Investigating the Features of Indonesia Stock Price During Covid-19 pandemic: An Application of Merton Jump Diffusion Model

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Abstract

The Covid-19 pandemic has had a major impact on global financial problem increasingly erratic stock price movement, including in Indonesia. In general terms, stock prices have some features that describe price movements. These features are jump, volatility smile, and leptokurtic. These features are obtained by modelling the stock price with the best model. This paper investigates the Merton Jump Diffusion (MJD) model and implemented stock prices in Indonesia to see if the model could capture some stock price features during the Covid-19 pandemic. MJD model is built based on the Black Scholes model by adding a Poisson Jump Process with the parameters are intantaneous expected return, volatility, jump intensity, mean, and standar deviation. The parameter values estimated by using the Maximum Likelihood Estimation algorithm and computed using MATLAB. The Indonesian stock price being modelled is 10 Blue Chips stocks during the Covid-19 pandemic period 23/12/2019 –23/12/2020. The result shows that Blue Chips Stocks in Indonesia exhibit several jumps by jump intensities values. Moment density of MJD reveals the presence of leptokurtic feature by excessive kurtosis and indicated *volatility smile* by skewness. It is found that the MJD model is suitable for modelling Indonesia's stock prices during the Covid-19 pandemic

Keywords
Merton Jump Diffusion, Indonesia Stock Price, Jump, Leptokurtic, Maximum Likelihood Estimation

1. Introduction
The Covid-19 Pandemic, an epidemic since early 2020, has a major impact on global financial problems, including in Indonesia. It has resulted in increasingly erratic stock price movements. This condition causes many investors to sell off their investment by selling share ownership which has an impact on the value of share prices and investment growth. Investors gave up their investment due to diminishing consumer interest during the Covid-19 Pandemic. Dwindling consumer interest also counts on the number of layoffs or scattering during times of the pandemic. This is

what causes the value of shares to experience erratic movements beyond normal conditions, even with fatal consequences, that is make Indonesia Composite Index (ICI or IDX Indonesia) value drop far from the price value under normal conditions. Several empirical studies show that stock price movements' dynamics have a stochastic volatility pattern and fatter tails than the standard normal (Musnadi et al., 2020; Sinurat et al., 2020; Novat et al., 2019). The stochastic volatility pattern is a volatility curve that has implied to resemble a 'smile' or called a volatility smile and a fat tail (Sukono et al., 2019). The normal standard is a curve with a higher peak than the normal distribution due to excess kurtosis, called leptokurtic kurtosis (Sukono et al., 2019; Kou, 2002). The dynamics of stock price obtained are the price features captured by a model. Black Scholes is a basic model used to capture asset price dynamics (Yi, 2010). Black Scholes model assumed that the price of an asset follows a geometric Brownian motion. Still, the Black Scholes model cannot properly capture stock price features such as fat tail (leptokurtic) and abnormality called volatility smile (Burger and Kliaras, 2013).

Several models have been developed and proposed to capture the features of stock prices and have been applied to several world stock markets (Lin et al., 2018). The Merton Jump Diffusion Model (MJD) applied to the East African stock market (Novat et al., 2019). Merton's approach to stock prices adds a simple parameter of the compound Poisson jump process to the Black Scholes model to provide excess skewness and kurtosis of the price density (Matsuda, 2004). The Merton model is also applied to the Standard & Poor's (S&P) 500 Index and compared to the Black Scholes model, where Merton's approach can provide clearer features than the Black Scholes (Gugole, 2016). Apart from the Merton model, several other models applied to the world stock market, such as Kou Model which is applied to the Japanese stock market (Maekawa et al., 2018). The ARJI-EGARCH Model which is applied to the Egyptian, Nigerian, and South African stock markets (Kuttu, 2017), Mellin's transformation of the American S&P 500 stock index (Frontczak, 2013) and the GARCH model for modelling the return volatility on the Uganda Securities Exchange (Namugaya et al., 2014). Therefore, this paper's main objective is to apply the Merton Jump Diffusion model to the 10 stock market prices included in Indonesia's Blue Chips to investigate whether the model can capture stock features based on the stock's daily closing price during the Covid-19 pandemic.

2. Methodology

2.1. Merton Jump Diffusion Model

Merton Jump Diffusion (MJD) model is a model that can capture skew and excess kurtosis asset price which is built on the Black Scholes model with adding three parameters of compound Poisson Process, namely λ, μ, and δ. The Poisson process is the basic process of Levy jump process (Lawler, 2014), so that the MJD model is in the form of an exponential Levy model as follows:

$$S_t = S_0 e^{L_t} \tag{1}$$

where the stock price process S_t is modelled as an exponential Levy process L_t with a time interval $0 \le t \le T$. The Levy process chosen is a Brownian motion with drift (continuous diffusion process) and additional a compound Poisson process (continuous jump process) such that:

$$L_t = (\alpha - \frac{\sigma^2}{2} - \lambda k)t + \sigma B_t + \sum_{i=1}^{N_t} Y_i \tag{2}$$

where B_t is a standard brownian process, $(\alpha - \frac{\sigma^2}{2} - \lambda k)t + \sigma B_t$ is a Brownian motion with drift process and $\sum_{i=1}^{N_i} Y_i$ is a compound Poisson jump process. Thus, the log-return of MJD Model is given in Levy process as:

$$\ln\left(\frac{S_t}{S_0}\right) = L_t = (\alpha - \frac{\sigma^2}{2} - \lambda k)t + \sigma B_t + \sum_{i=1}^{N_t} Y_i \tag{3}$$

2.2. Model Derivation

Assumed that asset price jumps occur independently and identically and the probability during a time interval dt can be written using a Poisson process dN_t as (Merton, 1976):

$$Pr\{\text{an asset price jump once in } dt\} = Pr\{dN(t) = 1\} \cong \lambda dt$$

$$Pr\{\text{an asset price jums more than once in } dt\} = Pr\{dN(t) \ge 2\} \cong 0$$

$$Pr\{\text{an asset price does not jump in } dt\} \cong 1 - \lambda dt$$

where λ is the intensity of the process of the jump or the number of jumps per unit of time.

Suppose in interval dt the asset price jumps from S_t to y_tS_t , with y_t is absolute price jump size, then the relative price jump size where the percentage change in the asset price occurs due to jump is written as:

$$\frac{dS_t}{S_t} = \frac{y_t S_t - S_t}{S_t} = y_t - 1 \tag{4}$$

where Merton assumes that y_t is nonnegative random variables drawn from a lognormal distribution, i.e. $\ln(y_t) \sim i.i.d.N(\mu, \delta^2)$. It in turn implies that:

$$E\left[y_t\right] = e^{\mu + \frac{1}{2}\delta^2} \text{ and } E\left[(y_t - E[y_t])^2\right] = e^{\mu + \frac{1}{2}\delta^2}(e^{\delta^2} - 1)$$

It because if $\ln x \sim N(a,b)$,then $x \sim Lognormal(e^{a+\frac{1}{2}b^2}, e^{2a+b^2}(e^{b^2} - 1))$.

Incorporates the above properties to takes the SDE of MJD dynamics in the form:

$$\frac{dS_t}{S_t} = (\alpha - \lambda k)dt + \sigma dB_t + (y_t - 1)dN_t \tag{5}$$

where, B_t is a standard Brownian motion process, N_t is a Poisson process with intensity λ, α is the instantaneous expected return on the asset, and σ is the instantaneous volatility of the asset return conditional on that jump does not occur.

Supposed that (B_t), (N_t) and (y_t) independent. The relative price jump size of S_t , $y_t - 1$ is lognormally distributed with the mean

$$E\left[y_t - 1\right] = e^{\mu + \frac{1}{2}\delta^2} - 1 = k \tag{6}$$

and variance

$$E\left[(y_t - 1) - E[y_t - 1])^2\right] = e^{2\mu + \delta^2}(e^{\delta^2} - 1) \tag{7}$$

MJD model assumes that the log price jump size $\ln(y_t) \equiv Y_t$ is a normal random variable such that:

$$\ln\left(\frac{y_t S(t)}{S(t)}\right) = Y_t = \ln(y_t) \sim i.i.d.N(\mu, \delta^2) \tag{8}$$

2.3. Solution Model for MJD

Considered equation (5) and multiply S_t on both sides, then

$$dS_t = (\alpha - \lambda k)S_t dt + \sigma S_t dB_t + (y_t - 1)S_t dN_t \tag{9}$$

From Ito's formula for Jump Diffusion (Cont and Tankov, 2004):

$$\begin{aligned} df(X_t, t) = \frac{\partial f(X_t, t)}{\partial t} dt + b_t \frac{\partial f(X_t, t)}{\partial x} dt + \frac{\sigma_t^2}{2} \frac{\partial^2 f(X_t, t)}{\partial x^2} dt \\ + \sigma_t \frac{\partial f(X_t, t)}{\partial x} dB_t + [f(X_{t-} + \Delta X_t) - f(X_{t-})] \end{aligned} \tag{10}$$

where b_t corresponds to the drift term and σ_t corresponds to the volatility term of a jump-diffusion process $X_t = X_0 + \int_0^t b_s ds + \int_0^t \sigma_s dB_s + \sum_{i=1}^{N_t} \Delta Y_i$ and $f \in C^{1,2}([0,T] \times \mathbb{R}0)$

Let $f(S_t, t) = \ln(S_t)$ (11)

$$\frac{\partial f}{\partial t} = 0 \tag{12}$$

$$\frac{\partial f}{\partial S} = \frac{1}{S_t} \tag{13}$$

$$\frac{\partial^2 f}{\partial S^2} = -\frac{1}{S_t^2} \tag{14}$$

From equation (9):

$$b_t = (\alpha - \lambda k) S_t \tag{15}$$
$$\sigma_t = \sigma S_t \tag{16}$$

Substituting the result in equation (11) to (16) into equation (10), then

$$d \ln S_t = \frac{\partial \ln S_t}{\partial t} dt + (\alpha - \lambda k) S_t \frac{\partial \ln S_t}{\partial S_t} dt + \frac{\sigma^2 S_t^2}{2} \frac{\partial^2 \ln S_t}{\partial S_t^2}$$
$$+ \sigma S_t \frac{\partial \ln S_t}{\partial S_t} dB_t + [\ln y_t S_t - \ln S_t]$$
$$d \ln S_t = (\alpha - \lambda k) S_t \frac{1}{S_t} dt + \frac{\sigma^2 S_t^2}{2} \left(-\frac{1}{S_t^2} \right) dt + \sigma S_t \frac{1}{S_t} dB_t + [\ln y_t + \ln S_t - \ln S_t]$$
$$d \ln S_t = (\alpha - \lambda k) dt - \frac{\sigma^2}{2} dt + \sigma_t dB_t + \ln y_t$$
$$d \ln S_t = \left(\alpha - \lambda k - \frac{\sigma^2}{2} \right) dt + \sigma_t dB_t + \ln y_t \tag{17}$$

Integrating equation (17) with the time interval $0 \le s \le t$, then we get

$$\int_0^t d \ln S_s = \int_0^t \left(\alpha - \lambda k - \frac{\sigma^2}{2} \right) ds + \int_0^t \sigma dB_z + \sum_{i=1}^{N(t)} \ln y_i$$
$$\ln S_t \Big|_0^t = \left(\alpha - \lambda k - \frac{\sigma^2}{2} \right) t \Bigg|_0^t + \sigma B_t \Big|_0^t + \sum_{i=1}^{N(t)} \ln y_i$$
$$\mathrm{l} \ln S_t - \ln S_0 = (\alpha - \frac{\sigma^2}{2} - \lambda k)(t - 0) + \sigma_t (B_t - B_0) + \sum_{i=1}^{N_t} \ln y_i$$
$$\ln S_t = \ln S_0 + (\alpha - \frac{\sigma^2}{2} - \lambda k) t + \sigma_t B_t + \sum_{i=1}^{N_t} \ln y_i$$
$$\exp(\ln S_t) = \exp\left\{ \ln S_0 + (\alpha - \frac{\sigma^2}{2} - \lambda k) t + \sigma_t B_t + \sum_{i=1}^{N_t} \ln y_i \right\}$$
$$S_t = S_0 \exp\left\{ (\alpha - \frac{\sigma^2}{2} - \lambda k) t + \sigma_t B_t \right\} \exp\left\{ \sum_{i=1}^{N_t} \ln y_i \right\}$$
$$S_t = S_0 \exp[(\alpha - \frac{\sigma^2}{2} - \lambda k) t + \sigma_t B_t] \prod_{i=1}^{N_t} y_i$$

or

$$S_t = S_0 \exp[(\alpha - \frac{\sigma^2}{2} - \lambda k) t + \sigma_t B_t + \sum_{i=1}^{N_t} \ln y_i] \tag{18}$$

Using the definition of the log-return jump size $\ln(y_t) \equiv Y_t$, then:

$$S_t = S_0 \exp[(\alpha - \frac{\sigma^2}{2} - \lambda k) t + \sigma B_t + \sum_{i=1}^{N_t} Y_i] \tag{19}$$

Such that we get the solution of the log-return $\ln\left(\frac{S_t}{S_0}\right)$ which is modeled as the following Levy process:

$$\ln\left(\frac{S_t}{S_0}\right) = L_t = (\alpha - \frac{\sigma^2}{2} - \lambda k) t + \sigma B_t + \sum_{i=1}^{N_t} Y_i \tag{20}$$

Note that the compound Poisson jump process $\prod_{i=1}^{N_t} y_i = 1$ or $\sum_{i=1}^{N_t} \ln y_i = \sum_{i=1}^{N_t} Y_i = 0$, if $N_t = 0$ (no jumps between time 0 and t) then positive and negative jumps cancel each other.

The probability density of log return $x_t = \ln\left(\frac{S_t}{S_0}\right)$ for MJD model is:

$$\mathsf{P}(x_t \in A) = \sum_{i=0}^{\infty} \mathsf{P}(N_t = i)\mathsf{P}(x_t \in A \mid N_t = i)$$

$$\mathsf{P}(x_t) = \sum_{i=0}^{\infty} \frac{e^{-\lambda t}(\lambda t)^i}{i!} N(x_t; (\alpha - \frac{\sigma^2}{2} - \lambda k)t + i\mu, \sigma^2 t + i\delta^2) \tag{21}$$

2.4. Moment of MJD Model

The moment of the merton jump diffusion model is obtained using the Fourier transform method, which produces the annual mean, variance, skewness, and excess kurtosis of the log-return density as follows (Tang, 2018):

$$E[x_t] = (\alpha - \frac{\sigma^2}{2})dt + \mu\lambda dt \tag{22}$$

$$Variance[x_t] = \sigma^2 dt + (\delta^2 + \mu^2)\lambda dt \tag{23}$$

$$Skewness[x_t] = \frac{(3\delta^2 + \mu^2)\mu\lambda dt}{(\sigma^2 dt + (\delta^2 + \mu^2)\lambda dt)^{\frac{3}{2}}} \tag{24}$$

$$Excess\ Kurtosis[x_t] = \frac{(3\delta^4 + 6\mu^2\delta^2 + \mu^4)\lambda dt + (3\lambda^2(\delta^2 + \mu^2)^2 + 6\lambda\sigma^2(\delta^2 + \mu^2) + 3\sigma^4)dt^2}{(\sigma^2 dt + (\delta^2 + \mu^2)\lambda dt)^2} \tag{25}$$

2.5. Maximum Likelihood Estimation for MJD Model

The initial parameters for MJD model are $\mu, \sigma, \lambda, \delta$, dan α. These initial parameters used to estimate the numerical optimization of the likelihood of Merton Jump Diffusion. Considered a definition of the probability density function and the MJD model equation, the probability density function of the MJD model is given as follows:

$$\mathsf{P}(x_t) = \sum_{i=0}^{\infty} \frac{e^{-\lambda t}(\lambda t)^i}{i!} N(x_t; (\alpha - \frac{\sigma^2}{2} - \lambda k)t + i\mu, \sigma^2 t + i\delta^2)$$

The objective function of the MLE method to maximize the likelihood function is

$$L(\theta; x) = \prod_{i=1}^{n} \mathsf{P}(x_t) \tag{26}$$

where $\mathsf{P}(x_t)$ is the probability density function of the MJD model and $x = (x_1, ..., x_n)$ is the log-return of empirical data (Tang, 2018).

3. Result and Discussion

3.1. Data

The data used in this study came from the official website of Yahoo Finance. The data used are daily stock price closing data from 10 Indonesian Blue Chips stocks, namely BBCA, BBRI, ASII, JSMR, PGAS, UNVR, TLKM, PTBA, GGRM, and INDF, during the Covid-19 pandemic from 23/12/2019 to 23/12/2020. Thus, for each stock there are 244 daily stock price closing data.

3.2. Parameter Estimation of Merton Jump Diffusion Model

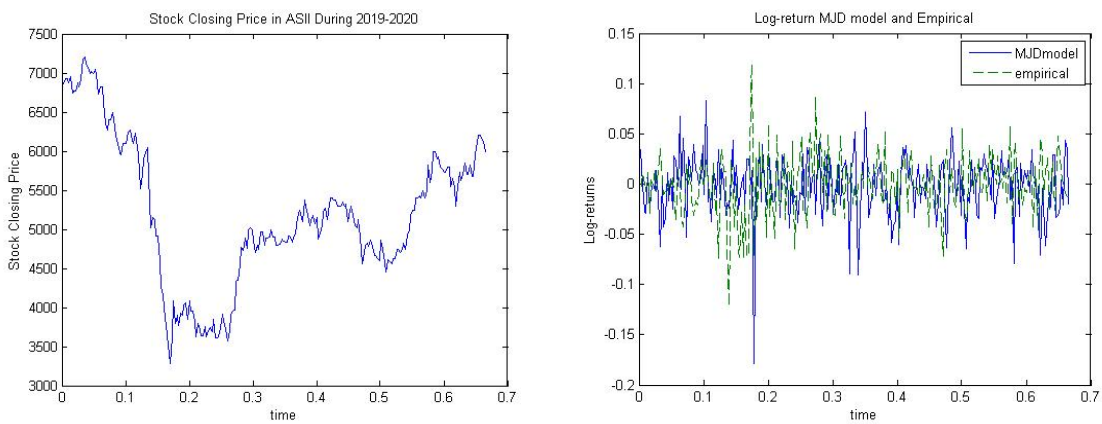
The probability density function of the MJD model in equation (21) used to estimate the model parameters using the Maximum Likelihood Estimation method with the objective function in equation (26). Numerical simulation for model estimation calculated using MATLAB. The estimation results of the variables in each stock market, as shown in Table 1.

Tabel 1. Estimation Result of MJD Model for Indonesian Blue Chips Stocks

Stock	α	σ	λ	μ	δ
BBCA	-0.3014	0.2270	138.2957	0.0025	0.0320
BBRI	-0.6470	0.2350	300.1708	0.0019	0.0333
ASII	0.6504	0.3768	195.7032	-0.0040	0.0317
JSMR	-0.5612	0.2198	395.7537	0.0010	0.0313
PGAS	0.2835	0.1520	649.2636	-0.0011	0.0289
UNVR	-0.4945	0.2089	111.9394	0.0031	0.0369
TLKM	-1.4604	0.2893	142.8654	0.0085	0.0331
PTBA	-0.1680	0.5381	18.7831	0.0228	0.1738
GGRM	-0.3186	0.2704	131.0443	-0.0003	0.0434
INDF	0.0415	0.2270	179.4166	-0.0014	0.0343

Table 1 shows that the jump intensity (λ) in Perusahaan Gas Negara (PGAS) shares is very high, which is around 649 jumps compared to other stocks' jump intensity. It shows that PGAS tends to be more sensitive to the factors that affect stock prices during the Covid-19 pandemic. Meanwhile, PTBA shares have the lowest jump intensity value among other stocks, around 18 jumps. So that PTBA shares are the stocks least affected by stock factors during the Covid-19 pandemic. Based on all the results of the intensity value, no stock has a zero jump value. It indicates that the stock price varies randomly.

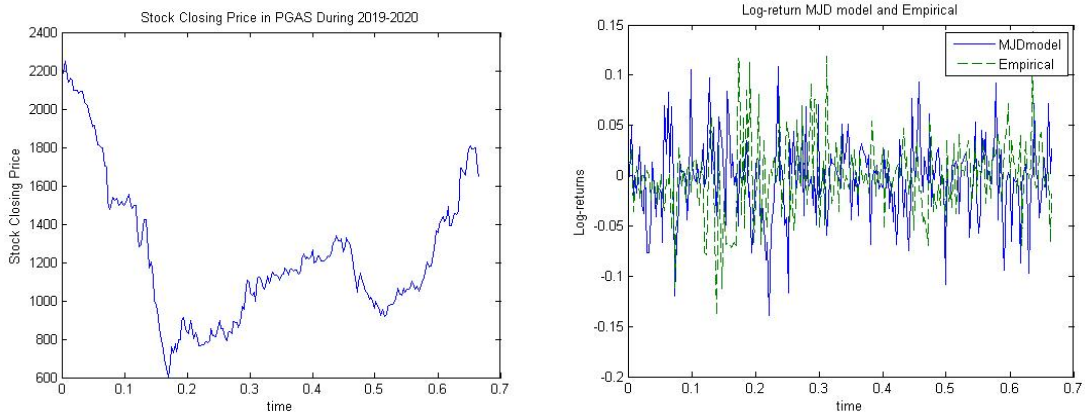
For the expected return value obtained based on the α parameter, only ASII, PGAS and INDF stocks experienced an increase in return because they were positive. Meanwhile, other stocks experience a decline in return with a value that tends to be negative. It shows that during the Covid-19 Pandemic, Indonesian stocks tended to experience a decline in their rate of return. However, not all stocks experienced a decline in return. The three stocks had a positive value of the instantaneous expected return to maintain returns during the Covid-19 pandemic crisis.



(a) ASII daily stock closing price level (b) ASII log return

Figure 1. ASII daily stock closing price level and log-return (Dec, 2019 to Dec, 2020)

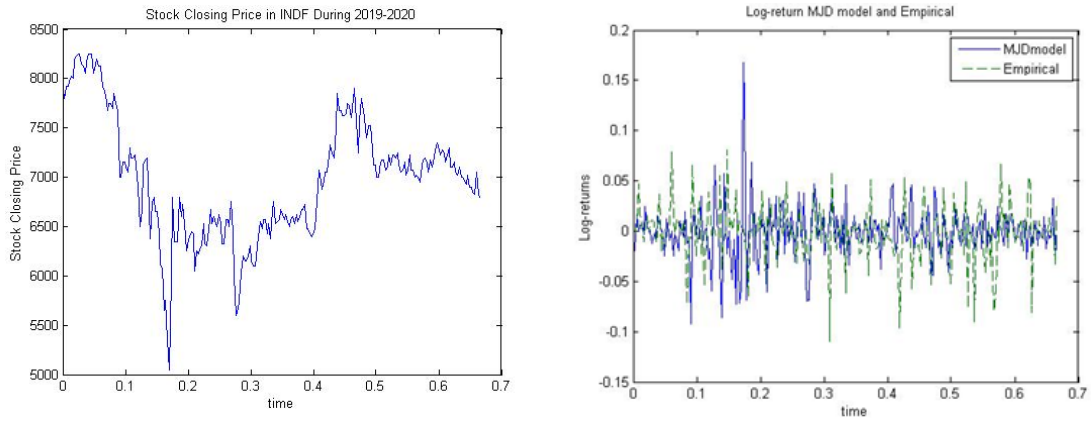
Figure 1a shows that ASII experience price fluctuations, where the stock price has increased and decreased in price randomly. And experienced a very drastic decline in price from the stock's initial price for some time and then increased until the end time. Figure 1b shows the comparison of the MJD log-return model results with the empirical log return on ASII stocks. The empirical log return is obtained by estimating the probability density function using kernel density estimation to reference the stock log-returns reality results for the MJD model. Figure 1b shows many high jumps and occurs randomly. Likewise, empirical shows several jumps with values that are not far from the MJD model. The difference between the two approaches lies in the one higher jump captured by the MJD model towards negative values, whereas empirical tends to be positive. Many jumps generated by log-returns support the jump intensity parameter (λ) estimation results in table 1, which shows ASII has a high jump of about 195 jumps. The number of jumps that occurs causes asset prices to jump randomly. Hence, the result of the jump size is also randomly. Since MJD can detect the same number of log-return jumps as the empirical results, MJD matches ASII stocks for log-return values and captures any jumps.



(a) PGAS daily stock closing price level (b) PGAS log-return

Figure 2. PGAS daily stock closing price level and log-return (Dec 2019 to Dec 2020)

Figure 2a shows that PGAS experienced a very drastic decline in price from the shares' initial price and continued to fall for some time. It slowly began to increase again even though they had dropped again until finally, they continued to increase until the end. Figure 2b shows that the MJD model shows very high and very frequent jumps. Likewise, empirically shows a jump with a value that is not far from the MJD model. The number of jumps and the jumps' density that occurs from the log return supports the estimation results of the jump intensity parameter (λ) in table 1 which shows that PGAS has the largest jumps from other stocks, which is around 649 jumps. The number of jumps that occurs causes asset prices to jump randomly so that the resulting jump size is also random. Because MJD can detect the same number of log-return jumps as the empirical results, MJD matches the PGAS stock for the log-return value and captures any jumps.



(a) INDF daily stock closing price level (b) INDF log return

Figure 3. INDF daily stock closing price level and log-return (Dec 2019 to Dec 2020)

Figure 3a shows that INDF experience very tight fluctuations; after experiencing a price increase, the stock price has decreased again. When the share price has decreased in price very far from the initial price, the stock does not decrease significantly because it still has time to experience a price increase, although it falls back and then rises again. However, the share price has decreased again. Figure 3b shows that the MJD model has several jumps that occur randomly. Likewise, empirically shows a jump with a value that is not far from the MJD model. But the MJD model manages to capture the one highest jump towards positive values, whereas the empirical does not. A number that occurs from log-returns supports the estimation of the jump intensity parameter (λ) in table 1 which shows that INDF has a high jump, which is about 179 jumps. The number of jumps that occurs causes asset prices to jump randomly,

so the resulting jump's size is also random. Because MJD can detect the same number of log-return jumps as the empirical results, MJD is suitable for INDF stock for log-return values and captures any jumps.

From figures 1, 2 and 3 show Covid-19 pandemic which began to spread since early 2020, to be precise in March 2020, made stock prices plummet and experienced a very drastic decline. It illustrates that Indonesia is experiencing a financial crisis when the Covid-19 pandemic is slowly spreading. Meanwhile, stock returns continue to experience high jumps in both positive and negative values. However, these three stocks are stocks that have positive returns among other stocks.

3.3. Moment Density of Log-Return MJD Model

Considered moment density of log-return MJD Model equation (22) to (25), we get mean, variance, skewness, and excess kurtosis of the log-return density as follows:

Tabel 2. Moment Density of MJD Model for Indonesian Blue Chips Stocks

Stock	Mean	Variance	Skewness	Kurtosis
BBCA	0.00003	0.00053	0.23527	7.2673
BBRI	-0.00027	0.00108	0.15017	5.6878
ASII	-0.00057	0.00094	-0.22865	4.9095
JSMR	-0.00054	0.00119	0.00394	5.1887
PGAS	-0.00112	0.00155	-0.07685	4.5517
UNVR	-0.00047	0.00054	0.30721	8.9271
TLKM	-0.00078	0.00069	0.62167	6.3934
PTBA	0.00031	0.00237	0.92588	28.8511
GGRM	-0.00109	0.00087	-0.02621	7.972
INDF	-0.00064	0.00072	-0.1253	6.9451

Table 2 shows that all stocks have kurtosis more than 3, which means that all stocks have excess kurtosis and indicate that they have leptokurtic features (fatter tail and taller than normal curve). All the value of kurtosis, PTBA shares have the largest kurtosis, namely 28. This leptokurtic shows that Indonesian stocks are in a condition where the potential return is large, but with a very high risk. In addition to leptokurtic features, skewness values (where the resulting skewness values are negative and positive skewness) indicate that stock prices have non-symmetric returns and suggest that stocks have an empirical abnormality called volatility smile.

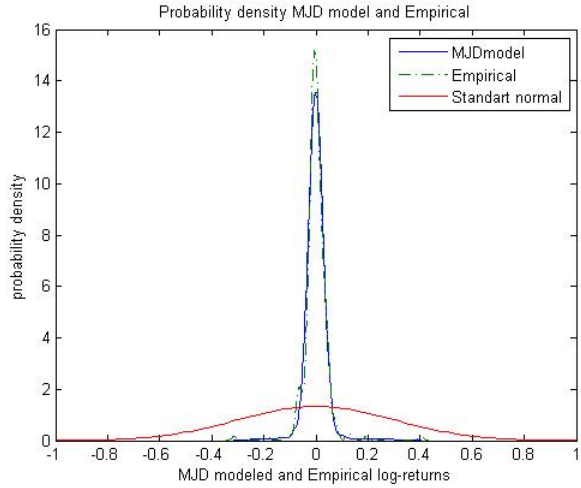


Figure 4. Kurtosis Leptokurtic for PTBA

Figure 4 shows the leptokurtic curve generated by the MJD model for PTBA stocks. The green line is a leptokurtic curve based on the probability density function's empirical results using kernel density estimation, which produces the moment value; mean = 0.00031, variance = 0.00237, skewness = 1.191, and kurtosis = 29.4064. The results obtained by the MJD model in table 2 indicate that the moment value is close to the empirical result, with excess kurtosis of

28.851. It shows that PTBA stocks have kurtosis higher than the normal standard (red line), i.e. kurtosis > 3. Thus, it indicates that PTBA has a leptokurtic return distribution.

4. Conclusion

In conclusion, the Indonesian Blue Chips stocks have several jump prices, which jump parameters results and the log-return. The probability density function shows that the stock has leptokurtic characteristics as evidenced by a kurtosis value that exceeds 3. It shows the abnormalities of stocks, namely the volatility smile feature as evidenced by positive and negative skewness values indicating stock returns are non-symmetrical. Therefore, the MJD model fits into Indonesia's Blue Chips share price data because it can detect stock features during the financial crisis caused by the Covid-19 Pandemic.

References

Burger, P and Kliaras, M., Jump Diffusion Models for Option pricing vs. Black Scholes Model, *Working Paper Series by University of Applied Science bfi Vienna*, no 81, pp. 1-73, 2013

Cont, R. and Tankov, P., *Financial Modelling with Jump Processes*, CRC Press Company, London, 2004.

Frontczak, R., Pricing Options in Jumps Diffusion Models Using Mellin Transforms, *J. Math Financ.,* vol. 32, no. 3, pp. 366-373, 2013.

Gugole, N., Merton Jump-Diffusion Model Versus The Black and Scholes Approach for the Log-Returns and Volatility Smile Fitting, *International Journal of Pure and Applied Mathematics,* vol. 109, pp. 719-736, 2016.

Kou, S. G., A jump Diffusion Model for Option Pricing, *Informs Management Science*, vol. 48, no. 8, pp. 1086-1101, 2002.

Kuttu, S., Time varying conditional discrete jumps in emerging African equity markets, *Glob. Financ. J.,* vol. 32, pp. 35-54, 2017.

Lawler, G.F., *Stochastic Calculus An Introduction with Application*, 2014.

Lin, X.C.S., Daniel, W.C.M., and Wan, L.C., Analysis of a Jump-Diffusion Option Pricing Model with Serially Correlated Jump Sizes, *Communications in Statistics – Theory and Methods*, vol. 47, no 4, pp. 953-979, 2018.

Maekawa, K., Marimoto, T., and Kawai, K., Jump Diffusion Model with Application to the Japanese Stock Market, *Hiroshima University*, vol. 78, pp. 223-236, 2018.

Matsuda, K., *Introduction to Merton Jump Diffusion Model*, The City University of New York, New York, pp. 1-26, 2004.

Merton, R.C., Option Pricing when Underlying Stock Returns are Discontinuous, *Journal of Financial Economics,* vol. 3, pp. 125-144, 1976.

Musnadi, S., Syamni, G., Nasir,, Faisal,, Saputra, J. (2020). Investigating the cash holding factors of mining industries in Indonesia stock exchange. Industrial Engineering and Management Systems, 2020, 19(3), pp. 527–537.

Namugaya, J., Weke, P., and Charles, W.M, *Modelling Stock Return Volatility on Uganda Securities Exchange,* vol 8, no. 104, pp. 5173-5184, 2014.

Novat, K., Wilson, M.C., dan Verdiana, C.M., Merton's Jump Diffusion Model an Application to Stock Markets of East African Countries, *International Journal of Advances in Scientific Research and Engineering (IJASRE)*, vol. 5, no. 8, pp. 16-24, 2019.

Sinurat, M., Erlina, Daulay, M., Saputra, J., Sadalia, I., Ilham, R.N. (2020). Supply chain strategy for assessing the stock prices of property sector companies in Indonesia stock exchange. International Journal of Supply Chain Management, 2020, 9(4), pp. 248–266.

Sukono,, Riaman,, Kartiwa, A., Saputra, J., Bon, A.T. (2019). *Stock return prediction based on some forms of capital asset pricing model (CAPM)*. Proceedings of the International Conference on Industrial Engineering and Operations Management, 2019, (July), pp. 1566–1573.

Sukono,, Susanti, D., Aisah, I., Saputra, J., Bon, A.T. (2019). *Stock assessment using a dividend discount model with growth rate following a time series pattern.* Proceedings of the International Conference on Industrial Engineering and Operations Management, 2019, (July), pp. 1574–1580.

Tang, F., *Merton Jump-Diffusion Modeling of Stock Price Data*, Linnaeus University, Sweden, 2018.

Yi, L., *The Pricing of Options with Jump Diffusion and Stochastic Volatility,* Iceland, 2010.

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