or negative log-returns) $X_t = -(\log S_{t+1} - \log S_t)$. The researchers conjecture that the losses X_t form a stationary time series where$X_t = \mu_t + \sigma_t Z_t$and, where Z_t are independent and identically distributed continuous random variables with mean zero and unit variance. The value at risk (VaR) at time *t* is given by the smallest number x_q such that the loss X_{t+1} will fall below x_q with probability q:

$$\mathrm{VaR}_q^t = \inf\{x_q \in \mathbb{R}: P\big(X_{t+1} \leq x_q\big) \geq q\} = \inf\{x_q \in \mathbb{R}: P\big(X_{t+1} > x_q\big) \leq q\}$$

The expected shortfall (expected value at time t of the loss in the next period which is conditional on the loss exceedingVaR_q^t) at level q is $ES_q^t = E_t[X_{t+1}|X_{t+1} > \mathrm{VaR}_q]$.

In this paper, we will carry out two stages EVT-GARCH approach, as suggested by McNeil & Frey (2000). In addition, presumption has been made on the underlying innovation distribution to be a normal distribution data wherein extreme value theory

(EVT) is adopted to the modelling of tails behaviours. The two-stage approach is summarized as follows: (i) fit AR(1)-GARCH(1,1) model to the return data by using normal distribution and student-t distribution and maximum likelihood (ML) approach. Then, we will estimate μ_{t+1} and σ_{t+1} using the fitted model and calculate the implied model residual; and (ii) use peaks over threshold (POT) method of EVT to model the tail of residuals and estimate the innovations z_q for $q = 0.95$.

ESTIMATING μ_{t+1} AND σ_{t+1} USING ML

The coefficient of generalised autoregressive conditional heteroscedastic (GARCH) model We consider a most frequently used GARCH model, which is the AR(1)-GARCH(1,1) model in which the conditional variance of the mean-adjusted series $\epsilon_t = X_t - \mu_t$ may be written as $\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta \sigma_{t-1}^2$, where $\alpha_0 > 0, \alpha_1 > 0$ and $\beta > 0$. The conditional mean is given by $\mu_t = \phi X_{t-1}$. The volatility is referred to the speediness of response of investors to market movements whereby it appears spiky if the α_1 is large relative to β. If α_1 is smaller than β, the volatility will appear to be constant.

In the AR(1)-GARCH(1,1) model, we can calculate 1-step forecasts which is the estimates of the conditional mean and variance for day $t + 1$ by

$$\hat{\mu}_{t+1} = \hat{\phi} x_t$$
$$\hat{\sigma}_{t+1} = \hat{\alpha}_0 + \hat{\alpha}_1 \hat{\epsilon}_t^2 + \hat{\beta} \hat{\sigma}_t^2$$

where $\hat{\alpha}_0, \hat{\alpha}_1$ and $\hat{\beta}$ will be estimated using maximum likelihood method.

ESTIMATING z_q USING POT/EVT

When we are measuring the risk of a financial asset, we will focus on the upper tail of the loss distribution. EVT is an approach that enables us to extract more information from the large losses we observe and allow us to predict future losses.

We will choose an appropriate threshold u and assume the excess residuals over this threshold to be distributed as generalised Pareto (GPD) with distribution function as follows:

$$H(y) = 1 - \left(1 + \frac{\xi y}{\tilde{\sigma}}\right)^{-\frac{1}{\xi}}$$

where $\tilde{\sigma} = \sigma + \xi(u - \mu)$ with scale σ, shape ξ and location μ. The special case $\xi = 0$ is treated as a limit $\xi \to 0$ of H. The shape parameter ξ controls the thickness of the tail distribution. The case $\xi > 0$ indicates a heavy-tail, $\xi = 0$ implies thin-tail and $\xi < 0$ corresponds to a tail with finite endpoint.

The q-quantile (or VaR_q) of Z is given by

$$z_q = u + \frac{\sigma}{\xi}\left(\left(\frac{1-q}{\varsigma_u}\right)^{-\xi} - 1\right)$$

where $\varsigma_u = P(Z > u)$, $z_q > u$ and $\xi \neq 0$ (Coles 2001).

For $z_q > u, Z - z_q | Y > z_q \sim \text{GPD}(\sigma + \xi(z_q - u), \xi)$, we have the ES_q for Z written as

$$E\left(Z \middle| Z > z_q\right) = \frac{z_q}{1-\xi} + \frac{\sigma - \xi u}{1-\xi}$$

We will use maximum likelihood method to estimate σ and ξ, while ς_u can be estimated by $\hat{\varsigma}_u = N_u/n$, where N_u is the number of exceedances above threshold and n is the total observations. We will implement the double bootstrap methodology of Danielsson et. al. (2001) to choose the appropriate threshold in the peak over threshold approach.

BACKTESTING VAR AND ES

To measure the adequacy of models under consideration, we will apply the backtesting method to test whether the forecasts of the model are consistent with the distribution of the residuals for losses. Due to the lack of backtesting theory for expected shortfall, we will perform different tests for both VaR and ES. For VaR, we will implement the conditional coverage test of Christoffersen (1998), while for ES, we will perform exceedance residual test of McNeil & Frey (2000).

CONDITIONAL COVERAGE TEST FOR VaR

Conditional coverage test is combined to test jointly for correct coverage and independence. The test statistic for conditional coverage is $LR_{CC} = LR_{UC} + LR_{ind}$ where LR_{UC} is the likelihood ratio statistic for unconditional coverage test and LR_{ind} is the likelihood ratio statistic for independence test. Monte Carlo simulation will be performed to generate more accurate p-values.

EXCEEDANCE RESIDUAL TEST FOR ES

Backtesting for ES aims to estimate the difference between the next-day return X_{t+1} and the estimate of the expected shortfall at time *t*. The exceedance residuals will be denoted as

$$r_{t+1} = \frac{x_{t+1} - \widehat{ES}_q^t(X_{t+1})}{\hat{\sigma}_{t+1}}$$

A nonparametric bootstrap is proposed by Efron & Tibshirani (1993) will be executed to compute p-value.

RESULTS AND DISCUSSION

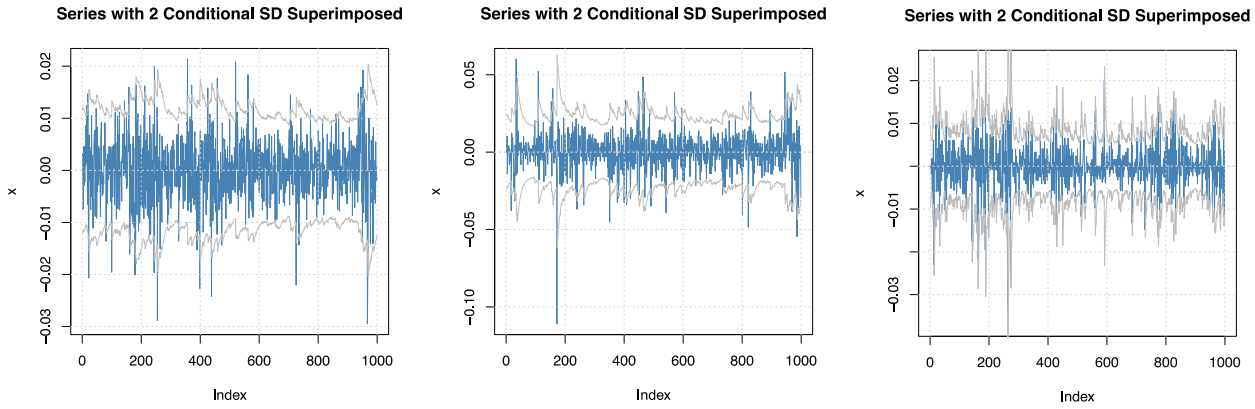
Table 2 shows some summary statistics for the three data sets. Acronym POF is used to represent palm oil futures (1FCPOc1), FGVH is used for Felda Global Ventures Holdings Bhd and GENP is for Genting Plantations Bhd.

Table 2: Summary statistics for the prices

Data set	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
POF	2464	327.56	1759	3306	0.41	-0.29
FGVH	1.722	0.33	0.64	2.94	-0.29	1.48
GENP	10.35	0.58	8.91	11.72	0.12	-0.49

From Table 2, the volatility has been signified using coefficient of variation (CV), which is defined as the ratio of the standard deviation to the mean. The percentages of CV for POF and FGVH are 13.29% and 19.16% respectively, which demonstrates a greater dispersion of these two data sets. In contrast, GENP has a CV of 5.60% only, which implies a lesser volatility. On the other hand, the skewness designates the amount and direction of skew. POF and GENP have a slight positive skewness, while FGVH has an insignificant negative skewness. By comparing the value of kurtosis, we can tell that FGVH has higher and sharper peaks. It also shows that most of the variance is caused based on the result of infrequent extreme deviations.

Figure 1: Time series with conditional standard deviation fitted to AR(1)-GARCH(1,1) model



(a) POF (b) FGVH (c) GENP

From Figure 1, we can clearly see volatility clusters for all three data sets, this means the conditional variances are heteroskedastic. This also shows that the variance conditioned on 1-day before is time-dependent. Downside risk measures like VaR and ES are sensitive to the changes in the volatility compared to changes in the mean. Therefore, GARCH effects in the underlying time series deteriorate their estimations heavily.

Table 3: Number of exceedances and parameters estimated

Data set	N_u, no. of exceedances	u, threshold	σ, scale	ξ, shape
POF	107	2120	6378.39	-3.01
FGVH	103	1.4	2.585	-1.847
GENP	96	9.51	24.790	-2.607

For the three data sets, the optimal values for the number of *k* observations in the tail are remarkably close to the value of 100 used by McNeil & Frey (2000). The approximated all shapes are scrutinised as negative which indicating a finite endpoint. It also shows that the limiting distribution of POT models are likely to be beta distribution.

Table 4: p-values for conditional coverage (CC) test and exceedance residuals (ER) test of original model and POT model

Data set	Original Model		POT Model	
	CC	ER	CC	ER
POF	0.0000	0.0000	0.0010	0.0000
FGVH	0.0000	0.0000	0.0012	0.0000
GENP	0.0000	0.0000	0.0018	0.0000

Models can be compared based on their p-values, the higher p-values indicate a more favourable model, and contrariwise low p-values speak otherwise. Based on the result in Table 4, all of the models are performing incompetently with low p-values. However, it is detected that for the conditional coverage test in accordance with POT model, the p-values seems a bit larger, although still below a significance level of 0.05. This designates that POT model is comparatively better than original model.

CONCLUSION

Amidst the mounting mindfulness of the stakeholders' environmental and social responsibility, it has compelled the palm oil planters to engage their sustainability practices through the imposition of well-recognized environmental standards (i.e. RSPO, ISCC, MSPO & ISO 14001:2015) in order to assure firms' performance as well as the appreciation of the market price of company shares. VaR is extensively espoused to solve the puzzle on the greatest amount of loss that might be suffering throughout a period of time, on condition of given confidence level. In this paper, we two stages EVT-GARCH approach (McNeil & Frey, 2000) is implemented, coupled with findings that all of the models are performing inferiorly with low p-values. For further studies, we can include different volatility structures, or take into consideration of different GARCH orders. Other than that, we may look into the multivariate models for value at risk and expected shortfall using copulas.

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