Valuing risk of changes on corn (*zea mays*) prices by considering skewness and kurtosis parameters

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Abstract. Value at Risk (VaR) is a measure of risk value by estimating the potential of maximum loss that might occur in future in certain time and a certain level of confidence. The risks faced in agriculture might be in production and marketing of agricultural products. This research aims to estimate the risk value in agricultural commodity – particularly dried shelled corn. Data used was the monthly data of the price of producers in Grobogan in period of November 2015 to July 2018. The data showed the return with the normally undistributed value of skewness and kurtosis. For this, the method of Cornish-Fisher was used in this research to measure the VaR in return that was normally undistributed. At the confidence level of 95%, with the initial capital of 1 million Rupiah, the risk that probably occurred in the following month (1 period) was by Rp 369,173.40 without considering the skewness and kurtosis, and by Rp 22,439.13 by considering skewness and kurtosis. The result of the research showed that, for the return that was normally undistributed, the level of risk obtained from the measurement of VaR by concerning skewness and kurtosis was found more accurate compared to the one without considering the skewness and kurtosis.

1. Introduction

Maize or corn (*zea mays*) is one of strategic and economic valued cereals that provides an opportunity to be developed in considering its existence as the main source of carbohydrate and protein following the rice [1]. Most parts of maize plant can be used for various needs. In addition, to being the staple food, maize can be used for animal feed, pharmaceutical raw material, dextrin, adhesives, textiles, cooking oil, and ethanol. In 2002, more corns were used on food industry.

Maize is a quite significant commodity for Indonesia [2]. It has been categorized as the main food commodity prioritized in the main target of Cabinet of President Joko Widodo. However, on the other side, the fulfillment of national maize needs until today is still dependent upon the import. The low level of role of local maize in fulfilling the needs of animal feed industry has led the maize as the food commodity with the highest value of import following sugar and soy. As informed by [3], the corn import had experienced a quite significant decrease in 2017 compared to the previous year. In the period of January-May 2017, the volume of imported maize decreased by 68.38% from 880.91 thousand tons in the period of January-May 2016 to be 278.57 thousand tons in January-May 2017. At the provincial level, East Java and Central Java are the provinces as the main maize producers with the contribution to national production by 46.12%.

Grobogan is the largest corn producer in Central Java [4]. The agricultural sector in this regency is the very strategic primary sector for contributing to approximately 43.6% of PDRB (Gross Regional Domestic Product) every year. Thus, the income per capita of people in Grobogan is highly
determined by the achievement in the agricultural sector. There are three main commodities in Grobogan: paddy, corn, and soy. The Central Java Governor Ganjar Pranowo stated that the maize commodity in Grobogan is one of the mainstays at both national and provincial level. The high production of corn in Grobogan has led this plant to be the mainstay commodity. Such condition is supported by the expertise of farmers by seeing the variety used. Thus, high production also has become a reason of the establishment of some multi-national animal feed industries such as PT Japfa Comfeed, PT Malindo Feedmill Tbk, Cargill, PT Karya Tunas Glorindo, and CV Wiguna in addition to the local companies.

With the abundant corn production, the government of Grobogan Regency has started to use corn as the icon of alternative food by empowering the female farmer communities to proceed with this plant. In 2012, a total of six female farmer communities were under guidance of Department of Food Security, Grobogan focused on the corn processing to be the alternative food such as corn rice, corn chip, and corn flour. Corn rice becomes the alternative for rice. If this habit can be socialized, the paddy can be gradually substituted with corn.

Being simpler than the rice cultivation, corn can be cultivated in all regions in Indonesia. Then it has encouraged the fulfillment of national food needs without imports, even it can be exported. In 2017, the total area of corn harvest in Grobogan was estimated not less than 120 thousand ha. If the average productivity was 6 tons per ha, corn production in Grobogan during 2017 could be not less than 720 thousand tons. In early 2018, changes in price of dried shelled corn occurred significantly. At the level of farmers, its price in January 2018 was at Rp. 3,200 per kilogram, lower than that of December 2017 at Rp. 3,650 per kilogram. This decreasing price was due to the declining quality of dried shelled corn produced due to the pest attack and unpredictable weather. The dried shelled corn is for sale for animal feed and for making cornstarch.

Any existence of various problems has made the corn farmers must always be ready for the applied selling price every time before the harvest. The corn farmers, when the price is quite good, can cover all operational costs and will have a large profit. In contrast, when the price falls, they must also be prepared for the loss. Given the fluctuating price of dry shelled corn, the farmers normally plant the corn only for the replacement of other crops - not as the main crop.

From the description above, the researcher views that it is deemed important to consider the price of dried shelled corn in Grobogan purposely to prevent the farmers from the losses. Overall, the previous research has only viewed the prices of agricultural commodities from the things that influence them - not on the approach of the nature of the data itself. In fact, too many factors affect the selling price level of dried shelled corn; as a consequence, it is probably that the research that has been done did not include all factors. In this study, the method of Value at Risk (VaR) of Cornish-Fisher was used to analyze the data on dried shelled corn price at the level of producers whose returns are not normally distributed. The test on the normal distribution used skewness-kurtosis. VaR is commonly used in the stock market to measure the risk of the largest loss that can be suffered by certain shareholders or portfolios. This study used VaR to measure the risk of loss of farmers due to changes in dry shelled corn prices occurred in Grobogan.

2. Literature Review

2.1. Dried Shelled Corn

As informed in [5], corn (Zea mays spp. mays) is the most important carbohydrate-producing food crop in the world, in addition to wheat and rice. For people in Central and South America, corn grains are the staple food, as for some Africans and some regions in Indonesia. Today, corn has also become an important component of animal feed. Other uses are as the sources of food oil and corn starch. Various derivatives of corn products have become the raw materials for various pharmaceutical, cosmetics and chemical industry products. Meanwhile, the dried shelled corn is corn traded for animal feed and for making corn starch. For animal feed, it can be given either in the full form, separated, mashed, until in the powdered form.

2.2. Return
Return is the result obtained from investment [6]. In this study, return refers to the result obtained from the results of corn planting based upon the applied price of dry shelled corn. Profits or losses are two possible outcomes obtained by corn farmers. Mathematically, [7] formulated the return at the following t-time:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$  \hspace{1cm} (1)

With $R_t$ as the return at t-time, $P_t$ is the price at t-time and $P_{t-1}$ is the price of dry shelled corn at time (t-1).

2.3. Normality Test

Residual normality test is used to determine the normality of residual data [8]. The residual normality test used in this study is the Jarque Bera test. This test functions to test the normal distribution of data measuring the difference between skewness and kurtosis of data from normal distribution. The tests are presented as follows:

Hypothesis:
- $H_0$: data of return follows the normal distribution
- $H_1$: data return does not follow the normal distribution

Level of significance: $\alpha$

Statistics Test:

$$JB = \frac{n}{6} \left( S^2 + \frac{(K - 3)^2}{4} \right)$$ \hspace{1cm} (2)

With

$$S = \frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^3 \left( \frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^2 \right)^{-3/2}$$

$$K = \frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^4 \left( \frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^2 \right)^{-2}$$

With
- $n$: number of samples
- $S$: skewness
- $K$: kurtosis

Test criteria:

$H_0$ is rejected if $JB < \chi^2 \alpha .2$ or $p_{value} < \alpha$.

2.4. Value at Risk by considering Skewness and Kurtosis

Value at Risk (VaR) is defined as the maximum loss that will be obtained due to the changes in asset prices with a normal distribution [9]. Regarding this data, [10] furthermore developed the data by introducing the nature of data with normal distribution using skewness-kurtosis. The nature of this data was then developed to measure the risk with Value at Risk by [11]. The Value at Risk modeling then develops so rapidly by adjusting the nature of the available data. [12], he has examined the risk of stock investment by concerning with the nature of financial data.

The application of Value at Risk to the problem of agricultural data problems is the following development. [13], they conducted research on the application and potential of the Value at Risk method on agricultural problems with normal distribution data. [14], they determined the risk of agricultural price with Value at Risk on data containing the extreme data. Value at Risk used was the Expected Shortfall and Extreme Value method. [15], they and [7] also applied extreme value data to measure the risk among farmers using Conditional Value at Risk (CVaR). Research in Indonesia, meanwhile, has not contributed significantly to quantitative risk measurement for agricultural data.

Several studies in Indonesia related to agricultural data include [16] conducting research on risk management of semi-organic rice production with qualitative analysis. [17], they examined the risk of...
rice farming in Bali by searching factors that influenced the risk of rice production using dummy variable regression. [18], they analyzed the risk preferences in organic cabbage farming by means of functional models. From all descriptions above, this research in turn would provide a better risk analysis based upon the previous studies, particularly the risk for the price of dried shelled corn in Grobogan quantitatively based on the reference of Value at Risk. This research would provide theoretical and applicative contribution concerning the quantitative risk measures based upon the nature of data on prices of dried shelled corn in Grobogan. The nature of the data would affect the risk value generated. This study specifically would measure the risk of dried shelled corn prices in Grobogan based on the normal distribution data with skewness-kurtosis. With the existence of this research, it is expected that it will contribute to the risk analysis of changes in the price of dried shelled corn at the farmer level in Grobogan with a method in line with the available data.

According to [9] and [11], the risk of price changes would be calculated based on the VaR value at the level of confidence (1-α) in the period of r days with the following formula:

$$VaR_{(1-\alpha)}(r) = R^* \sqrt{r}$$

With

- $R^*$: the α-quartile value of the return distribution
- $\sqrt{r}$: period

The VaR value obtained was the maximum loss that would be obtained due to the change in the commodity price. For normal distribution data with skewness-kurtosis, then the calculation of the excess kurtosis ($\gamma_2' = \gamma_2 - 3$) from the distribution found empirically, would be calculated through Cornish-Fisher expansion, so that the form of α-quartile would be expanded as:

$$a'(\alpha) = a(\alpha) + \frac{\gamma_1}{6} \left(2 \alpha(\alpha) - 1\right) + \frac{\gamma_2}{24} \left(a^3(\alpha) - 3a(\alpha)\right) - \frac{\gamma_2'}{36} \left(2a^3(\alpha) - 5a(\alpha)\right)$$

With

- $\gamma_1$: skewness (S)
- $\gamma_2$: kurtosis (K)
- $\gamma_2'$: excess kurtosis

where $a(\alpha)$ was obtained from the 5% of the highest return that has been ordered [12], he stated that with the adjustments using the Cornish-Fisher VaR expansion it could be calculated as follows:

$$VaR_{sk} = \mu - a(\alpha)\sigma$$

Then the VaR value concerned not only with the first and second moments, but also skewness and the excess kurtosis from the return data distribution.

3. Research Methods
3.1. Data Source
The data used in this study included the secondary data, namely the monthly price data on dried shelled corn in Grobogan for the period from November 2015 to July 2018. The prices used were those at the level of producer or farmer. The data were obtained from the Information of Regional Agricultural Commodity Price (2018) on the website of http://aplikasi.pertanian.go.id/.

3.2. Analysis Methods
The stages carried out in the research implementation is presented as follows:
1. Determining the return of dried shelled corn price data in Grobogan without concerning the equation (1).
2. Determining the risk of the changes in the price of dried shelled corn in Grobogan without any concern with the skewness and kurtosis parameters.
3. Examining the return of the dried shelled corn price data in Grobogan by observing the skewness and kurtosis parameters in accordance to the standard (skewness = 0, kurtosis = 3) or test on the normality of Jarque Bera was fulfilled.

4. Measuring the risk of the changes in dried shelled corn prices in Grobogan with Value at Risk based on the Cornish-Fisher expansion.

5. Comparing the methods without regard to the parameters of skewness and kurtosis with method concerning the skewness and kurtosis.

4. Analysis

4.1. Description of Research Object

The data used is the return data obtained from the monthly price of dried shelled corn in Grobogan since November 2016 until July 2018.

**Table 1. Descriptive Analysis of the Data**

| Statistic | Value (rupiahs) |
|-----------|-----------------|
| Average   | 3,581           |
| Maximum   | 4,993           |
| Minimum   | 1,500           |

Based on table 1, it is known that the price of dried shelled corn in Grobogan, during the period of November 2015 to July 2018 had an average of Rp. 3,581 per kilogram. The highest price was IDR 4,993 occurred in March 2017. While the lowest price was Rp 1,500 occurred in January 2016.

4.2. VaR Analysis without considering Skewness and Kurtosis

Based on equation (3) the output of VaR value was obtained without concerning skewness and kurtosis for the return data of dried shelled corn in Grobogan as follows:

**Table 2. The output of VaR value without considering Skewness and Kurtosis**

| Confidence Interval | VaR value |
|---------------------|-----------|
| 95%                 | 369,173.4 |

Based on table 2, if a corn farmer spent the capital of Rp. 1 million (1,000,000 IDR), the risk that will occur within one month ahead due to a change in the price of dried shelled corn in Grobogan is Rp. 369,173.4.

4.3. Test on Normality of Return Value

Before measuring the Cornish-Fisher VaR calculation, it should test whether the data return was normally distributed. The return from the price of dried shelled corn in Grobogan was tested for its normality using the Jarque Bera test.

Hypothesis:

- $H_0$: data of return follows normal distribution
- $H_1$: data of return does not follow the normal distribution

Significance level: $\alpha = 5\%$

Test statistics:

$$JB = \frac{n}{6} \left( S^2 + \frac{(K-3)^2}{4} \right)$$

Test criteria:

- Rejected $H_0$ if $JB < \chi^2_{\alpha,2}$ or $p_{value} < \alpha$.

Decision:
Table 3. The output of Normality Test Jarque-Bera for Return Data

| JB   | Skewness | Kurtosis | p-value       | Decision          |
|------|----------|----------|---------------|-------------------|
| 59,822 | 1,117    | 5,705    | 1.023 $10^{-11}$ | $H_0$ is rejected |

From table 3, it can be seen that the return of dry shelled corn data did not meet the normality assumption, by looking at the skewness value not equal to 0 and kurtosis was not equal to 3. In addition, based on the kurtosis value that exceeded three it indicated the existence of a fat tail that characterized the existence of extreme data on the return of dried shelled corn price. It showed that the data on the return of dried shelled corn prices in Grobogan at some time experienced a quite sharp increase or decrease.

Based on the value of $p$-value < $\alpha$, it means that the data return did not follow the normal distribution, then analysis of VaR Cornish-Fisher was used by observing skewness and kurtosis of data return.

4.4. Analysis of VaR Cornish-Fisher by Concerning Skewness dan Kurtosis

Based on equation (5), the output of the VaR Cornish-Fisher value was obtained by observing skewness and kurtosis for the return data of dried shelled corn prices in Grobogan as follows:

Table 4. The output of VaR Cornish-Fisher’s value by considering Skewness and Kurtosis

| Confidence Interval | VaR value |
|---------------------|-----------|
| 95%                 | 22439.13  |

Based on table 4, if a corn farmer spent the capital of Rp. 1 million (1,000,000 IDR), the risk that would occur by the following month due to a change in the price of dried shelled corn in Grobogan was Rp. 22,439.13

4.5. Comparison

If a farmer spent the capital of Rp. 1 million, the risk that would occur in the following month due to changes in the price of dried shelled corn in Grobogan was Rp. 369,173.40 without concerning skewness and kurtosis and Rp 22,439.13 by concerning skewness and kurtosis. So it can be concluded if concerning skewness and kurtosis, the size of the risk obtained would be much less than the one without concerning skewness and kurtosis.

Based on the VaR value obtained, if the nature of statistical data was not considered, then the size of the risk obtained was inappropriate. The VaR value without concerning the increase in data caused the risk obtained seemed to be quite large. With the accurate statistical method concerning the nature of the data, the risk value obtained became a more accurate calculation.

5. Conclusion

Data on dried shelled corn prices in Grobogan, during the period November 2015 to July 2018 was in the average of Rp. 3,581. The highest price was Rp 4,993 occurred in March 2017. The lowest price was IDR 1,500 occurred in January 2016.

Based on VaR value without concerning skewness and kurtosis for the data of the return of dried shelled corn price in Grobogan, if a corn farmer spent the capital of Rp. 1 million, the risk that would occur in the following month due to changes in dried shelled corn prices in Grobogan was Rp. 369,173.40. While the VaR value by concerning skewness and kurtosis for the return data of dried shelled corn price in Grobogan, if a corn farmer spent the capital of Rp. 1 million, the risk occurred in the following month due to changes in dried shelled corn prices in Grobogan was Rp. 22,439.13.

The nature of data was very influential on the use of statistical methods. If the statistical method used incorrectly, then the results obtained were inaccurate.
Acknowledgment
This paper is the result of research financed by DIPA Grant from the Faculty of Science and Mathematics, Diponegoro University in 2018.

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