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Calculation of Value At Risk using Historical Simulation, Variance Covariance and Monte Carlo Simulation Methods

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Abstract: The purpose of this study is to measure the Value at Risk of single assets of companies listed on the Jakarta Islamic Index using the Historical Simulation, Variance Covariance and Monte Carlo Simulation methods. The research method is defined as a scientific way to obtain data with specific purposes and uses. The research design used in this study is a comparative study, this study uses data analysis methods with a quantitative approach. The results of the research are based on validity testing using the *Backtesting Kupiec method* and *Basel traffic light* known that all three methods are used in this study produces a valid (accurate) VaR value for used.

Keyword: Value At Risk, Historical Simulation, Variance Covariance, Monte Carlo Simulation.

INTRODUCTION

Economic activity is currently growing along with the times. One of the developments in economic activity is investment. One of the most popular investment alternatives today is stocks, which are issued by companies to raise capital. Shares are securities that prove the deposit of funds from investors to the company. Even though investing in the same industrial sector, the benefits and risks that will be received from investments between shares will not be the same due to internal factors including management, marketing, financial conditions, product quality and competitiveness as well as external factors which include government policies, politics, economics, social and cultural, defense and security of competitors as well as people's tastes and purchasing power. It can be concluded that investment is a commitment to a number of funds or other data sources that are carried out at this time, which aims to gain profits in the future (Tandelilin, 2010).

Investment has a very important role for the company's growth. One example is a large company in the world like Google. In July 2018, shares of Google's parent company Alphabet recorded earnings per company share of US$11.75 (Rp 171,226), of which Alphabet's revenue exceeded US$32.66 billion. The company's capital expenditure almost

doubled from 2017, namely US$2.8 billion to US$5.5 billion. The increase was due to the company's investment in data centers and facilities and production equipment to support Google's business and product development which is increasing. Through these investment activities the company will gain significant benefits such as being able to maintain *market share* , avoid catastrophic greater losses, improve services and improve business quality by developing innovation (Wirayani, 2018).

Based on IDX data from 2016 to March 2018, the JCI investment yield reached 11.59%. The positive performance achievement by the IDX in 2016 made the JCI yield rate the fifth largest among world exchanges and the second largest in the Asia Pacific region, namely 15.32%, and in 2017 it was 19.99% (India, 2016). The increasing development of the Indonesian capital market has also increased public interest in investing. According to the Indonesia Stock Exchange (IDX) and the Indonesian Central Securities Depository (KSEI), in 2018 the number of investors in the capital market increased by 44% compared to the previous year, reaching 1,617,367 SID (*Single Investor Identification*). The value of asset ownership in the form of shares is currently no longer controlled by foreign investors, since March 2018, local investor ownership is greater than foreign investors. In April 2018 the total value of local ownership was 51.38% while foreign ownership was 48.62%. It's just that, in special instruments, such as equity instruments foreign ownership still dominates. Even though currently local investor ownership dominates, it is possible that share ownership will be dominated again by foreign investors because previously the proportion of foreigners in Indonesian share ownership reached 60% even though the percentage of foreign investors to total SID was only 2.13% (Purnomo, 2018).

Based on this phenomenon, research is needed that can increase the knowledge of local investors to make stock investment decisions in Indonesia. In general, the goal of investors in investing is to gain profit or return on the investment made. However, in reality, investment in a stock is inseparable from failure, no *return* can be obtained without risk because no one knows for sure what will happen in the future. Every investor should first understand the risk, by analyzing how big the financial impact can be borne, or how much is the ability to accept losses from the investment undertaken. Every investor must be able to deal with and protect investment assets according to their ability to face a risk. Therefore risk measurement has an important role in investment activities.

The main problem faced by every investor is determining which risky assets to buy. Every investor must be able to deal with and protect investment assets according to their ability to face risks. There are two basic things in every investment including Islamic capital market investment, namely the level of profit *(return)* and the risks that will be faced, and an important consideration is the measurement of risk. Risk management is needed in this case to detect risk factors that might affect the level of profit in stock investment so that risks can be identified and losses to be faced can be identified.

The application of risk management will provide benefits in the form of an overview of possible losses in the future. Risk in investment is the uncertainty faced because the price of an asset or investment becomes lower than the expected return on investment . At this time there have been many developed calculations of the value of risk in investing to reduce risk so that investors can know the value of risk earlier. In addition to *returns* , risk measurement is also very important. Risk analysis which uses a lot of statistical methods plays a very important role in determining the size of risk which is an important element in risk management. One form of measuring the value of risk that is often used is *Value at Risk* (VaR).

The Value at Risk (VaR) method is part of risk management. At this time VaR is considered a standard method of measuring risk, so it is widely accepted and applied in calculating risk. According to Jorion (2007), VaR is defined as the estimated maximum loss that will be obtained during a certain time period *under* normal market conditions at a certain

confidence level . Determining the type of methodology and assumptions that are appropriate to the distribution *of returns* is the most important aspect in calculating VaR because VaR calculations are based on the distribution of security *returns* , where securities are proof of money or proof of payment of capital. In order to produce an accurate VaR calculation to be used as a measure of risk, it is very important to apply the right methods and assumptions. There are three main methods for calculating VaR, namely the *Variance Covariance method* , the Monte Carlo simulation method and the Historical simulation method. The three methods have their own characteristics.

Variance Covariance Method was chosen because this method is the most widely used method for measuring VaR and can calculate various exposure arrangements (stocks). This method assumes that returns are normally distributed and portfolio returns are linear with respect to single asset returns. Furthermore, this factor causes a lower estimate of the potential volatility (standard deviation) of the asset or portfolio in the future. The Monte Carlo simulation method is used in this study because compared to the other two methods this method is more realistic and uses a large number of random simulations where each simulation will be different but the total simulation will be accumulated with the selected statistical parameters. This method assumes that returns are normally distributed which is simulated using the appropriate parameters, and does not assume that portfolio returns are linear to single asset returns. While the historical simulation method was chosen for this study because this method is the simplest method and avoids some of the hidden difficulties of the correlation method.

The selection of companies focuses on stocks that are members of the Jakarta Islamic Index (JII) on the Indonesia Stock Exchange (IDX) for the period June 2017- May 2018. The Jakarta Islamic Index (JII) is a stock index consisting of 30 shares and is made based on Islamic sharia principles . The sharia concept in question is based on the direction of the Sharia Supervisory Board of PT Danareksa Investment Management in collaboration with the Indonesian Stock Exchange to form JII. The development of the Islamic capital market in Indonesia has progressed, there have been several developments and advances in the Islamic capital market, this is evidenced by the issuance of six Fatwas of the National Sharia Council of the Indonesian Ulema Council (DSN-MUI) relating to the capital market industry (Aziz, 2010). The growth and development of the sharia-based capital market in recent years has been very rapid. This can be seen from the emergence of sharia industries, especially the financial industry and sharia business units.

This study uses the Jakarta Islamic Index (JII) because the companies included in the index are companies that have gone public and meet sharia criteria. So many Islamic stocks are listed on the Indonesian Stock Exchange (IDX), so the stocks included in the Jakarta Islamic Index (JII) not only meet the criteria for Islamic stocks but are also superior from a market aspect because they have the best market capitalization and liquidity among Islamic stocks. which exists. So that it can be said that JII members are superior sharia stocks.

Several previous studies have been carried out in calculating *the Value at Risk* of stock assets, both single and portfolio. These studies include research conducted by Hadi Ismanto (2016) measuring *Value at Risk* in forming an optimal portfolio using the Monte Carlo method. Achmad Dimas Adrianto and Muhammad Azhari Khairunnisa (2018) calculated *Value at Risk* (VaR) using the Historical and Monte Carlo methods for shares in the cigarette sub-sector where the method using Monte Carlo simulations gives greater results. Handoyo Lestdwinanto (2016) compared the VaR *Risk Metric, Historical Back Simulation and Monte Carlo Simulation methods* on properties with the results of the Monte Carlo method which produces the greatest risk value. However, there is still little research on the comparison of *Value at Risk* with Historical, Variance Covariance and Monte Carlo methods on stocks listed on the JII index, especially in developing countries like Indonesia.

This research was conducted to see how the value of risk is compared using the Value at Risk method on the JII index, therefore the researcher is interested in analyzing it further, so the researcher wants to raise the title "Calculation of Value at Risk Using Historical Simulation Methods, Variance Covariance and Monte Carlo Simulation (Comparative Study: Companies Registered on the Jakarta Islamic Index)"

LITERATURE REVIEWS

Value at Risk

The concept of VaR has basically been around for a long time, but systematic VaR for various financial risks has just been developed. In economics and finance, Value at Risk is the maximum loss that will not be exceeded for a probability, which is defined as the confidence level, over a certain period of time.

Value at Risk (VaR) is a form of risk measurement that is quite popular because VaR has the simplicity of the concept but also has the ability to implement various statistical methodologies. VaR is an estimate of an amount of money/value based on probability, so the level of certainty cannot be determined (Suhadi, 2012). According to Jorion (2007), VaR is defined as the estimated maximum loss that will be obtained during a certain time period under normal market conditions at a certain confidence interval. It is possible that the actual loss may be worse, so the limitation of VaR is that it cannot say anything about how much the loss actually occurred and does not determine the worst possible loss. However, investors can use the VaR value as a benchmark that can determine how big the risk target is. VaR is the worst loss expected from an institution that suffers for a certain time interval under normal market conditions at a certain level of confidence (Butler 1999). According to Penza and Banzal (2001), with a probability of one percent and time t days, the VaR of an entity is the loss that is expected to be exceeded with probability only x percent in the time period t-days.

Backtesting

From several previous studies, Value at Risk is stated to have good predictive abilities. Previously the VaR had to be validated first to get the right model. There are many methods that can be used, one of which is the backtesting method. According to Jorion (2001), the backtesting method is a statistical framework which consists of the process of ensuring that the actual loss matches the predicted loss . The backtesting method is carried out by comparing *the actual daily profit loss* that occurs with the daily VaR value. When the number of observations exceeds the estimated VaR value according to the confidence level of the model, the VaR mode can be said to be perfect. So backtesting is a process of comparing the results of the VaR calculation with *the actual loss* . The purpose of the validation is to assess the accuracy of the VaR model that has been obtained.

If the deviations that occur are within the limits of the study then a model can be said to be valid. The backtesting method works by making a comparison between the estimated VaR which is calculated by the negative change in the value of an asset that occurs. If the negative change is greater than the VaR calculation, then the event is called *an exception* . If a model after being validated turns out that no deviations are found, then the model can be said to be a conservative model and vice versa if the number of deviations that occur is relatively large, the model is unable to estimate VaR, so it is very necessary to set deviation limits.

METHODS

In general, the research method is defined as a scientific way to obtain data with specific purposes and uses (Sugiyono, 2014). The research design used in this study is a *comparative study* . According to Sugiyono (2014) *comparative study* is research that compares the condition of one or more variables with two or more different samples, or two

different times. Comparative research is also research that compares two or more symptoms (Silalahi, 2009). In essence, comparative research is research that is used to be able to find similarities and differences about objects, people, work procedures, ideas, criticism of people or groups (Anas, 2009).

This research is also included in the type of quantitative research, which is a process of finding knowledge that uses data in the form of numbers as a tool to analyze information about what one wants to know (Kasiram, 2008). According to Azwar (2007) quantitative research is research that emphasizes numerical data (numbers) that are processed using statistical methods.

Data analysis by using methods that can assist in processing data, analyzing and interpreting the data. Based on the research objectives, this study uses data analysis methods with a quantitative approach.

RESULTS AND DISCUSSION

Based on the calculations that have been done, it is obtained that the VaR values do not differ much between the *Varince-Covariance, Historical Simulation* and *Monte Carlo Simuation methods* . However, when sorted, the following results will be obtained:

1. The company that has the highest VaR Value based on the Historical method is the PGAS company of -42212994.1
2. The company that has the highest VaR value based on the Variance Covariance method is a PGAS company of -56584871.97
3. The company that has the highest VaR value based on the Monte Carlo method is a PGAS company of -56223806.5
4. The company that has the lowest VaR value based on the Historical method is the UNVR company of -20351578.7
5. The company that has the lowest VaR value based on the Variance Covariance method is the ICBP company of -21596980.02
6. The company that has the lowest VaR value based on the Monte Carlo method is the UNVR company of -22095813.9

Based on the results of observing *the Value at Risk values* for the three methods, the average results are not significantly different. Of the three methods used in this study, the three methods prove that the PGAS company has the highest Value *at Risk* . That way the risk that the PGAS company has is the highest compared to other companies. Meanwhile, of the three methods used, two of them prove that UNVR companies have the lowest Value *at Risk* , which means they have the smallest potential risk.

From the annual report published, Perusahaan Gas Negara faced a number of challenges throughout 2017. Several external factors caused PGN's shares to have the highest risk compared to stocks on other JII indexes, namely, such as world crude oil prices which were still unstable since a sharp decline which is now at level of US$ 49 per barrel per year, so that consumers think that the competitive advantage of natural gas over oil has weakened drastically, and consumers expect gas prices to be cheaper. However, at the same time the costs that are borne by PGN have not been able to keep up with these consumer expectations. For many potential consumers, the conversion from industrial fuel oil or *high speed* diesel to gas is an unattractive option due to the smaller difference between oil and natural gas prices, which in turn has an impact on the reduction of Perusahaan Gas Negara's profits.

One of the factors causing risk and declining performance of PT Perusahaan Gas Negara (Persero) Tbk (PGAS) is directly or indirectly related to existing sentiments and regulations issued by the government, namely to reduce the selling price of gas to industrial customers and the public as well as to make profits. state gas companies experienced a decline. PGN's business which has a large contribution to revenue is from gas distribution activities which reach 83% of PGN's total revenue. PGN's revenue depends on sales volume

and selling price. The slight increase in the selling price of gas cannot compensate for the reduced revenue if there is a decrease in sales volume. So, it is only natural that PGN's revenue will decrease.

PGN last adjusted the selling price of natural gas in 2012-2013. After that, management did not increase gas prices in order to support government policies contained in Presidential Regulation Number 40 of 2016 concerning Natural Gas Pricing. PGN supports the instructions of the Ministry of Energy and Mineral Resources to reduce the selling price of gas to industrial customers in accordance with the Decree of the Minister of Energy and Mineral Resources No. 434.K/2017. Based on the regulation, PGN was asked to sell gas from the previous average price of US$ 1.35 per MMBTU to US$ 0.9 per MMBTU, which forced the company to bear a burden of US$ 3 million per year. In addition, the assignment from the Ministry of Energy and Mineral Resources to build Gas Fuel Filling Stations (SPBG) and Household Gas Networks (Jargas) also requires PGN to provide funds of at least US$ 4.9 million per year . As a result, PGN's revenue and profits are limited, while PGN has to bear quite high operational costs. Government policy is also an external factor that can put pressure on PGN's performance. However, it is PGN's risk to be willing to carry out the tasks given by the majority shareholder, namely the government, even if this interferes with its performance.

PT Perusahaan Gas Negara (Persero) Tbk continues to record declining profits. in the last five years. The company's profit decreased from US$ 845 million in 2013 to US$ 143.1 million or IDR 1.92 trillion at the end of 2017. The company's net profit fell 52.96%. This happened because PGN as a State-Owned Enterprise (BUMN) has a duty to support government policies to provide affordable domestic gas prices for industry and the public. (Isana, 2018)

Internal factors that cause PGN shares to have the highest risk compared to other stocks analyzed in the JII index, firstly, a number of assets were acquired when oil prices were still quite high, while oil prices are currently declining sharply thereby putting pressure on the company and impacting namely there are non- *cash* factors that erode the company's net profit even though the performance is still quite good. Second, there is uncertainty regarding the establishment of an oil and gas holding which has caused PGN's share price performance to decline. Regarding holding, PGN will merge with Pertamina's subsidiary, Pertagas. The share price of PT Perusahaan Gas Negara Tbk (PGAS) continued to decline following the acquisition of 51% of Pertagas' shares. This is because the market views the acquisition purchase price as too expensive, so they have to pay up to IDR 16.60 trillion for the Pertagas acquisition. PGN's declining performance in five years was also due to an increase in operating costs due to rental payments for a Floating Storage Regasification Unit (FSRU) or a place to convert liquid natural gas (LNG) into gas in Lampung and the coercion of management strategies in determining investment, especially upstream, namely by Saka Energi. FSRU Lampung is not operating optimally as planned. So that PGN has to continue to pay rent of more than US$ 90 million.

Various efforts have been made by PGN's management to prevent the company's profits from falling further. Among them is to suppress operational costs to US$ 457 million at the end of 2017. This means that in the last five years, PGN has succeeded in reducing the CAGR of operating costs by 3% from US$ 511 million in 2013. Management has also succeeded in reducing the amount of the company's short-term and long-term debt or liabilities. Until the end of 2017, PGN's liabilities were recorded at US$ 3.10 billion, a significant decrease compared to the 2016 liability position of US$ 3.66 billion. (Isana, 2018)

The low level of household consumption which suppressed the growth of the consumer goods industry in Indonesia became a business challenge in 2017, but in the midst of weakening public purchasing power, sales of PT Unilever Indonesia Tbk (UNVR) in 2017 still grew, although only slightly. UNVR invests and always strives to strengthen brand

equity by looking for the relationship between consumers and the products they buy. Through UNVR's strategy, which always provides new innovations to its products every year, UNVR's products remain the market leaders in the market so that consumers don't get bored with UNVR's products. Apart from launching new initiatives, in the third quarter of 2018 UNVR also carried out a corporate action to sell assets in the spreads category with a net transaction value of IDR 2.8 trillion.

Based on published financial reports, UNVR's sales grew slightly 2.87% *year-on-year* (yoy) from IDR 40.05 trillion in 2016 to IDR 41.20 trillion in 2017. Even though sales grew slightly, UNVR's profits rose last year 9.61% (yoy) from IDR 6.39 trillion to IDR 7 trillion. Profit growth of nearly 10% was triggered by UNVR's efficiency during 2017. Meanwhile, the company's cost of goods sold only increased from IDR 19.5 trillion to IDR 19.9 trillion. The total assets of the company also grew from IDR 16.74 trillion at the end of 2016 to IDR 18.9 trillion. It consists of total current assets of IDR 7.9 trillion and total non-current assets of IDR 10.9 trillion. Meanwhile, the company's total liabilities rose from Rp 12 trillion to Rp 13.7 trillion. Meanwhile total equity increased from Rp 4.7 trillion to Rp 5.1 trillion. (Rahman, 2018)

PT Unilever Indonesia Tbk (UNVR) is still the most stable company in terms of profitability. Looking at the past five years, UNVR's net profit margin has always been in the range of 16% to 17%. This is driven by various transformation efforts that are carried out on an ongoing basis, both through innovations that are launched, as well as through digitalization efforts in several aspects of business operations that are owned. Through these innovations, consumers will be loyal to Unilever products because they fulfill every community need. Through promotions in the media, both electronic and print media as well as the internet and social media, Unilever's products are increasingly recognized by the public so that the profits generated will increase and investors will evaluate Unilever's performance well.

Through backtesting the validity of *Value at Risk* in capturing actual loss movements has been tested on a sample of companies in the Jakarta Islamic Index. Testing the validity of the backtesting carried out resulted in a valid single asset VaR calculation. Valid because the deviations that occur are still within the safe scope of the backtesting test. The estimated value of VaR as the maximum value of loss can cover the *actual loss* that exists in general, because the estimated value of VaR is mostly greater than *the actual loss* . In risk management, it means that the VaR of the three methods can be used to calculate a good probability of risk. All models are valid because there are no *failure numbers* that enter the red zone on the Basel *traffic light backtesting* and there are no LR numbers that exceed the *critical value* (CV) on the Kupiec backtesting test.

The results of this study state that the best backtesting results are produced by the *Monte Carlo Simulation method* because the *number of exceptions* is the minimum. The results of the validation of the VaR value using the Backtesting *Traffic Light method* show the least number of exceptions in the *Monte Carlo Simulation method* even though it is in the yellow zone. This proves that the Monte Carlo Simulation method is still the best compared to the other two methods.

A company must be able to compete with other companies by maintaining the company's existence and winning the competition with competitors so that companies need continuous performance improvement. Companies must invest in strategic planning, among others by developing new products and looking at consumer desires, investing in increasing production capacity, innovating production tools, keeping abreast of market developments, workforce management and so on. This investment requires a certain source of funds as a guarantee of certainty and smoothness in financing.

CONCLUSION

Based on a comparative analysis of Value at Risk calculations in the Historical Simulation, Variance-Covariance, Monte Carlo Simulation methods and the tests and discussion in the previous chapter, conclusions can be drawn from the results of this study, namely:

1. Based on validity testing using the *Backtesting Kupiec* and *Basel traffic light methods* , it is known that the three methods used in this study produce valid (accurate) VaR values to use.
2. VaR measurement results with a 95% confidence level with a period of 1 day in the three methods are not significantly different. These three methods are considered capable of predicting VaR values well. However, overall the method that produces a risk estimate that has a higher value than the other methods and provides the largest VaR value calculation results is the Monte Carlo simulation method.

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