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Monitoring Volatility Point of Sukuk Ijarah Using a Hybrid MCEWMA Control Chart: Double Bootstrap Approach

[1]*L. Muhamad Safiih* and [2]*Z. Nurul Hila*

[1]Institute of Biotechnology Marine, [1]Kenyir Research Institute,
[1,2]School of Informatics and Applied Mathematics,
Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

Abstarct: Sukuk Ijarah of Malaysia Airports Capital Berhad is one of Islamic financial instrument issued in Bursa Malaysia. The daily log-return of this dukuk is exmined its statictical characteristic and it is found to be serial correlated. Considering this correlation, volatility point of sukuk Ijarah can be monitored using MCEWMA control chart. Even though the chart is efficient in detecting small shift, it is said to be under influence of biasness and uncertainty estimation. In this research, these problems are solved by proposes a construction of double bootstrap MCEWMA control chart. This proposes chart is used to minitor the volatility points of sukuk Ijarah and also tested it's its efficiency in detecting small, medium and greater shift magnitude. The test is considered efficiency comparison of standard chart with two different limits, i.e. standard and bootstrapping control limit. For the result, both of standard chart are sensitive to medium shift magnitude but inconsistent when tested for smallest and largest shift. Meanwhile, the double bootstrap MCEWMA chart is found to be more sensitive to all shift magnitude and efficient in detecting the out-of-control point.

Key words: Double bootstrap · MCEWMA · Sukuk · Shift magnitude

INTRODUCTION

Sukuk Ijarah is an investment instrument of Islamic financial issued in Bursa Malaysia. Sukuk Ijarah practically refers to an alternative financial funding using leasing agreement of an asset. Generally, the implementation of sukuk Ijarah is basically contrary to conventional instrument procedure, where the leasing agreement is need to comply three Islamic transaction prohibitions that involves usury (*riba*), gambling and ambiguity (*gharar*) [1, 2].

The development of sukuk Ijarah issuance in Bursa Malaysia seems to give positive implication in creating competitive investment with conventional and others sukuk instrument for example *Musyarakah*, *Mudharabah*, *Bai' Bithaman Ajil* and *Wakalah* [3-5]. Formerly, the most highlighted competitive prospect is volatility point where its perpose is basically to determine the activeness of an investment that lead to useful information such as high return, medium return based on current market and maximum loss of trading. In term of sukuk Ijarah, the volatility point estimation involves log-return from simple calculation of daily prices of sukuk Ijarah trading [6].

According to [7, 8], the characteristic of log-return is usually found to be serial correlated. In Statistical Process Control (SPC), the occurance of serial correlation data seems to be a crucial problem in monitoring process of standard control chart, such as EWMA and CUSUM. Several researches, for example of [9-11], have stated that the chart will lead to increase false alarm rate and Type I error. However, Montgomery [12] has proposed a modified EWMA chart which is specifically used to monitor the serial correlation sample data. This modification chart is known as Moving Centerline Exponentially Weighted Moving Average (MCEWMA) where it is a combination of a base model in the center and control limit,i.e. upper and lower. This chart is recognised to be efficient in detecting small shift in individual and subgroup observation [10-14].

Corresponding Author: Z. Nurul Hila, School of Informatics and Applied Mathematics,
Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.

Formally, the application of MCEWMA base model is widely used in estimating volatility point of conventional investment, see for research example of [15, 16], because of its advantages of increasing the most recent parameter, i.e. weight and gives greater parameter to the most recent log-return. By considering these advantages, this research is motivated to estimate volatility point of sukuk Ijarah using MCEWMA base model and further estimation of its control limit to monitor the out-of-control points at various shift magnitude.

Even though MCEWMA chart is well constructed, its biasness and uncertainty estimation are remained to be perpetually problem in research discussion. According to [17-19], these problems can be solved using bootstrapping approach into control limit so that the estimation is more consistent and decrease the uncertainty. However, it has also been pointed out that this method does not reliable and almost gives inefficient performance when dealing with sample data of heavy-tailed distribution [20, 21]. Despite of this minor issue, [22] has improved the method by introducing the repeatition concept of first sampling data. The concept is named as double bootstrap method. In several researches, it has been proven that this new methods increase the power of accuracy of single bootstrap [23, 24].

In this research, the double bootstrap method is represented in an alternative procedure where it is motivated from Pascual [6] case study. The procedure is basically drawn by the residual of MCEWMA base model randomly that will lead to construction of new base model, namely double bootstrap MCEWMA (BB-MCEWWA). With this new base model, the upper and lower of control limit can be estimated to be functioning in monitoring process. This research is motivated to monitor volatility point of sukuk Ijarah and efficient control chart, due to its high accuracy and low uncertainty estimation, is needed. Thus by proposing a new chart, monitoring process of sukuk Ijarah volatility can be done and to test its efficiency, this research has used the average run length estimation.

MATERIALS AND METHODS

Data: This research is motivated by sukuk Ijarah volatility estimation where daily log-return of sukuk needs to be calculated from its historical daily losing price. In this research, the information of sukuk Ijarah price is taken from stock VN100268 which is issued by Malaysia Airports Capital Berhad, Malaysia under Islamic Medium-Term Notes Programme 2010/2025. The update closing price is started from 30 August 2010 until 28 October 2015 where the sample saiz is m = 348 counted for this period. All detail information of this sukuk is downloaded from Bon Info Hub, Bank Negara Malaysia database. Thus, the daily log-retun of sukuk Ijarah VN100268 is calculated and plotted in Fig. 1.

An important guiding in analysing log-return of sukuk Ijarah is to recognise its sample characteristics which are in terms of randomness, serial colleration and existence of heteroskedasticity. In this research, the randomness is tested using Wald-Wolfowitz and Man-Whiteney U method. For heteroskedasticity test, the Breusch and Pagan method is considered. Meanwhile, the serial colleration is examined using Durbin and Watson method. The corresponding p-values based on log-return for all the characteristic tests result are given in Table 1.

Table 1: Sukuk Ijarah sample characteristic tests

Tests		*p*-value Log-return
(A) Randomness:	Wald-Wolfowitz	0.000
	Mann-Whiteney U	0.966
(B) Heteroskedasticity:	Breusch and Pagan	0.560
(C) Serial Correlation:	Durbin and Watson	1.966

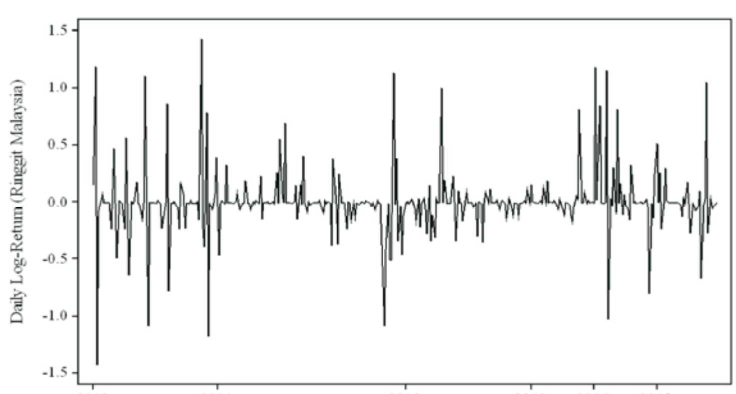

Fig. 1: Time series plot of sukuk Ijarah VN100268

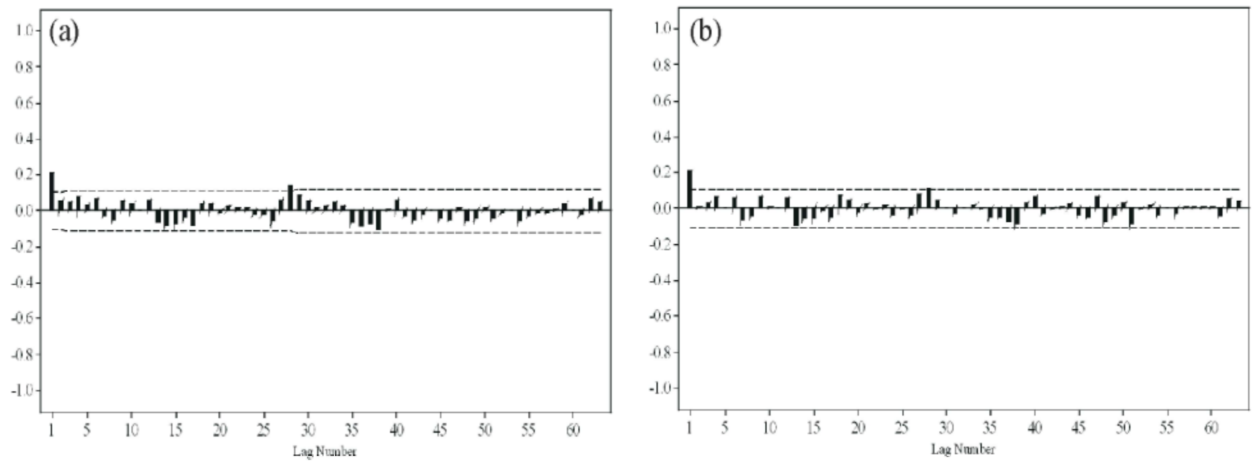

Fig. 2(a,b): a) Autocorrelation function
b): Partial autocorrelation function

By referring Table 1, p-value of randomness tests are 0.000 and 0.966 for Wald-Wolfowitz and Mann-Whiteney U respectively. Considering α = 0.05, then its enough evidence to confirm that log-return sample of sukuk Ijarah VN100268 is non-independent and identically distributed (non-iid). Some published examples of this non-iid sukuk data can be found in [25-28].

Based on Breusch and Pagan test result, the sampel data is showed to be no heteroskedasticity with p-value is equal to 0.560. It is not uncommon that sukuk data have no heteroskedasticity, a publish example in [29] has claimed log-return sample could have homoskedasticity.

Note that in serial colleration test, the p-value is found to be 1.966 which is smaller than Durbin dan Watson colleration value. The only reason of this is due to the existence of residual serial correlation in sukuk Ijarah VN100268 sample data. The presence of correlation in this sample could be further examine by evaluating autocorrelation function (ACF) and partial autocorrelation function (PACF). The ACF in Fig. 2(a) and the PACF in Fig. 2(b) indicate that the log-return of sukuk Ijarah is not dependent and it would be appropriate to apply the double bootstrap moving centreline exponentially weighted moving average control chart for monitoring the volatility points of this sukuk Ijarah. The same pattern result can be found in published example of [29, 30].

The Double Bootstrap MCEWMA control chart: To construct the double bootstrap MCEWMA control chart, consider the individual observation (n=1) for log-return sukuk Ijarah VN100268. The notation of proposed chart is BB-MCEWMA and its base model for estimating volatility points can be given by:

$$x_i = W_{i-1} + \varepsilon_i \qquad (1)$$

$$W_i = \lambda x_i + (1-\lambda) W_{i-1i} \qquad i = 1,\dots,m \qquad (2)$$

where x_i denote as log-return of sukuk Ijarah, λ = 0.94 which is for daily volatility estimation [31, 32], ε_i is a white noise process and W_i is the base model. Meanwhile the three sigma upper and lower control limits can be given by:

$$UCL_{x_{i+1}}, LCL_{x_{i+1}} = W_i \ \pm 3\sigma_e \qquad (3)$$

where the σ_e calculation in Equation (3) can be refered to [34]. Once the model, W_i is estimated, the residual is estimated using this formula, i.e. $\hat{\varepsilon}_i = x_i - \hat{W}_{i-1}$.

To implement the residual double bootstrap procedure, first, it is necessary to have a set of $X_i^* = \{x_1^*,\dots,x_m^*\}$ replication from single bootstrap. The X_i^* can be obtained using the following recursions:

$$x_i^* = \hat{W}_{i-1}^* + \varepsilon_i^* \qquad (4)$$

$$\hat{W}_i^* = \lambda x_i^* + (1-\lambda)\hat{W}_{i-1}^* \qquad i = 1,\dots,m \qquad (5)$$

where ε_i^* is random draws with replacement of B*=1,...,1700 replication from $\hat{\varepsilon}_i$ and " * " notation is refered to single bootstrap approach. Once the first bootstrapping model is estimated, $\hat{W}_i^*$ the corresponding estimation of control limit can be obtained using $\hat{C}L_{x_{i+1}}^* = \hat{W}_i^* \pm 3\hat{\sigma}_e^*$.

Alternatively, in this research, the double bootstrap procedure is extended from [6] of single bootstrap procedure. The implementation of double bootstrap can be made by draws ε_i^{**} randomly with replacement using B**=1,...,2000 replication from $\hat{\varepsilon}_i^* = x_i^* - \hat{W}_{i-1}^*$ and

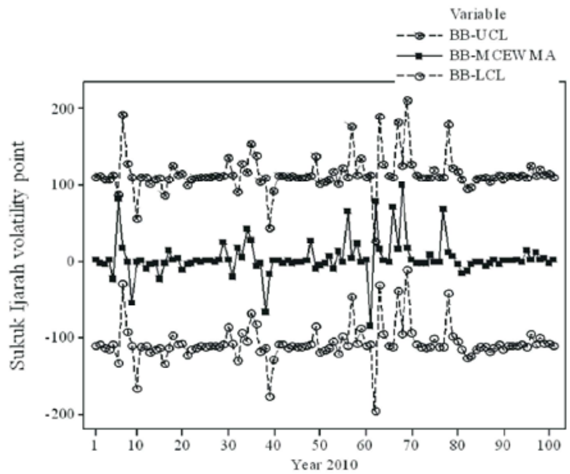

Fig. 3: The BB-MCEWMA control chart for daily volatily point of sukuk Ijarah

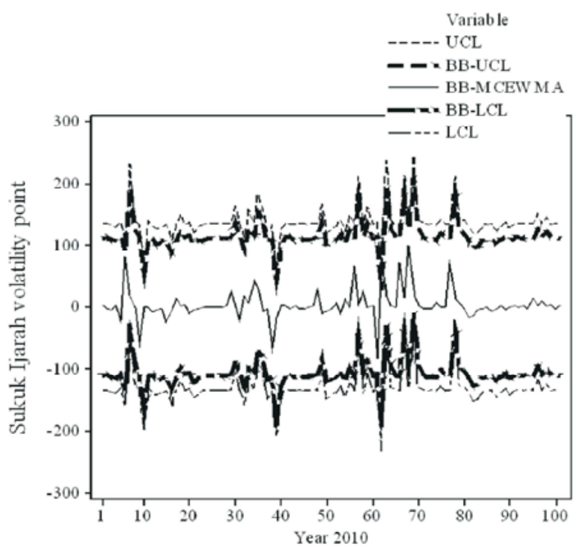

Fig. 4: The difference between standard and double bootstrap control limit estimation

the notation of " ** " is refered to double bootstrap approach. Once the replication is made, a set of double bootstrap sample can be obtained using the notation $X_i^{**} = \{x_1^{**},...,x_m^{**}\}$ which simultaneously leads to double bootstrap MCEWMA model and its control limit estimation:

$$\hat{W}_i^{**} = \lambda x_i^{**} + (1-\lambda)\hat{W}_{i-1}^{**} \quad (6)$$

$$\hat{C}L_{x_{i+1}}^{**} = \hat{W}_i^{**} \pm 3\hat{\sigma}_e^{**} \qquad i = 1,...,m \quad (7)$$

The complete double bootstrap MCEWMA control chart for the 100 volatility point of sukuk Ijarah is shown in Fig. 3 and comparison of control limit estimation is shown in Fig. 4. Note that the double bootstrap control limit points are less wide and more approaching to base model compare to standard limit.

Average Run Length Estimation: In order to detect upward shift, according to [19], basically the MCEWMA C_n is defined by $C_n = 0$ and the following recursive can be considered:

$$C_n = \max(\hat{W}_i^{**} + 3\hat{\sigma}_e^{**}, 0) \text{ for } n \geq 1 \quad (8)$$

Let T_n be the time elapse after the last C_n of MCEWMA equall to 0. The estimation of T_n can be in following recursive:

$$\hat{T}_n = \begin{cases} 0 & \text{if} \quad C_n = 0 \\ j & \text{if} \quad C_n \neq 0,...,C_{n-j+1} \neq 0 \\ & \text{if} \quad C_{n-j} = 0; \quad j = 1,...,n \end{cases} \quad (9)$$

where n = 1 with $\{i(c):1,..,m\}$ and j = 1. Draws the $\hat{T}_n$ randomly with replacement to obtain a set of $\hat{T}:\{\hat{T}_1,\hat{T}_2,...,\hat{T}_n\}$ using JJ = 1000 times of draws. Consider a 90% two-tailed confidence interval and its confidence limit can be estimate using the following recursive:

$$\left[\hat{T}_{Lower}, \hat{T}_{Upper}\right] = \left[\hat{T}^{-1}_{(\frac{\alpha}{2})M}, \hat{T}^{-1}_{(1-\frac{\alpha}{2})M}\right] \quad (10)$$

where the ARL can be estimated through Equation(10) by finding the difference between upper limit and lower limit. In this research, the standard single bootstrapping procedure in SPC is also considered. In order to estimate ARL of MCEWMA using single bootstrap control limit, the C_n notation need to be obtained using the following recursive:

$$UCL^*_{C_n} = E(UCL^*_{x_{i+1}}) - UCL^*_{x_{i+1}} \quad (11)$$

Once the C_n is obtained, a set of $\hat{T}^b$ estimation is drawn randomly with replacement using $b = B^*$ times. However, ARL for double bootstrap MCEWMA control chart is estimated by obtaining the $\hat{T}^{bb}$ using $bb = BB^*$ replication.

Now, consider the magnitude shift is $\{\delta$: 0.5, 1.0, 1.5, 2.0, 3.0$\}$ for out-of-control process and the starting value is $W_0 = \mu_p + \delta(\sigma_p)$. The μ_p and σ_p are desired mean and variance which is setted to be 0.5 and 1.5 respectively. The ARL estimation for given magnitude shift values and different control limits are shown in Table 2.

Table 2: ARL estimation for volatility points of sukuk Ijarah VN100268

	Mcewma		BB-Mcewma
δ	Standard[a]	Bootstrap (CL*)[b]	Double Bootstrap (CL**)[c]
0.5	131.80	62.72	5.05
1.0	135.85	64.90	2.15
1.5	69.19	64.51	1.56
2.0	66.99	3.80	0.96
3.0	197.71	67.41	0.35

[a,b,c]Refer to standard, single bootstrap and double bootstrap of control limit.

Note that ARL for standard control chart of MCEWMA is inconsistently decreased as δ increase. This indicates that MCEWMA chart is biased and unsensitive to detect shift of volatility point. However, this standard chart is shown it's efficiently on detecting smaller shift from magnitude 1.0 up to 2.0.

The same outcome is shown by single bootstrapping control limit, eventhough the ARL value is found to be smaller than standard control limit. For example, δ=0.5, the ARL using standard and bootstrapping control limit of MCEWMA are 131.80 and 62.72 respectively. Both of control limit are given greatest value at magnitude shift of 3.0, this means that the MCEWMA is not effectively performs in greater shift.

The ARL estimation for double bootstrap MCEWMA chart is consistenly decreased as δ increase from 0.5 up to 3.0. This indicates that the proposed chart is sensitive and quicker detector of any pattern of magnitude shift, i.e. small, medium and greater shift. Moreover, the ARL values are shown to be smaller compare to standard chart. For example, δ=1.5, the ARL for BB-MCEWMA is 1.56 compare to 69.19 and 64.51 of standard and single bootstrap control limit respectively. This outcome indicates that BB-MCEWMA needs only 2 volatility point to detect the shift process meanwhile MCEWMA (standard control limit) and MCEWMA (single bootstrap control limit) need 69 and 64 volatility point respectively [30-33].

CONCLUSION

In this research, the volatility points of sukuk Ijarah was measured and monitored using double bootstrap Moving Centreline Exponentially Weighted Moving Average control chart. This chart has shortest length in detecting the out-of-control volatility point in small, medium and greater shift magnitude. Meanwhile, the sensitivity of standard chart only limite at certain small and medium shift. These outcomes indicated that the proposed chart, BB-MCEWMA was most efficient compared to standard chart with standard and single bootstrapping control limit. The efficiency of BB-MCEWMA chart could help investor in providing accurate information, for example the changes of structural volatility point of sukuk Ijarah and confirm the accurate return of sukuk Ijarah at standard market price.

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