ปีที่ 2 ฉบับที่ 2 เดือนกรกฎาคม - ธันวาคม 2563

Sources of Risk Analysis and Industrial Portfolio Allocation in the Stock Exchange of Thailand

Kanisorn Jeerasinkul[1*]

Received: June 25, 2020

Revised: August 4, 2020

Accepted: August 30, 2020

Abstract

This study investigates the appropriate portfolio allocation in the Stock Exchange of Thailand consists of eight industry groups (agriculture and food industry, consumer products, financials, industrials, property and construction, resources, services, and technology). It investigates risk contribution in each industry group, using the Component Expected Shortfall (CES) approach. This paper applies the dynamic conditional correlation multivariate GARCH model to measure the dynamic correlation between each pair of industry group index and Thailand's stock market system. The empirical results show that the financial sector contributes to the highest risk in the Thai stock market, while consumption introduces the lowest risk source. Thus, the investor should consider investing the money in the consumption sector to reduce portfolio risk.

Keywords: CES, Portfolio Allocation *JEL Classification Codes:* C32, G11, G32 SET Industry Group Index

[1] Faculty of Economics, Chiang Mai University, Chiang Mai, 50200

* Corresponding E-mail: tonkns23@gmail.com

การวิเคราะห์ต้นกำเนิดของความเสี่ยงและการจัดสรรการลงทุนอุตสาหกรรม ในตลาดหลักทรัพย์แห่งประเทศไทย

คณิศร จีรสินกุล[1*]

บทคัดย่อ

การศึกษานี้เสนอการจัดสรรพอร์ตการลงทุนที่เหมาะสมในตลาดหลักทรัพย์แห่งประเทศไทย ซึ่งประกอบด้วย 8 กลุ่มอุตสาหกรรม (เกษตรกรรมและอุตสาหกรรมอาหาร, สินค้าอุปโภคบริโภค, การเงิน, อุตสาหกรรม, อสังหาริมทรัพย์และสิ่งก่อสร้าง, ทรัพยากร, บริการและเทคโนโลยี) และตรวจสอบผลกระทบของความเสี่ยงของแต่ละกลุ่มอุตสาหกรรมโดยใช้วิธีการที่เรียกว่า Component Expected Shortfall เราใช้แบบจำลอง DCCGARCH เพื่อวัดความสัมพันธ์แบบไดนามิกระหว่างดัชนีกลุ่มอุตสาหกรรมแต่ละคู่กับระบบตลาดหุ้นของประเทศไทย ผลการวิจัยพบว่าสัดส่วนการลงทุนในบางกลุ่มอุตสาหกรรมจะให้ความเสี่ยงต่ำกว่าการลงทุนในทุกอุตสาหกรรมในสัดส่วนที่เท่ากัน

คำสำคัญ: การจัดพอร์ตการลงทุนที่เหมาะสม การวัดค่าเฉลี่ยของความเสียหายส่วนเกิน ดัชนีตลาดหลักทรัพย์กลุ่มอุตสาหกรรม

[1] คณะเศรษฐศาสตร์, มหาวิทยาลัยเชียงใหม่, จังหวัดเชียงใหม่, 50200

Introduction

The risk management approach relies on the historical data (such as market returns, total asset returns, option prices, or CDS spreads) (Jorion, 2007). The baseline idea is to reveal the financial interdependency from these market-data without any knowledge of financial institutions' cross-positions. The common financial risk measurement techniques are the Value-at-Risk (VaR) or the Expected Shortfall (E.S.). These two methods allow us to quantify each contribution firm to the overall risk of the system (Yang and Hamori, 2020).

Investors often face the risk of return on assets in the financial market due to fluctuations in asset prices in the market. This allows investors to receive both positive and negative return on investment. Portfolio management can help to reduce and distribute the risks of return on investment. The study of Markowitz suggested that portfolio management is selecting the best portfolio (asset distribution) according to some objective. The objective typically maximizes expected return and minimizes financial risk (Markowitz, 1952).

It is widely accepted that the stock exchange is an essential market in the financial market structure. This market is the place for securities trading, and it is an intermediary connect the savings or excess funds from the household sector to the manufacturing sector, which seeks capital investment. People with savings have more motivation to save and have more alternatives for saving and investing. When savings enter the financial system intensively to capital market mechanisms, there will be more opportunities for long-term fundraising in the capital market. As a result, the excess resources of financial system are directly contributed to the development of businesses and the economy. Besides, the stock market can also help to reduce the foreign debt of the company. Therefore, the stock exchange acts as an important mechanism to help meet the country's capital needs. It also helps to reduce the needs for loans from domestic financial institutions and reduces the needs for foreign currency loans (The Stock Exchange of Thailand, 2015).

This study focuses on the Stock Exchange of Thailand (SET). It has the highest liquidity in ASEAN and a market value of 544 billion U.S. dollars, by ranked at 23rd compared to 78 global stock exchanges in the first half of 2019. The Stock Exchange of

Thailand is still growing a lot of compared to the past. Besides, the Thailand stock market has a total return at the end of March 2019, increasing 16.37 times from 2000. This makes Thailand stock market attractive to investment (The Stock Exchange of Thailand, 2019).

At present, the Stock Exchange of Thailand has more than 500 listed companies divided into eight industrial groups, which each business group have similar basic characteristics, and stock prices in the same industrial group tend to move in the same direction. This paper focuses on all of eight industrial groups in the Stock Exchange of Thailand to find the contribution risks and total risk of the optimized portfolio. Meanwhile, this study compares the optimized portfolio with the equal proportion weight (Equal-weighted portfolio), both individual and total risk. The systemic risk analysis is then closely related to the portfolio risk analysis based on the CES approach.

As sources of risk are the component of the market risk, it is necessitate to identify these components to understand the actual source contributing to the risk of the eight industry groups in Thailand stock market. By understand these sources of risk, the investor could reduce the overall risk of the investment portfolio.

This study applies a lately systemic risk measure called Component Expected Shortfall or CES proposed by Banulescu and Dumitrescu (2015), which addresses the main drawbacks of MES (Marginal Expected Shortfall) and SRISK. This new approach provides several advantages as it can be used to assess contribution of each industry group to the overall system at a precise date. Specifically, this study conducts the CES to find the sources of risk in portfolio optimization. This method is a new methodology that can be used as an alternative to the Value-at-Risk (VaR) method. Besides, it provides a better measurement and also identifies sources of risks.

Before measuring one–period-ahead, the stock market time-varying correlations and industry group index need to be computed. This study uses the dynamic conditional correlation GARCH (DCC-GARCH) model to compute conditional volatility, standardized residuals for the Stock Exchange of Thailand, and each industry group. The DCC-GARCH (Engel, 2002) decomposed the conditional covariance matrix into a conditional standard deviation matrix and a conditional correlation matrix. This model takes into account with time-varying co-movement. This model allows the variance and correlation to vary over time.

This study aims to propose the appropriate portfolio allocation for investment in the Stock Exchange of Thailand consisting of eight main industry groups and investigate the contribution of risk from all groups in the Stock Exchange of Thailand using the CES approaches. This will help the investor to classify the level of risk and to understand the sources of risk in the Stock Exchange of Thailand. In addition, the stock manager can use this information to limit the market risk by intervening the sector that contributing the highest risk to the market.

The rest of the paper is set out as follows. Section 2 reviews the literature. The methodology used and the scope of the study are described in Sections 3 and 4. Section 5 discusses the empirical results. The final section concludes the study.

Literature Review

Several studies have examined the systemic risk using Component Expected Shortfall (CES) approach (Banulescu and Dumitrescu, 2015; Tansuchat et al., 2017; Wu, 2019; Liu et al., 2020). Banulescu and Dumitrescu (2015) studied systemically risky firms during the 2007–2009 financial crisis, employ Component Expected Shortfall (CES) developed by analogy with the Component Value-at-Risk concept. The results revealed that there are four risky financial institutions, including Citigroup, Bank of America, JPMorgan, and A.I.G. Liu et al. (2020) developed CES to forecast the systemic risk of global financial markets and found that developing portfolios can provide valuable insights for financial institutions and policymakers to diversify portfolios and spread risk for future investments and trade.

In the case of stock markets, Liu et al. (2015) applied the time-varying copula-GARCH and the DCC-GARCH models to estimate the Value–at-Risk (VaR) and Expected Shortfall (E.S.) of G7 stock markets and constructed the optimal portfolio. The empirical results showed that the time-varying copula-GARCH model successfully captured the tail dependences and extreme losses for G7 returns. The Canadian index held a high weight for the optimal portfolio, while the Italian index had the smallest weight. In addition, the systematic risk of G7 reached a higher level after the financial crisis due to the European debt crisis. Tansuchat et al. (2017) studied seven stock markets from Thailand, Malaysia, Indonesia, Vietnam, the Philippines, and Singapore and investigated their risk contribution to the ASEAN stock system using the Component Expected Shortfall approach. The empirical results indicated that the Philippines stock index contributed to the highest risk of ASEAN stock system.

The multivariate GARCH (generalized autoregressive conditional heteroskedasticity) model has been widely used to measure the dynamic volatility and correlations between market risk and other assets. This model estimates the covariance matrix between the assets by extending a univariate GARCH into a multivariate GARCH model. To extend the univariate to multivariate GARCH under the dynamic context, the dynamic conditional correlation (DCC) (Engle, 2002) was proposed to decompose the conditional covariance matrix into a conditional standard deviation matrix and a conditional correlation matrix. For instance, Celik (2012) studied the existence of financial linkage between foreign exchange markets of emerging and developed countries during the subprime crisis by employing DCC-GARCH analysis. Zinecker et al. (2016) studied the relations among Poland, Czech Republic, and Germany capital markets by applying the DCC-GARCH model with the t-student conditional distribution. Bhatia et al. (2018) used the DCC-GARCH approach to investigate the dynamic correlation between crude oil, and precious metals include gold, silver, platinum, and palladium. Chu (2020) studied contagion effects by analyzing the 1997 East Asian financial crisis in the equity markets of eight countries (Hong Kong, Thailand, South Korea, Malaysia, Philippines, and Indonesia) using dynamic conditional correlation (DCC). They revealed the presence of contagion across these stock markets.

Methodology

This study utilizes the DCC-GARCH model, and CES o measures the contribution of an asset to systemic risk. This model could capture the volatility clustering of each sector, and it can be used to forecast the precise returns of all sectors simultaneously. Then, obtained forecasting returns are used to measure the CES of eight stock sectors in the Stock Exchange of Thailand market.

GARCH Model

Time series analysis often assumes that the variance of the data is constant (Homoscedasticity). However, it is in fact that the variance is not constant over time (Heteroscedasticity). Thus, Bollerslev (1990) proposed Generalized Autoregressive Heteroscedasticity (GARCH) to forecast the conditional variance, and the model structure can be written as;

$$r_t = \mu_t + \varepsilon_t \quad (1)$$

$$\varepsilon_t = z_t \sqrt{\sigma_t^2} \quad (2)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha \varepsilon_{t-q}^2 + \sum_{i=1}^{p} \beta \sigma_{t-p}^2 \quad (3)$$

where z_t is the stock index return on time t, μ_t is constant term, ε_t is error term, z_t is white noise, σ_t^2 is the volatility of ε_t at the time t and α, β are parameters at the time t.

Fernandez and Steel (1998) has proposed the application of skewed distributions (Skewed distribution) and estimation from GARCH simulation by distributions of normal distribution model (White noise)

$$f\left(v_{i,t} | \xi\right) = \frac{2}{\zeta + \frac{1}{\zeta}} \left[f\left(\zeta v_{i,t}\right) H\left(-v_{i,t}\right) + f\left(\frac{v_{i,t}}{\zeta}\right) H\left(v_{i,t}\right) \right], \quad (4)$$

where $v_{i,t}$ is the distribution of securities index information and ξ is asymmetry parameter.

Dynamic Conditional Correlation GARCH Model

Bollerslev (1990) introduced the concept to develop the constant conditional correlation GARCH (CCC-GARCH) model to estimate the correlation. Nevertheless, the model restriction is constant correlation with no change through time (not time-varying). Later, Engle (2002) developed the dynamic conditional correlation GARCH (DCC-GARCH) model to solve this problem in the following way;

$$H_t = D_t R_t D_t \quad (5)$$

where H_t is $n \times t$ matrix of conditional variance at time t, R_t is conditional correlation matrix at time t and D_t is diagonal matrix of σ_t^2 at time t as follows:

$$D_t = diag\left\{\sqrt{\sigma_{1t}},....,\sqrt{\sigma_{nt}}\right\} \tag{6}$$

After estimating the volatility from the GARCH model, the result is in the form of a vector. So, it's converted to a matrix (Orskaug, 2009).

$$D_t = \begin{bmatrix} \sqrt{\sigma}_{11} & 0 & \cdots & 0 \\ 0 & \ddots & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & \sqrt{\sigma}_{nt} \end{bmatrix} \tag{7}$$

The result will be in the form of a correlation matrix. The equation is as follows (Orskaug, 2009).

$$R_t = diag\left\{Q\right\}_t^{-1} Q_t diag\left\{Q\right\}_t^{-1}, \tag{8}$$

where R_t is conditional correlation matrix at time t and Q_t is conditional correlation matrix with time varying at time t.

Therefore, the Dynamic Conditional Correlation (GARCH) model (Engle, 2002) is expressed by;

$$Q_t = \left(1-\theta_1-\theta_2\right)\bar{Q} + \theta_1 Q_{t-1} + \theta_2 \varepsilon_{t-1}\varepsilon_{t-1}^2, \tag{9}$$

where Q_t is conditional correlation matrix with time varying at time t in condition $\bar{Q} = \frac{1}{T}\sum_{t=1}^{T} \varepsilon_{t-1}\varepsilon_{t-1}^{'}$, T is time, θ_1 and θ_2 are parameters in range $0 \le \theta_1 + \theta_2 < 1$.

Component Expected Shortfall

This section introduces the Component Expected Shortfall (CES) proposed by Banulescu and Dumitrescu (2015). This study applies the CES to assess contribution of each industry group to the risk of Stock Exchange of Thailand (SET). Let r_{it} denotes the rate of return of industry group index i at time t and r_{mt} denote the aggregate return of the SET index at time t.

$$r_{mt} = \sum_{i=1}^{n} w_{it} \cdot r_{it}, \tag{10}$$

where w_{it} is an individual weight the value-weighted of industry group index i, i = 1,...,n, at time t. These weights are given by the relative of industry group index i capitalization to Thailand stock market system, and CES is defined as the part of Expected Shortfall (E.S.) of the SET index due to industry group index.

$$\begin{aligned} CES_{it} &= w_{it}\frac{\partial ES_{m,t-1}(C)}{\partial w_{it}}, \\ &= -w_{it}E_{t-1}(r_{it} \mid r_{mt} < C) \end{aligned} \tag{11}$$

where $-E_{t-1}(r_{it} \mid r_{mt} < C) = \partial ES_{m,t-1}(C)/\partial w_{it}$ is the Marginal Expected Shortfall (MES) which measures the marginal contribution of industry group index to the risk of the Thailand's stock market.

$$MES_{mt} = \left[h_{it} \cdot k_{it} \frac{\sum_{t=1}^{T} \gamma_{mt} \Phi\left(\frac{C-\gamma_{mt}}{h_{mt}}\right)}{\sum_{t=1}^{T} \Phi\left(\frac{C-\gamma_{mt}}{h_{mt}}\right)} \right] + \left[h_{it} \cdot \sqrt{1-k_{it}} \frac{\sum_{t=1}^{T} e_{it} \Phi\left(\frac{C-\gamma_{mt}}{h_{mt}}\right)}{\sum_{t=1}^{T} \Phi\left(\frac{C-\gamma_{mt}}{h_{mt}}\right)} \right], \tag{12}$$

where $\Upsilon_{mt} = r_{mt}/h_{mt}$ and $e_{it} = (r_{it}/h_{it}) - k_{it}$ are standardized SET index return and industry group index i, which h_{mt} and h_{it} are variance of error at time t. C = $1/h_{mt}$ is the threshold value depends on the distribution of the r_{mt}, Φ is the cumulative normal distribution function and k_{it} is the time varying Kendall's tau which can be transformed from the expected dependence parameter (Ek_t)

$$Ek_t = \sum_{j=1}^{2}\left[k_{(S_t=j),t}\right] \cdot \left[Pr\left(S_t = j \mid \xi_{t-1}\right) \times P\right]. \tag{13}$$

However, this study aims to assess the contribution of risk of each industry group to the Thailand stock market system, thus it is better to measure the risk in terms of percentage by

$$CES_{it}\% = \left(CES_{it} / \sum_{i=1}^{n} CES_{it}\right) \times 100. \tag{14}$$

Portfolio Optimization

The minimized expected shortfall with respect to maximized returns of a portfolio ES_t, based on Markowitz (1952) is defined as the sum of the weighted risk of each industry group expressed as follows;

$$ES_t = \sum_{i=1}^{n} CES_{it} , \qquad (15)$$

with CES_{ti} being the Component Expected Shortfall of industry group index i during period t expressed as a value between 0.01 to 1.00.

Results of the Study

This study collectes daily data returns from June 17, 2005, to May 20, 2019, a total of 3879 observations from the Thomson Reuters database. The variables used in this study consist of an index of industries group in the Stock Exchange of Thailand, including agriculture and food (AGRO), consumer products (CONSUMP), industries (INDUS), financials (FINCIAL), property and construction (PROPCON), resources (RESOUC), services (SERVICE), and technology (TECH). All of the industry indexes have been transformed into the difference of the logarithm.

Table 1 Descriptive Statistic

	AGRO	CONSUMP	INDUS	FINCIAL	PROPCON	RESOUC	SERVICE	TECH
Mean	0.000367	-1.47E-05	5.22E-06	8.55E-05	8.93E-05	0.000109	0.000405	0.000104
Median	0	0	0	0	0	0	0.000304	0
Maximum	0.06354	0.06782	0.085712	0.107258	0.100252	0.125999	0.080628	0.128959
Minimum	-0.122484	-0.066289	-0.148169	-0.193563	-0.154725	-0.174704	-0.112111	-0.208436
Std. Dev.	0.010714	0.006996	0.014828	0.014586	0.012404	0.016135	0.010599	0.014408
Skewness	-1.038807	-0.87164	-0.796542	-1.065232	-1.139355	-0.818599	-1.219913	-1.009583
Kurtosis	13.9245	16.42113	12.69039	20.11953	18.5739	17.78364	18.24419	21.68997
Jarque-Bera	19986.75*	29604.18*	15587.36*	48102.39*	40040.79*	35757.34*	38521.38*	57116.96*
ADF Test	-40.03*	-26.18*	-43.21*	-37.79*	-43.35*	-39.71*	-40.75*	-34.32*

Note: "*" the strong evidence supports the alternative hypothesis.

Table 1 shows the descriptive statistics of the returns on industry group in the Stock Exchange of Thailand. This study transforms the p-value of the test to be the Maximum Bayes Factor (MBF), and found that it strongly rejects the normality data for all series. Thus, the data are not normally distributed. Finally, according to the Augmented Dicky Fuller(ADF) test, the data series are stationary indicated by the MBF.

Empirical Result

This section consists of three parts, including (1) Model selection and empirical result of an estimated parameter, (2) Dynamic conditional correlation result, and (3) Portfolio allocation and risk estimation result.

In the first section, the performance of CCC-GARCH model, DCC-GARCH model, and Skewed-DCC-GARCH model paired in this section are based on the lowest Akaike Information Criterion (AIC). There are evaluated at the highest value of log - likelihood. The result represents that the Skewed-DDC-GARCH AIC model has the lowest pair with the CCC-GARCH and DCC-GARCH model. Therefore, the Skewed-DCC-GARCH model is the best model on the basis of AIC (Skewed-DCC-GARCH has -15,333.4, DCC- GARCH has -11,398.35, and CCC-GARCH has -725.987).

Table 2 The Model Selection

Models	CCC-GARCH	DCC-GARCH	Skewd DCC-GARCH
AIC	-725.987	-11,398.35	-15,233.4

After the suitable ARMA-GARCH is selected, ARMA (1,1)-GARCH (1,1), to the DCC-GARCH model, the margin returns series of each pair of industry in the SET market. This paper mainly focuses on the skewed student-t distribution, which has the best performance due to the fact of financial series having fat tails (Phochanachan et al, 2016).

Table 3 Estimation Result of DCC-GARCH (1, 1) Models

	AGRO	CONSUMP	INDUS	FINCIAL	PROPCON	RESOUC	SERVICE	TECH
ω	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
α	0.112*	0.175*	0.099*	0.092*	0.105*	0.090*	0.102*	0.073*
β	0.864*	0.766*	0.892*	0.903*	0.893*	0.905*	0.878*	0.914*
skew	0.955	0.948	0.986	0.995	0.921	1.002	0.937	0.969
shape	4.698	3.471	4.702	4.992	4.934	4.693	4.722	4.092
$\theta_{i,1}$		0.019		$\theta_{i,2}$		0.946		

Note: "*" the strong evidence supports the alternative hypothesis.

The DCC estimates of the conditional correlations between the industry returns are represented in table 3. As the estimates of both $\theta_{i,1}$, the impact of past shocks on current conditional correlations and $\theta_{i,2}$, the impact of previous dynamic conditional correlations are statistically significant. It clearly indicates that the conditional correlations are not constant (Chang et al., 2013). It has been used for simulating the conditional correlation. All estimates are based on the in-sample period of the empirical dataset and all of DCC parameter values are estimated by maximum likelihood.

The estimation results (dynamics correlation) obtained from the DCC model provide that the results vary over time. Therefore, to make a straightforward interpretation, this study finds an expected (Engle, 2002) and briefly descriptive statistic (including the maximum, minimum, and standard deviation) of dynamics conditional correlation. The range of correlation is between -1 to 1, which a correlation value close to -1 or 1 indicates a strong positive or negative relationship (Hanson et al., 1992), and the standard deviation represents the correlation volatility of the pair of the variable.

Table 4 represents the correlations of all industries in SET markets. The results suggest that the industry co-movements become a positive relationship (Hanson et al., 2013) and, on average, It remains at this level afterward. For the FINCIAL-PROPCORN pair, the correlation range is 0.7508, correlation values are very high. On the other hand, the CONSUMP-TECH pair seems weakly co-movement. Therefore, the results of the conditional correlation lead to investment portfolio allocation. Moreover, The SERVICE-TECH pair has the highest standard deviation indicated that they have a high fluctuation correlation.

Table 4 Summary Statistics Results of Conditional Correlation

Variable	Correlation	Max	Min	S.D.	Variable	Correlation	Max	Min	S.D.
ARGO-CONSUMP	0.416	0.728	0.327	0.065	INDUS-PROPCON	0.668	0.892	0.696	0.038
ARGO-INDUS	0.548	0.679	0.350	0.066	INDUS-RESOUC	0.702	0.849	0.560	0.059
ARGO-FINCIAL	0.587	0.749	0.352	0.072	INDUS-SERVICE	0.613	0.571	0.055	0.101
ARGO-PROPCON	0.650	0.730	0.424	0.065	INDUS-TECH	0.495	0.581	0.129	0.093
ARGO-RESOUC	0.552	0.717	0.347	0.077	FINCIAL-PROPCON	0.751	0.944	0.805	0.022
ARGO-SERVICE	0.656	0.457	0.076	0.079	FINCIAL-RESOUC	0.654	0.909	0.680	0.040
ARGO-TECH	0.489	0.492	-0.011	0.084	FINCIAL-SERVICE	0.677	0.607	0.106	0.097
CONSUMP-INDUS	0.396	0.904	0.728	0.033	FINCIAL-TECH	0.567	0.619	0.156	0.096
CONSUMP-FINCIAL	0.413	0.914	0.703	0.031	PROPCON-RESOUC	0.687	0.878	0.629	0.048
CONSUMP-PROPCON	0.472	0.889	0.610	0.043	PROPCON-SERVICE	0.749	0.616	0.110	0.096
CONSUMP-RESOUC	0.394	0.830	0.528	0.058	PROPCON-TECH	0.600	0.623	0.166	0.099
CONSUMP-SERVICE	0.450	0.591	0.101	0.092	RESOUC-SERVICE	0.624	0.586	0.092	0.098
CONSUMP-TECH	0.360	0.578	0.146	0.083	RESOUC-TECH	0.525	0.605	0.125	0.101
INDUS-FINCIAL	0.620	0.919	0.680	0.036	SERVICE-TECH	0.578	0.586	0.049	0.103

To achieve the study goal, Portfolio optimization is the process of selecting the best portfolio (asset distribution) according to various objective. The objective typically maximizes factors such as expected return and minimizes costs like financial risk. Considered factors may range from tangible (such as assets, liabilities, earnings, or other fundamentals) to intangible (such as selective divestment). The optimal portfolio weight based on the mean-variance model (Markowitz, 1952). It is generally known that the standard portfolio optimization problem model is Markowitz' Mean-Variance portfolio optimization model.

Table 5 The Result of Portfolio Allocation and Risk

	Portfolio 1		Portfolio 2	
	Weight	CES	Weight	CES
AGRO	0.1075	0.1225	0.125	0.0893
CONSUMP	0.8481	0.8130	0.125	0.0709
INDUS	0	0	0.125	0.0975
FINCIAL	0	0	0.125	0.1726
PROPCON	0	0	0.125	0.1350
RESOUC	0	0	0.125	0.1661
SERVICE	0.0445	0.0643	0.125	0.1124
TECH	0	0	0.125	0.1556
Expected Shortfall 5%		0.8773%		0.9994%

Table 5 compares the portfolio in an optimal weighted (Portfolio 1) and equal-weighted (Portfolio 2). The result reports the under minimized expected shortfall concerning maximized returns. This study compares the equal-weighted (Portfolio 2) to optimal weighted (Portfolio 1) of the portfolios. The optimal portfolio weighted results suggest investing in the largest proportion in the consumer products industry is 0.8481, followed by the agriculture and food industry and the service industry are 0.1075 and 0.0445, respectively.

Finally, as the main purpose of the study is the contribution of an asset to systemic risk and decomposes the overall risk of the portfolio the study employs the DCC-GARCH to CES approach as a tool to assess the percentage of individual industry group contribution to the overall risk of the optimized portfolio (Banulescu and Dumitrescu, 2015). Table 5, in CES's portfolio 1 reports the individual risk, which found that the three portfolios of industry arrangement have the highest proportion of investment and the highest risk is the consumer products industry which is, 0.8130, followed by agriculture and food, and service industries have risks equal to 0.1225 and 0.0643, respectively. Meanwhile, the CES refers to the risk contribution to the optimized portfolio, such as the risk in the consumer products industry affects the total risk of investment, while the expected shortfall is 0.8773, indicating a 5% chance this portfolio facing the loss of

0.8773%. Compare with the equally weighted (0.9994%), unequally weighted produces a lower expected shortfall. Also, the expected shortfall represents the total risk of their portfolio. Therefore, the result confirms that the optimal weighted has a lower risk than the same weight portfolio.

The result presents that optimal portfolio (portfolio 1) shows a lower risk than unequally weighted portfolio. Although Thailand stock market (Stock Exchange of Thailand) has more volatility and risks cannot be eliminated, investors can allocate their investments to reduce risks. However, there are researches related to portfolio allocation in Thai financial markets, market (Kong-ied, 2017; Thitipatlertdech, 2016). In this study, the optimal portfolio based on the lowest total risk is considered, and the components or sources of risk can be justified.

Conclusions and Discussions

This study proposes the appropriate portfolio allocation for investment in the Stock Exchange of Thailand consisting of eight main industry groups and also investigates the contribution of risk from each of the eight industry groups in the Stock Exchange of Thailand using the CES approaches. It will help the investor to classify the level of risk and understand the sources of risk in the Stock Exchange of Thailand.

This study assesses the contribution risk of each industry into an optimized portfolio. Thus, this study employed the Component Expected Shortfall (CES) to measure systemic risk based on the study of Banulescu and Dumitrescu (2015). The CES is a tool for accessing contribution of each industry group to the overall risk of portfolio. First of all, the Skew-DCC-GARCH model has been employed to investigate the dynamic conditional correlation. This study focuses on the skewed student-t distribution, which has the best performance due to the financial series with fat tails.

The findings on the conditional correlation in this study clearly show that the correlation varies over time, and the financial industry-property and construction industry have correlation values that are very highly dependent. On the other hand, the consumer products industry and technology industry seem to be a weak co-movement. The CES result shows that the financial sector is contributed to the highest risk in Thai stock market, while consumption introduces the lowest source of risk. Thus, the investor should consider investing the money in the consumption sector to reduce portfolio risk. The results suggest the optimal investment allocation in some industry groups which are consumer products 0.8481, agriculture and food 0.1075, and services 0.0445, respectively.

References

Banulescu, G. D., & Dumitrescu, E. I. (2015). Which are the SIFIs? A Component Expected Shortfall approach to systemic risk. *Journal of Banking & Finance*, *50*, 575-588.

Bhatia, V., Das, S., & Mitra, S. K. (2018). Crude Oil Hedging with Precious Metals: a DCC-GARCH Approach. *Academy of Accounting and Financial Studies Journal*, 22(1), 1-8.

Bollerslev, T. (1990). Modelling the coherence in short-run nominal exchange rates: a multivariate generalized ARCH model. *The review of economics and statistics*, 72(3), 498-505.

Celik, S. (2012). The more contagion effect on emerging markets: The evidence of DCC-GARCH model. *Economic Modelling*, *29*(5), 1946-1959.

Chang, C. L., McAleer, M., & Tansuchat, R. (2013). Conditional correlations and volatility spillovers between crude oil and stock index returns. The North American Journal of Economics and Finance, 25(2013), 116-138.

Cho, J. H. (2020). East Asian financial contagion under DCC-GARCH. *International Journal of Banking and Finance*, 6(1), 17-30.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, 20(3), 339-350.

Hanson, B., Klink, K., Matsuura, K., Robeson, S. M., & Willmott, C. J. (1992). Vector correlation: review, exposition, and geographic application. *Annals of the Association of American Geographers*, 82(1), 103-116.

Jorion, P. (2007). *Financial risk manager handbook* (Vol. 406). John Wiley & Sons.

Kanokporn, K. (2016). *The Analysis of Volatility of Exchange-Traded Funds (ETF) Investment Returns Affecting Index in the Stock Exchange of Thailand (SET) Using Multivariate GARCH Models. Chiang Mai. Chiang Mai University.*

Kong-ied, A., M.S. (2017). *Return from Mutual Fund Portfolio Management in Thailand, Graduate School, Bangkok University.* (pp. 1-93).

Liu, J., Sriboonchitta, S., Phochanachan, P., & Tang, J. (2015). Volatility and dependence for systemic risk measurement of the international financial system. In *International Symposium on Integrated Uncertainty in Knowledge Modelling and Decision Making* (pp. 403-414). Springer, Cham.

Liu, J., Song, Q., Qi, Y., Rahman, S., & Sriboonchitta, S. (2020). Measurement of Systemic Risk in Global Financial Markets and Its Application in Forecasting Trading Decisions. *Sustainability*, 12(10), 4000.

Markowitz, H. (1952). Portfolio selection. *Journal of Finance*, 7(1), 77–91.

Orskaug, E. (2009). Multivariate dcc–garch model: with various error distributions (Master's thesis, Institutt for matematiske fag).

Phochanachan, P., Liu, J., & Sriboonchitta, S. (2016). On Mathematical Modeling and Analysis of Co-Movement and Optimal Portfolios of Stock Markets. *Thai Journal of Mathematics*, 14(2), 283-303.

Tansuchat, R., Yamaka, W., Khemawanit, K., & Sriboonchitta, S. (2017). Analyzing the contribution of ASEAN stock markets to systemic risk. *In Robustness in Econometrics* (pp. 649-666). Springer, Cham.

The Stock Exchange of Thailand. (2015). *History and roles*, from https://www.set.or.th/th/about/overview/history_p1.html.

The Stock Exchange of Thailand. (2019). *Annual Report 2019*, from https://www.set.or.th/th/about/annual/files/annual_report_2562_thai_full.pdf.

Thitipatlertdech, N. M.S. (2016). *The Effects of Macroeconomic Factors on Return of Portfolio, Graduate School, Bangkok University* (pp. 1-46).

Wu, F. (2019). Sectoral contributions to systemic risk in the Chinese stock market. *Finance Research Letters*, 31(c), 386-390

Yang, L., & Hamori, S. (2020). Forecasts of Value-at-Risk and Expected Shortfall in the Crude Oil Market: A Wavelet-Based Semiparametric Approach. *Energies*, 13(14), 3700.

Zinecker, M., Balcerzak, A. P., Faldzinski, M., Meluzin, T., & Pietrzak, M. B. (2016). Application of DCC-GARCH model for analysis of interrelations among capital markets of Poland, Czech Republic and Germany. *Chapters*, 1(67), 418-423.