CHAPTER 5

Conclusions, Discussion, and Recommendation

5.1 Conclusion

Almost all of the studies in finance focus only on gold and silver or focus only on gold with other assets for balance and diversity in the portfolio. Gold also can provide the investor with a "safe haven" in economic uncertainty and financial instability times. As precious metals are important in terms of investment, we, therefore, aimed to study in this subject matter and focused on all precious metals consisting of gold, palladium, platinum, and silver. In addition, this study also applied the econometric method in risk management for investment by using the GARCH model, Extreme value theory, and Copula model to estimate Value at Risk to calculate the optimal portfolios weights of the selected assets for investment. The empirical results can be shown as follows:

In the GARCH model, the asymmetric ARMA-GARCH model was used to remove the autocorrelation and to capture the conditional heteroskedasticity. The appropriated distribution found that student-*t* distribution is suitable for modeling because AIC and BIC in model with student-*t* distribution is less than normal distribution. In selecting the optimal lag for ARMA(*p*,*q*) found that the return on Gold, Palladium, Platinum, and Silver satisfied ARMA(1,1), ARMA(3,3), ARMA(3,3), and ARMA(2,1) with GARCH(1,1), respectively.

After that, we estimated the semi-parametric cumulative distribution function for the standardized residual (*i.i.d.*) obtained from the ARMA-GARCH model. EVT was then applied to those residuals which Generalized pareto distribution (GPD) is specially for tail estimation. We chose the exceedances to be the 10^{th} percentile of the sample for the upper and lower tail of the residual distribution of the residuals. We assumed that excess residuals over threshold follow the GPD and used the Gaussian kernel estimate for the remaining part.

Then, the standardized residuals were transformed to uniform variates and calibrated GARCH-EVT-*t* copula to data by maximum log-likelihood method. If it fits the *t* copula to the transformed data above, then the dependence structure can be captured between time series. After we had the empirical GARCH-EVT-*t* copulas parameters, the simulation algorithm was applied which can simulate the returns at time *t*+1 *t*+10 *t*+22 based on the correlation structure of GARCH-EVT-*t* copula or copulas parameters. We could then estimate VaR which is the risk prediction in the future for risk management.

Moreover, the Expected shortfall was estimated which shows the loss exceeds VaR, appropriating to analyze portfolio risk. So the optimal portfolios weights of the selected assets were calculated under minimized expected shortfalls with respect to maximized returns. The result demonstrated that most of the investment proportions are gold and silver, whereas palladium and platinum have little investment proportion, especially palladium that has zero proportion in the precious metal portfolio.

5.2 Discussion

This study illustrated the importance of precious metal investment. Especially, in last result, the optimal portfolio weights of the selected assets represents the reason that gold and silver were the focus of many works of finance and necessary for investors in times of economic uncertainty and financial instability. Additionally, the result can be utilized for the investment decision of investors and necessary for the economy of the world which can be the recommendations to the economic development agency.

The methods applied to estimate the risk in this study (GARCH model, Extreme value theory, and Copula model) are tools that have been recognized for financial analysis. They were applied in many works, but in this study, we adapted how to estimate risk differently from other works, using the cumulative return to analyze and apply portfolio optimization CVaR. This adaptation can generate a better and more accurate analysis.

5.3 Recommendation

5.3.1 Recommendation from the study

1) This study allows to evaluate the future risk and also acknowledges the ratios for appropriate investment, return, and expected risk which could be the guideline for decisions making of investors.

2) The value at risk obtained from this study can indicate that investors should reserve enough minimum funding for the loss value. Therefore, investors should consider this loss value to be the appropriate choice with reserved funding and investment strategy, which can be the way for investment and risk management.

3) In this study, there were predictions in risk of investment that could be taken into account for policy implications, in terms of possible risk, in order for investors to be informed about risk and return and finally be able to invest. As the study focused on the precious metals market in London, which has an important role on global economics, if the investors invest more, there will be influences on the world's economy.

4) The risk prediction in this work may be the way or the support data for the investor, but the real investment should have consideration with a current situation or information related to precious metal price changes.

5.3.2 Recommendations for further study

1) In this study, we used only the ARMA-GARCH model. Further studies should consider other GARCH models to choose the best GARCH and obtain the best residual data to conduct in research.

2) This study used only *t* copula model; we should have employed more copulas such as the multivariate Gaussian, Clayton, Gumbel, and vine copula.

3) The data used in this study was from the period 2007 to 2015, which in further studies should classify periods time to obtain the result that can illustrate a comparison of financial crisis time and general situation time. Moreover, we recommend the use of other assets or different markets in further studied to indicate necessary investments affecting the world's economy.