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Modeling Rubber Prices as a GBM Process

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Abstract

This paper shows that the prices of rubber type SMR and type centrifuged latex can be modeled as a geometric Brownian motion process. A numerical simulation of the prices of the rubbers is given to illustrate the approach.

Keywords: Forecasting, Geometric Brownian Motion, Numerical Simulation, Rubber Prices

1. Introduction

In finance, stock markets prediction has been the interest and many have introduced stock prices estimation model that are more accurate. Regression technique has been used widely in stock prices prediction[14–16]. However[5] show that artificial neural networks and random walk can also be used for prediction and [6]describes the stock market dynamics by a binomial model. In[7] propose a stock market model via finite-difference which uses intrinsic values and shows that by choosing suitable choice of parameters, the predicted prices are close to the actual prices for short time horizons. Moreover, [8]demonstrate genetic algorithmin predicting stock market crashes and the end of asset bubbles in stock prices. [9]On the other hand, attempt to improve upon the forecasting technique via an integration prediction approach.

Stock prices exhibit uncertain movements and the Efficient Market Hypothesis (EMH) is one of the reasons behind this random behaviour. The EMH states that the historical stock price is reflected by the current price of the stock[1]. Thence, the future price of a certain stock is dependent only on its current price. The randomness exhibit by the stock price can be explained by a Geometric Brownian Motion (GBM) – a mathematical approach to modelling stock prices. The GBM process has been the basis for many literature in option pricing[11–13] and it is a stochastic process that assumes normally distributed and independent stock returns. This process can be used to simulate the movement of stock prices for a short time interval and to model financial processes as shown in[10]. Hence[2] and[3] demonstrate the GBM process to forecast stock prices and indices in Bursa Malaysia. Additionally, [4]demonstrate the GBM process to study the time series behaviour of the number of passengers of Air Asia.

In this study, we aim to simulate the prices of rubber of type SMR and centrifuged latex using this mathematical approach. The organization of the paper is as follows. Section 2 gives an overview of the approach that is used in the simulation. Section 3 documents the numerical examples and the performance of this approach and Section 4 concludes.

2. The GBM Process

The behaviour of the rubber prices can be modelled through its relative change in time. Suppose the rubber price P_t follows the following dynamics:

$$dP_t = \mu P_t dt + \sigma P_t dB_t \tag{1}$$

where B_t is a standard Brownian motion that is normally distributed with zero mean and a standard deviation of a square root of the time step. Equivalently, by separation of variables, Equation (1) can be written in terms of the instantaneous rate of return on P_t as follows:

$$\frac{dP_t}{P_t} = \mu dt + \sigma dB_t, \tag{2}$$

and let $X_t = \ln(P_t)$. Then we can express Equation (2) as follows:

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$$dX_t = \left(\mu - \sigma^2/2\right)dt + \sigma dB_t, \quad (3)$$

which shows that X_t is follows an Arithmetic Brownian Motion process where the increments in the logarithmic rubber prices are normally distributed with mean $\left(\mu - \frac{1}{2}\sigma^2\right)dt$ and variance $\sigma^2 dt$. Following this, we integrate both sides of Equation (3). Hence, this gives us the solution of P_t as follows:

$$\ln P_t = \ln P_{t-1} + \left(\mu - \frac{1}{2}\sigma^2\right)dt + \sigma dB_t. \quad (4)$$

Similarly, Equation (4) can be written as such:

$$P_t = P_{t-1} e^{\left(\mu - \frac{1}{2}\sigma^2\right)dt + \sigma dB}, \quad (5)$$

which shows that the rubber price is a GBM process that follows a log-normal distribution.

The mean and standard deviation (volatility) of the rubber prices are estimated empirically from historical daily logarithmic returns at fixed intervals of time. Hence, suppose P_t is the closing price at the end of i[th] trading period, and $\tau\left(= t_i - t_{i-1}\right)$ for $i \geq 1$ is the length of time interval between two consecutive trading periods. Therefore, the daily logarithmic returns, x_i for $i = 1, \ldots, n$, over time interval τ is given by:

$$x_i = \ln\left(\frac{P_i}{P_{i-1}}\right), \quad (6)$$

On that account, the estimator of the standard deviation of the x_i's is:

$$v = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}, \quad (7)$$

where $\bar{x}$ is the unbiased estimator of the logarithm of the returns given as:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i. \quad (8)$$

Thus, the model is complete.

3. Data and Numerical Example

In this section, we illustrate the GBM process by applying data that is obtained from the official website of the Malaysian Rubber Board for the month of December 2015. The sets of data are the daily closing prices at noon for five different grades of rubber type SMR and the daily closing prices at noon of rubber type centrifuged latex. The closing prices are based on the sellers' offer price in MYR sen/kg. The prices for December 2015 are documented in Table 1. We estimate the mean and the volatility of each rubber prices using Equations (6) and (7). The estimations are provided in Table 2. In order to measure the accuracy (*Acc*) of the simulated prices, we use the following approach:

$$Acc = \left[100\% - \left(\left|\frac{A_t - F_t}{A_t}\right| \times 100\%\right)\right]^+, \quad (9)$$

where A_t is the historical (actual) price at time t, and F_t is the simulated (forecast) price at time t. We also compute the Mean Absolute Percentage Error (MAPE), to determine the accuracy of the simulated prices, given by the following:

$$MAPE = \frac{\sum_{i=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|}{n}, \quad (10)$$

where n is the number of trading days, A_t and F_t are as defined previously. The level of accuracy is determined via Lewis' judgment scale which indicates highly accurate forecast prices for errors that are less than 10%.

Table 3 documents the simulated prices for five grades of rubber of type SMR and of type centrifuged latex. The accuracy of the simulation for each trading period is also given for both SMR and centrifuged latex in Table 3. The accuracy is computed using Equations (9) and (10) and it can be seen that the accuracy of the simulated prices for both SMR and centrifuged latex are almost 100% accurate.

We plot the actual prices and simulation prices for the five grades of type SMR and the centrifuged latex in Figures 1, 2, 3, 4, 5, 6 and 7, respectively. It can be shown that for the whole month, the simulation (forecast) prices for the different types of rubbers are almost closed to the actual prices.

Table 1. Actual prices for SMR and centrifuged latex (MYR sen/kg)

Date	SMR						Latex
	CV	L	5	GP	10	20	
2-Dec	638.5	601	505.5	502.5	495.5	493.5	371.5
3-Dec	639	600.5	503.5	500.5	493.5	491.5	372
4-Dec	639.5	600.5	500	497	490	488	365.5
7-Dec	637.5	599.5	505.5	502.5	495.5	493.5	363
8-Dec	636	598.5	506.5	503.5	496.5	494.5	363.5
9-Dec	634.5	597.5	512.5	509.5	502.5	500.5	363.5
10-Dec	633.5	597	507.5	504.5	497.5	495.5	361.5
11-Dec	630.5	596	501.5	498.5	491.5	489.5	360
14-Dec	633.5	597.5	510.5	507.5	500.5	498.5	362.5
15-Dec	632	596.5	507.5	504.5	497.5	495.5	362
16-Dec	630	595.5	499	496	489	487	360.5
17-Dec	631	596.5	509	506	499	497	360.5
18-Dec	631	596	502	499	492	490	360
21-Dec	620.5	588.5	505.5	502.5	495.5	493.5	358.5
22-Dec	609	579	510.5	507.5	500.5	498.5	356
23-Dec	600	572	510.5	507.5	500.5	498.5	353.5
28-Dec	596	566	503	500	493	491	352.5
29-Dec	589	558	495	492	485	483	346.5
30-Dec	578	548.5	493	490	483	481	338.5
31-Dec	567.5	539.5	491.5	488.5	481.5	479.5	331.5

Source: Official Portal Malaysian Rubber Board

Table 2. Mean and standard deviation

	SMR						Latex
	CV	L	5	GP	10	20	
Mean	-0.00168	-0.00149	5.084×10^{-5}	5.115×10^{-5}	5.187×10^{-5}	5.208×10^{-5}	-0.00233
S.D.	0.00296	0.00246	0.00509	0.00512	0.00519	0.00521	0.00366

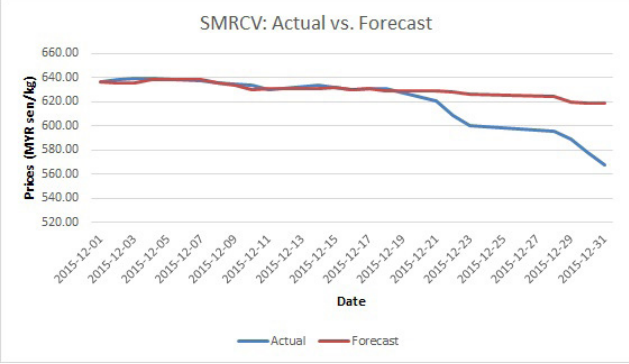

Figure 1. SMRCV (MYR sen/kg): Actual vs. forecast.

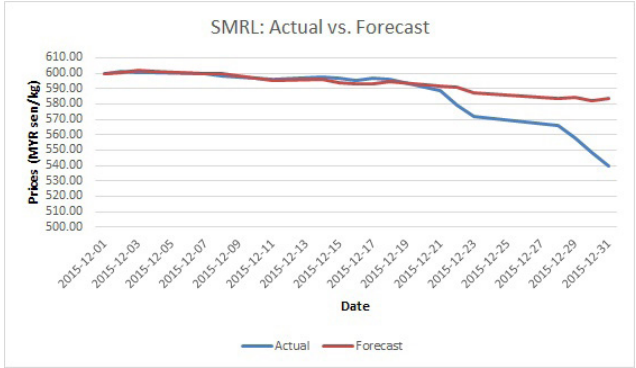

Figure 2. SMRL (MYR sen/kg): Actual vs. forecast.

Table 3. Simulation prices and accuracy for SMR and centrifuged latex (MYR sen/kg)

Date	SMR												Latex	Acc (%)
	CV	Acc (%)	L	Acc (%)	5	Acc (%)	GP	Acc (%)	10	Acc (%)	20	Acc (%)		
12-02	635.46	99.52	600.42	99.90	505.00	99.90	499.10	99.32	494.97	99.89	490.24	99.34	368.83	99.28
12-03	635.65	99.48	602.23	99.71	505.58	99.59	500.46	99.99	494.03	99.89	489.35	99.56	368.37	99.03
12-04	638.77	99.89	600.97	99.92	509.29	98.14	502.47	98.90	496.18	98.74	491.93	99.19	368.00	99.32
12-07	638.29	99.88	600.02	99.91	506.98	99.71	502.44	99.99	496.04	99.89	490.77	99.45	366.92	98.92
12-08	635.64	99.94	599.56	99.82	508.02	99.70	503.01	99.90	497.99	99.70	494.63	99.97	366.17	99.27
12-09	633.68	99.87	598.53	99.83	507.29	98.98	500.13	98.16	497.78	99.06	494.96	98.89	364.92	99.61
12-10	630.58	99.54	596.68	99.95	506.23	99.75	504.20	99.94	500.66	99.37	495.24	99.95	365.11	99.00
12-11	631.44	99.85	595.59	99.93	508.21	98.66	502.27	99.24	499.86	98.30	491.44	99.60	363.13	99.13
12-14	630.89	99.59	595.86	99.73	510.62	99.98	497.44	98.02	496.76	99.25	489.99	98.29	361.04	99.60
12-15	631.85	99.98	593.62	99.52	507.90	99.92	502.09	99.52	492.60	99.02	488.38	98.56	361.02	99.73
12-16	630.10	99.98	593.27	99.63	504.42	98.91	504.59	98.27	492.66	99.25	491.25	99.13	360.61	99.97
12-17	631.28	99.96	593.16	99.44	505.97	99.40	501.22	99.05	492.00	98.60	491.12	98.82	360.66	99.95
12-18	629.14	99.70	594.55	99.76	506.68	99.07	499.69	99.86	495.30	99.33	492.35	99.52	358.07	99.46
12-21	629.26	98.59	591.66	99.46	509.17	99.27	498.34	99.17	494.76	99.85	495.18	99.66	358.75	99.93
12-22	628.28	96.83	590.70	97.98	508.86	99.68	503.69	99.25	498.34	99.57	497.75	99.85	357.15	99.68
12-23	626.52	95.58	587.22	97.34	505.10	98.94	505.61	99.63	499.46	99.79	496.75	99.65	356.83	99.06
12-28	624.43	95.23	583.61	96.89	506.36	99.33	506.43	98.71	501.36	98.30	493.28	99.53	352.52	99.99
12-29	620.33	94.68	584.23	95.30	513.83	96.20	504.88	97.38	500.48	96.81	494.68	97.58	354.77	97.61
12-30	619.25	92.86	582.43	93.81	513.39	95.87	505.44	96.85	500.52	96.37	490.29	98.07	355.27	95.05
12-31	618.82	90.96	583.51	91.84	513.44	95.54	508.18	95.97	496.28	96.93	484.25	99.01	354.99	92.91
MAPE (%)	0.976		0.664		0.650		0.769		0.717		0.649		0.534	

In addition, from Table 3, it can be seen that the errors from MAPE for the five grades of rubber type SMR and type centrifuged latex are less than 10%. Hence, following Lewis' scale, the simulated prices for both rubber types are highly accurate.

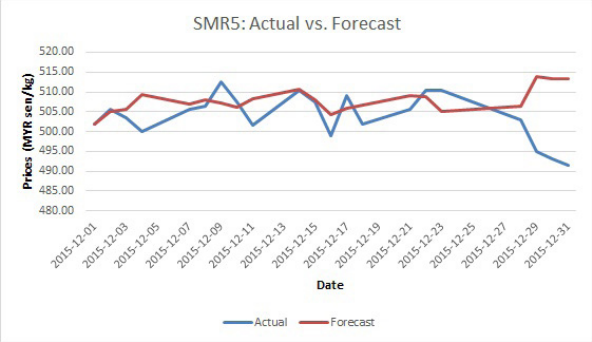

Figure 3. SMR5 (MYR sen/kg): Actual vs. forecast.

4. Conclusion and Future Work

In this study, we have shown that the prices of five grades of rubber type SMR and type centrifuged latex can be modelled via a mathematical approach, the Geometric Brownian Motion (GBM) process. Since commodities may exhibit mean-reversion, future work may consider incorporating this feature into modeling the rubber prices using a mean-reversion GBM process.

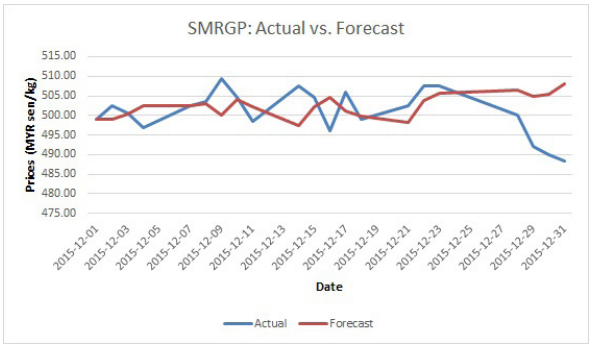

Figure 4. SMRGP (MYR sen/kg): Actual vs. forecast.

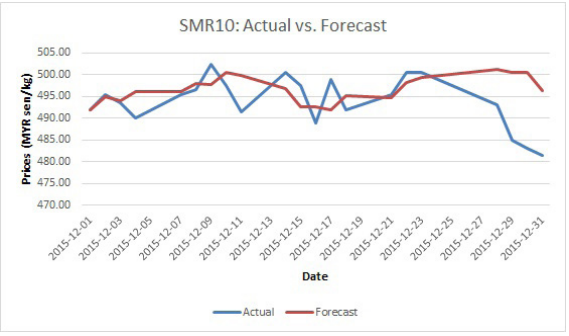

Figure 5. SMR10 (MYR sen/kg): Actual vs. forecast.

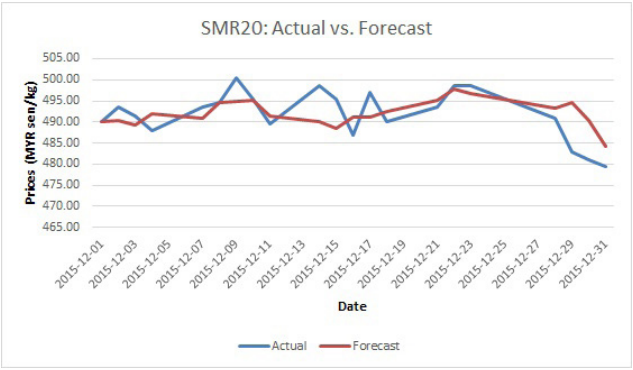

Figure 6. SMR20 (MYR sen/kg): Actual vs. forecast.

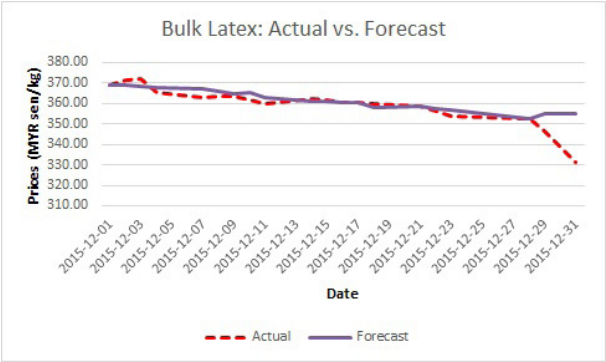

Figure 7. Centrifuged latex (MYR sen/kg): Actual vs. forecast.

5. Acknowledgements

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