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Are Frontier African Markets Inefficient or Adaptive? Application of Rolling GARCH Models

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Abstract

Time-varying calendar anomaly is thinly investigated in frontier stock markets. This study evaluates the day-of-the-week (DOW) calendar effects within the adaptive market hypothesis framework in frontier African stock markets. The study applies rolling analyses of the various GARCH family models to estimate daily stock indices return of Ghana stock exchange, Nairobi securities exchange, Botswana stock exchange and Bourse Régionale des Valeurs Mobilières (BRVM) for 2000:1-2020:6 periods. The results show changing DOW effects in Kenya and Botswana which is consistent with the AMH. However, DOW effects cannot be validated in BRVM and Ghana. It suggests that each market must be treated with their own peculiarity even though they are ranked as frontier markets. We conclude that the changing DOW effects in the AMH context cannot be generalised in the frontier African markets and the existence of DOW effects must be treated with caution in BRVM and Ghana.

Keywords: *Calendar Effect; Frontier Markets; GARCH; Adaptive Market Hypothesis; Market Efficiency; Rolling Window.*

JEL Classification: *G10, G12, G14, G41.*

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1. Introduction

For many years, the efficient market hypothesis (EMH) has been the most influential asset pricing theory. It holds that a share price fully reflects all available information and that investors have access to the same information. Additionally, prices are assumed to adjust quickly to new information (Fama, 1970). Based on the EMH, stock markets are efficient, reflecting available information about stock prices (Malkiel, 2003). If so, neither technical analysis, which is the analysis of previous share prices to forecast future prices nor fundamental analysis, which is the process of finding undervalued or overvalued shares would allow an investor to earn abnormal returns in a consistent manner (Malkiel, 2003). Despite the position of the EMH, there have been anomalies such as calendar anomalies, fundamental anomalies and technical anomalies which contradict the theory that markets are efficient.

Due to the discovery of the aforementioned anomalies, the power of EMH as the influential investing framework is being questioned with the development of behavioural finance, which seeks to explain these anomalies by showing how psychological influences can impact human decision making (Konstantinidis et al., 2012). In this context, calendar anomalies and other anomalies are said to have their basis in behavioural finance (Latif et al., 2011). Calendar anomalies can be defined as the likelihood of share prices to exhibit systematic patterns at a particular time of the year, month, week or day (Alagidede and Panagiotidis, 2009). The debate about the efficiency of financial market leads to formulation of Adaptive market hypothesis (AMH). The AMH of Lo (2004, 2005) postulates that market efficiency is not a static, but time varying feature as do the market conditions and participants.

In response to the changing efficiency and conditions, market participants under the AMH are assumed to be satisficing as opposed to making rational or irrational decision. In other words, market participants make satisfactory rather than optimal decisions, suggesting that they are boundedly rational (Lo, 2005). This occurs because trading strategy that is successful in one condition might fail when the condition changes, warranting a change in strategy suited to prevailing condition for the trader to survive or be in business. Consequently, certain market participants will go into extinction with time, others especially those who make significant profit will remain depending on their ability to adapt or innovate, while new ones will enter the market ecology. Furthermore, the AMH implies a changing market ecology where profit opportunities, number, and kind of market participants change with time (Lo, 2017, Obalade, 2019).

Recent studies on calendar anomalies in frontier African market such as Ferrouhi, Kharbouch, Aguenaou and Naeem (2021) and Mazviona, Mah and Choga (2021) did not consider adaptability of calendar anomalies, treating an anomaly as all-or-nothing. Conclusions derived from such absolute methodology produced conflicting findings and cannot be relied upon. By focusing on the DOW effect, this study examines whether calendar anomaly is seasonal and changing with time based on the implications of AMH. According to Abrahamson and Creutz (2018), the DOW effect is the most examined calendar anomaly. This study focuses on the frontier African markets, namely Botswana stock exchange (BSE), Ghana stock exchange (GSE), the Kenyan stock exchange (NSE) and the Bourse Régionale des Valeurs Mobilières (BRVM) (FTSE Russell, 2019). The selected frontier markets are of interest for three reasons. Firstly, there are rarely examined within AMH context. Secondly, frontier markets represent developing countries that are characterised by high economic growth and illiquid stock markets, these countries are normally at a premature development stage and have drawn attention due to their growth potential and diversification opportunities (FTSE Russell, 2014). Thirdly, frontier markets are usually adjudged inefficient; hence they form a good setting or sample for the examination of AMH considering that the developed market and the so-called efficient markets such as US and UK are now found to be adaptive.

The subsequent parts of this study entail the review of relevant theories and empirical studies in section 2. This is followed by research methods in section 3 which detail data and sample, analytical techniques as well as model specification. Subsequently, section 4 presents data analysis, results and interpretation. Section 4 discusses the key findings in terms of their economic implication and significance. In the last section, the key conclusions are highlighted along with the implication of findings to the key stakeholders. The study also proffers recommendations and suggestions for further studies.

2. Literature Review

Calendar anomaly and efficiency of financial markets have generated substantial research interest in the last five decades. In this section, empirical review of calendar anomaly under AMH are presented to show the state-of-the-art and gaps in existing literature. According to Brooks and Persand (2001), the returns on some of the weekdays appear significantly different from the returns on other weekdays. This situation is described as the DOW effect. Pandey and Samanta (2016) explained that the DOW effects reveal larger Friday returns and

lower returns on Monday, resulting in weekend effect (Lakonishok and Maberly, 1990).

Modern literature on financial market efficiency is underpinned by the AMH of Lo (2004, 2005). Urquhart and McGroarty (2014) observed Monday effect in the US data over the full sample period and showed that the Monday effect, among others, is time-varying. Similarly, Rosini and Shenai (2020) studied the London stock exchange and revealed that four-calendar effects including the DOW effect vary over time, suggesting that financial markets could experience transformations from the state of efficiency to inefficiency and vice versa. Earlier studies, such as Wong, Agarwal and Wong (2006) revealed that the DOW effect was present and significant during the full period, and the pre-crisis period; however, it disappeared post-crisis period. Borges (2009) investigates the DOW and MOY effect in seventeen European stock markets in which the results revealed that the calendar anomalies appeared and disappeared.

In the context of frontier markets, Adaramola and Adekanmbi (2020) showed how Monday, Tuesday and Friday effects found in the full sample analysis are all time-varying in rolling window framework. Furthermore, the Monday effect is traceable to bull market condition while the Tuesday and Friday effects are traceable in the bear market condition. By studying Dhaka stock exchange, Akhter and Yong (2019) applied sub-period and rolling analyses to show that that the momentum and contrarian effects are not static but varying. The changing behaviour of calendar anomaly are also demonstrated by Obalade and Muzindutsi (2019a&b) in selected emerging (South Africa) and frontier (Nigeria, Moroccan, Mauritius and Tunisia) African stock markets using rolling GARCH and Markov switching model. On the other hand, Ferrouhi, et al (2021) recently demonstrated the presence of absolute DOW and MOY effects in various African markets, including BRVM. However, the study was not built contemporary theory of AMH. Similarly, Mazviona, Mah and Choga (2021) showed that a Monday, post-holiday and turn of the month and October effects are positive in South Africa stock market.

The examination of AMH cut across different categories of markets. For example AMH has been widely examined in the stock (Urquhart & McGroarty, 2014; Obalade and Muzindutsi, 2019a), commodity (Ramirez, Arellano & Rojas, 2015; Ghazani, Ebrahimi, 2019), digital currency (Khursheed, Naheem, Ahmed & Mustafa, 2019), bond (Charfeddine , Khediri, Aye, Gupta, 2018) and forex (Abounoori, Shahrazi, and Rasekhi, 2012) markets. From the review of studies investigating calendar anomalies under AMH, researchers found the evidence supporting the calendar effects; however, these effects appeared and

disappeared. It was evident the developed, emerging, and frontier markets experienced periods of efficiency and inefficiency. However, many emerging and frontier markets have not been examined within the AMH framework. The evidence presented in the recent literature calls for further investigation on stock returns predictability in Frontier African stock markets. Hence, the study presented attempts to fill in the gap by examining the DOW effects in Botswana, Ghana, Kenya and Bourse Régionale des Valeurs Mobilières. This paper will assist investors in making informed decisions.

3. Research Methodology

3.1. Data and Sample Selection

This study analyses the daily returns of Ghana stock exchange (GSE), Nairobi securities exchange (NSE), Botswana stock exchange (BSE) and Bourse Régionale des Valeurs Mobilières (BRVM) market indices for the 2000:1-2020:7 period, based on the availability of balanced data. BRVM is a regional stock exchange serving Benin, Burkina Faso, Guinea Bissau, Cote d'Ivoire, Mali, Niger, Senegal and Togo. The selected frontier markets are rarely studied in AMH literature. According to Obalade and Muzindutsi (2019b), the use of daily indices provides more observations necessary for the implementation of the AMH. The period of this investigation is from the year 2000 January to 2020 June; however, for Kenya, the period is 2008 January to 2020 June due to data availability. The data for BSE and GSE stock market returns are sourced from Iress while the data for NSE and BRVM is sourced from Capital IQ Databases. The continuously compounded returns are calculated with the use of this formula:

$$r_t = 100\% \, x \ln\left(\frac{p_t}{p_{t-1}}\right) \quad (1)$$

where r_t is the continuously compounded return at time t, p_t is the current price of the stock index at time t, p_{t-1} is the previous period price of the stock index at time (t-1).

3.2. Model Specification

DOW centres on the idea that different weekdays tend to have unequal mean returns (Cai, Li and Qi, 2006). The equation estimated for the DOW effect in this investigation is as follows:

$$R_t = \sum_{i=1}^{5} \beta_i D_{it} + \sum_{i=1}^{k} \alpha_i DR_{t-1} + e_t \qquad (2)$$

$$H_0: \beta_i = 0 \qquad H_1: \beta_i \neq 0$$

where R_t represents the return on day t, D_1 represents a dummy variable which is 1 provided it is a Monday and 0 provided it is not, D_2 is a dummy variable that is equal to 1 for Tuesday and 0 if it is not a Tuesday. Similarly, D_3 is equal 1 for Wednesday and 0 if not, D_4 is equal to 1 if it is Thursday and 0 if not and D_5 is equal to 1 for Friday and 0 if not. β_i reflects the coefficients of the days-of-the-week (Obalade and Muzindutsi, 2019a).

3.3. Estimation Technique

Literature shows that GARCH model is appropriate for the estimation of calendar anomaly. GARCH models are useful for modelling stock markets and other financial instruments data (Gökbulut and Pekkaya, 2014). This study uses the GARCH (1,1) which is commonly used in academic finance literature (Brooks, 2019). Following the mean equation (2), the GARCH (1,1) variance equation is specified thus:

$$h_t = a_0 + a_1 e_{t-1}^2 + \theta h_{t-1} \qquad (3)$$

where $\alpha_0, \alpha_1, \theta$, reflect the GARCH model parameters and h_t, e_{t-1}^2 and h_{t-1}, the conditional variance, ARCH and GARCH terms respectively. Although the GARCH (1,1) is a simple model within the GARCH household, its limitations include the violation of non-negativity constraint and failure to account for leverage effects (Engle, 2001). Hence, this study considers also consider the exponential GARCH (EGARCH) and the Threshold GARCH (TGARCH) models which are asymmetric GARCH models (Brooks, 2019). The exponential GARCH model proposed by Nelson (1991) can be specified as:

$$ln\,(h_t) = \omega + \alpha \left[\frac{\varepsilon_{t-1}}{h_{t-1}} - \sqrt{\frac{2}{\pi}} \right] + \gamma \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \beta\, ln\,(h_{t-1}) \qquad (4)$$

where γ represent the leverage effect of ε_{t-1} which is expected to be negative. EGARCH model always result in a positive conditional variance even if its parameters $(\omega, \alpha, \gamma, \beta)$ are negative (Paradza, 2015). According to Chatzitzisi *et al.* (2019), the impact is asymmetric if it fulfils the condition $\gamma \neq 0$, and the leverage

impacts are established by the implementation of the hypothesis $\gamma < 0$. The TGARCH is given by:

$$h_t = \omega + \alpha_1 \varepsilon_{t=1}^2 + \beta \sigma_{t-1}^2 + \gamma \varepsilon_{t-1}^2 h_{t-1} \quad (5)$$

The TGARCH model has the potential to determine a positive and a negative shock of h_t, conditional variance (Paradza, 2015). For conditional variance to be positive in this model, certain restrictions on the parameters (ω ≥ 0, α ≥ 0, β ≥ 0, α + γ ≥ 0) must be met first (Paradza, 2015).

The rolling GARCH (1,1), TGARCH (1,1) and EGARCH (1,1) are applied in this investigation with the purpose of identifying and selecting the best model for each window, using the information criteria. Rolling analyses is used to investigate the pattern and cyclical movements of calendar anomalies (Urquhart and McGroarty, 2014). Rolling regression implies, working with sub-samples of your total observations, and simply rolling them over and over. In line with Chatzitzisi *et al.* (2019), this study adopts 5-year window size and 1-year step size, to generate seventeen rolling regressions over the study period.

4. Empirical Data and Analysis

Results of DOW BRVM analyses are presented in table 1. For the BRVM results, GARCH (1,1) is selected as the most appropriate model for the entire windows, taken into consideration the diagnostic test, information criteria and model requirement. The full sample results show that there is no evidence of DOW effects as coefficients are not statistically significant. Based on the EMH, this full sample (2000:1-2020:7) results suggest that the market is efficient. The proponents of AMH have argued that full sample results do not show true position of the market over time, hence generates conflicting results. To generate reliable results and recommendation for market participants, it is important to trace how the market evolve and track changes in efficiency (Obalade, 2019). To take AMH into consideration, sub-period and rolling window analysis have been deployed in literature. Tables 1-4 show the results of the rolling GARCH analysis used in this study. The 2001-2005 window shows significant coefficients for Tuesday, Wednesday and Thursday, suggesting the presence of DOW effect, particularly the Wednesday effect. There are no DOW effects over 2002-2006 to 2012-2016 windows except for positive Monday effect in 2008-2012 and negative Tuesday effect in 2005-2009 and 2008-2012. The last four windows reveal the presence of DOW effect particularly significant negative and low Mondays and Thursdays, with two windows of positive Wednesday effects, implying that the market switches between the period of efficiency and anomaly. Tuesday appears

more negative than Monday, while Friday returns are higher than other days of the week and significant in two windows (2010-2014 and 2012-2016) suggesting no evidence of weekend effect for most windows. Overall, not more than four out of 17 (1/5) windows show a significant DOW effect, suggesting the identified effects are not persistent. This finding is consistent with Chatzitzisi et al (2019), who found that calendar effects is varying rather than persistent.

Table 1. GARCH Results for DOW Calendar Anomalies in BVRM

SAMPLE	MODEL	MON	TUE	WED	THU	FRI	A	Γ	B
FULL	GARCH (1,1)	-0.0402	-0.0286	0.0002	-0.0239	0.0363	0.2680***	-	0.4526***
2000-2004	GARCH (1,1)	0.0013	0.1419	-0.0517	0.0470	-0.0082	0.2884***	-	0.5508***
2001-2005	GARCH (1,1)	0.0831	0.1707**	0.1830***	0.1286**	0.0430	0.3652***	-	0.4321***
2002-2006	GARCH (1,1)	0.0323	0.0476	0.0831	0.0418	0.0714	0.2296***	-	0.3791***
2003-2007	GARCH (1,1)	0.0006	-0.0214	0.0643	0.0360	0.0670	0.4292***	-	0.1820**
2004-2008	GARCH (1.1)	0.0263	-0.0523	0.0310	-0.0066	0.0922	0.4284***	-	0.27000***
2005-2009	GARCH (1,1)	-0.0636	-0.2046**	-0.1103	-0.1372	-0.0529	0.4003***	-	0.2007***
2006-2010	GARCH (1,1)	0.0768	-0.1169*	-0.0337	-0.0366	0.0630	0.2928***	-	0.3861***
2007-2011	GARCH (1,1)	-0.1113	-0.2856	-0.2694	-0.1280	-0.1819	0.2984***	-	0.1574***
2008-2012	GARCH (1,1)	0.1568**	-0.2255***	-0.1383*	0.0278	-0.0239	0.1607***	-	0.5096***
2009-2013	GARCH (1,2)	0.0877*	-0.0810*	-0.0851*	0.0857*	0.0089	0.6997*	-	0.2127** 0.1809*
2010-2014	GARCH (1,1)	0.0683	-0.0259	-0.0531	0.0889	0.0595**	0.4867***	-	0.3457***
2011-2015	GARCH (1,1)	0.0564	-0.0629	-0.0560	0.0330	0.0832*	0.5601***	-	0.1248*
2012-2016	GARCH (1,1)	0.0009	-0.0232	-0.0137	0.0169	0.0919**	0.4325***	-	0.0854
2013-2017	GARCH (1,1)	-0.1052**	0.0098	0.1084**	-0.0623	0.0541	0.3088***	-	0.5366***
2014-2018	GARCH (1,1)	-0.1795***	-0.0098	0.1036**	-0.1342***	0.0100	0.2532***	-	0.6268***
2015-2019	GARCH (1,1)	-0.2615***	-0.0338	0.0809*	-0.1349***	0.0077	0.2242***	-	0.6573***
2016-2020	GARCH (1,1)	-0.3174***	-0.0372	-0.0016	-0.1258***	0.0235	0.2040***	-	0.7125***

Note: ***, **, * signify significance at 1%, 5%, 10% level of significance. The ARCH parameters correspond to A (α-alpha), the leverage effect correspond to γ (Γ), the GARCH parameters to B (β-beta).

In the table 2 different models were selected for each window in GSE. The full sample and most windows show the absence of the DOW effect as all coefficients are insignificant at all levels of significance, suggesting GSE is efficient. However, For the windows of 2000-2004, 2001-2005, 2003-2007, 2004-2008, 2007-2011, 2011-2015 and 2013-2017, the results showed positive and significant Friday coefficients, indicating the Friday effect for these windows. 2001-2005, 2008-2012 and 2011-2015 show the presence of positive Monday effects which is

less positive than the Friday effect, suggesting a presence of Weekend effect in two windows. Tuesday, Wednesday and Thursday effects are generally absent except for 2010-2014 results which show significant coefficients for Tuesday. Only Friday effect seems to exist in Ghana at the 5 percent level of significance, however, the effect is weak, occurring in not more than four out of 17 windows (1/5). This finding is also consistent with Borges (2009) and Chatzitzisi et al (2019) in the US and Europe who show that the calendar anomalies appeared only in a few windows. This implies that the market is efficient for most period.

Table 2. GARCH Results for DOW Calendar Anomalies in Ghana

SAMPLE	MODEL	MON	TUE	WED	THU	FRI	A	Γ	B
FULL	GARCH(1,1)	-0.0093	0.0001	0.0048	-0.0027	0.0114	0.2376***	-	0.7669***
2000-2004	GARCH (1,1)	0.0569	0.0648	0.0757	0.0767	0.1018*	0.3950***	-	0.5797***
2001-2005	TGARCH(1,1)	0.0804*	0.0760	0.0626	0.0818	0.0953**	0.5555***	-0.1444**	0.5648***
2002-2006	GARCH (1,1)	0.0088	0.0142	0.0096	0.0095	0.0074	0.2979	-	0.6851***
2003-2007	GARCH (1,1)	0.0218	0.0270	0.0259	0.0249	0.0287*	0.3197***	-	0.6686***
2004-2008	GARCH (1,1)	0.0204	0.0147	0.0204	0.0205	0.0233*	0.2094***	-	0.7016***
2005-2009	GARCH (1,1)	0.0161	0.0125	0.0115	0.0138	0.0188	0.1245***	-	0.8028***
2006-2010	GARCH (1,1)	0.0134	0.0172	0.0135	0.0157	0.0223	0.0988***	-	0.8605***
2007-2011	EGARCH(1,1)	0.0167	0.0287	0.0192	0.0172	0.0457***	-0.0170***	-0.009***	0.9949***
2008-2012	EGARCH(1,1)	0.0272***	0.0432	0.0294	0.0405	0.0297	0.1591	0.4862	-0.0425
2009-2013	EGARCH(1,1)	-0.0005	0.0652	-0.0301	0.0093	0.0201	0.0745***	0.0553***	0.9242***
2010-2014	EGARCH(1,1)	0.0322	0.0628**	0.0168	0.0038	0.0849***	0.6958***	0.7747***	0.1561***
2011-2015	EGARCH(1,1)	0.0271***	0.0346	-0.0073	0.056	0.0854**	0.0631***	0.1191***	0.0474
2012-2016	GARCH (1,1)	-0.0190	-0.0025	-0.0439	0.0049	0.0273	0.2095***	-	0.5564***
2013-2017	GARCH (1,1)	0.0022	0.0291	0.0183	0.0233	0.0828*	0.1708***	-	0.6592***
2014-2018	GARCH (1,1)	-0.0353	-0.0377	-0.0069	-0.026	0.0282	0.1400***	-	0.7518***
2015-2019	GARCH (1,1)	-0.0235	-0.0400	0.0229	-0.0094	0.0381	0.1756***	-	0.7176***
2016-2020	GARCH (1,1)	-0.0476	-0.0422	0.0202	-0.0253	0.0132	0.2005***	-	0.7458***

Note: ***, **, * signify significance at 1%, 5%, 10% level of significance. The ARCH parameters correspond to A (α-alpha), the leverage effect correspond to γ (Γ), the GARCH parameters to B (β-beta).

Kenya DOW results are presented in the third section of table 3. The Full sample results in the NSE revealed the presence of DOW having negative Monday and positive Wednesday, Thursday and Friday coefficient. This implies that the NSE is not efficient and DOW effect may be exploited for an abnormal return. Considering rolling analysis, all windows display a negative Monday effect, which are not statistically significant at the 5 percent level of significance. There is no

Tuesday effect in full sample and rolling window. The positive Friday effect varies overtime, with 2008-2012, 2009-2013, 2010-2014 and 2012-2016 windows being statistically significant. Overall, Wednesday and Thursday have the highest return in the full sample and rolling windows, but there exist two or three windows of insignificant effect, meaning the effects vary with time. The results suggest that DOW effect is adaptive in NSE, except Monday and Tuesday effects which are nonexistent.

Table 3. GARCH Results for DOW Calendar Anomalies in Kenya

SAMPLE	MODEL	MON	TUE	WED	THU	FRI	A	Γ	B
FULL	GARCH(1,1)	-0.0491***	-0.0057	0.0515**	0.0857***	0.0473*	0.3883***	-	0.4519***
2008-2012	GARCH(1,1)	-0.0567	-0.0062	0.0465	0.0972***	0.0846**	0.2763***	-	0.6382***
2009-2013	GARCH(1,2)	-0.0601	0.0159	0.0832**	0.1107***	0.0901**	0.2788***	-	0.0204***
									0.4812
2010-2014	GARCH(1,1)	-0.0324	0.0588*	0.1335***	0.1181***	0.0734**	0.4021***	-	0.2352***
2011-2015	GARCH(1,1)	-0.0317	0.0500	0.1158***	0.0899***	0.0442	0.3983***	-	0.1676**
2012-2016	GARCH(1,1)	-0.0154	0.0429	0.1513***	0.1153***	0.0622*	0.3460***	-	0.0220
2013-2017	GARCH(1,1)	-0.0047	0.0220	0.1020***	0.1097***	0.0426	0.3875***	-	0.2458***
2014-2018	GARCH(2,1)	-0.0490	-0.0050	0.0591*	0.0719**	0.0283	0.1329	-	0.1926**
							0.3381***		
2015-2019	GARCH(2,1)	-0.0745*	-0.0144	0.0364	0.0651*	0.0326	0.0625	-	0.4255***
							0.2326***		
2016-2020	GARCH(1,1)	-0.0787*	-0.0533	0.0300	0.0904**	0.0564	0.2755***	-	0.6167***

Note: ***, **, * signify significance at 1%, 5%, 10% level of significance. The ARCH parameters correspond to A (α-alpha), the leverage effect correspond to γ (Γ), the GARCH parameters to B (β-beta).

Botswana DOW results are presented in table 4 where GARCH (1,1) was selected throughout. The full sample results present positive DOW effects as Tuesday, Wednesday, Thursday, and Friday are significant. Four windows each of Tuesday and Wednesday effects, five windows of Thursday effect as well as six windows of Friday effects are statistically significant, suggesting that they are not absolute but time varying. However, Friday and Thursday effects are stronger than other DOW effects. This finding is consistent with Urquhart and McGroarty (2014) and Rosini and Shenai (2020) who demonstrated that DOW effects follow the AMH as opposed to the absolute EMH.

Table 4. GARCH Results for DOW Calendar Anomalies in Botswana

SAMPLE	MODEL	MON	TUE	WED	THU	FRI	A	Γ	B
FULL	GARCH(1,1)	0.0034	0.0216***	0.0157*	0.0144**	0.0184**	0.1324***	-	0.7330***
2000-2004	GARCH(1,1)	0.0245	0.0301	0.0306	0.0158	0.064***	0.0565***	-	0.8577***
2001-2005	GARCH(1,1)	0.0688	0.0701	0.1220***	0.0477	0.1086***	0.0851***	-	0.8517***
2002-2006	GARCH(1,1)	0.0176	0.0454**	0.0502**	0.0219	0.0460**	0.0880***	-	0.75989***
2003-2007	GARCH(1,1)	0.0239	0.0498**	0.0406**	0.0300	0.0427*	0.0870***	-	0.7388***
2004-2008	GARCH(1,1)	0.0140	0.0438*	0.0319	0.0374	0.0340	0.1604***	-	0.6236***
2005-2009	GARCH(1,1)	0.0076	0.0529*	*0.0456	0.0367	0.0322	0.1266***	-	0.6115***
2006-2010	GARCH(1,1)	-0.0041*	0.0310*	0.0261*	0.0448**	0.0139	0.0961***	-	0.5964***
2007-2011	GARCH(1,1)	-0.0039	0.0179	0.0014	0.0241	0.0197	0.1914***	-	0.1998***
2008-2012	GARCH(1,1)	-0.0162	0.0074	0.0041	0.0103	0.0250	0.2068***	-	0.2088***
2009-2013	GARCH(1,1)	0.0168	0.0240	0.0267	0.0289*	0.0419**	0.1298***	-	0.2257***
2010-2014	GARCH(1,1)	0.0156**	0.0316	0.0217	0.0358***	0.0414***	0.1460***	-	0.1977***
2011-2015	GARCH(1,1)	0.0206	0.0396***	0.0320**	0.0420**	0.0374**	0.1289***	-	0.1920***
2012-2016	GARCH(1,1)	0.0139	0.0300**	0.0174	0.0351**	0.0351	0.0155***	-	0.8089***
2013-2017	GARCH(1,1)	0.0047	0.0220	0.0117	0.0283**	0.0052	0.0272***	-	0.8149***
2014-2018	GARCH(1,1)	-0.0121	0.0066	0.0055	0.0004	-0.0181	0.1031***	-	0.2876***
2015-2019	GARCH(1,1)	-0.0100	0.0045	0.0022	-0.0002	-0.0101	0.0389***	-	0.7125***
2016-2020	GARCH(1,1)	-0.018	-0.0058	-0.0094	-0.0152	-0.0162*	0.0604****	-	0.6487***

Note: ***, **, * signify significance at 1%, 5%, 10% level of significance. The ARCH parameters correspond to A (α-alpha), the leverage effect correspond to γ (Γ), the GARCH parameters to B (β-beta).

As presented in table 2, only Ghana DOW analyses selected TGARCH and EGARCH in certain windows. TGARCH for the window period of 2001-2005 with a negative and statically significant leverage term. For the window periods of 2007-2011, 2009-2013, 2010-2014 and 2011-2015 the study selected EGARCH showing positive and statistically significant leverage terms indicating that positive and negative shocks have different effects on the stock market returns. It shows that positive news causes volatility to rise by more than negative news of the same magnitude. The TGARCH and EGARCH leverage terms for Ghana shows there is asymmetric but there is no evidence of leverage effect. Considering that other markets favour general GARCH, leverage effect cannot be validated in the studied frontier markets. In addition, All ARCH A(Alpha) and GARCH B(Beta) parameters are statistically significant, except in few windows.

Table 5. Diagnostic Test for DOW Rolling GARCH Results

Period	BVRM		GHANA		KENYA		BOTSWANA	
	QSTAT	ARCH	QSTAT	ARCH	QSTAT	ARCH	QSTAT	ARCH
Full	0.999	0.998	0.998	0.877	0.942	0.878	0.998	0.989
2000-2004	0.105	0.791	0.947	0.891	-	-	0.942	0.96
2001-2005	0.216	0.737	0.966	0.823	-	-	0.151	0.282
2002-2006	0.344	0.914	0.819	0.942	-	-	0.692	0.761
2003-2007	0.999	0.983	0.993	0.915	-	-	0.228	0.87
2004-2008	0.999	0.982	0.974	0.883	-	-	0.246	0.918
2005-2009	0.999	0.982	0.999	0.867	-	-	0.516	0.708
2006-2010	0.999	0.982	0.988	0.895	-	-	0.326	0.882
2007-2011	0.999	0.982	0.999	0.975	-	-	0.999	0.978
2008-2012	0.329	0.965	0.999	0.977	0.114	0.487	0.998	0.977
2009-2013	0.692	0.833	0.999	0.977	0.166	0.363	0.998	0.977
2010-2014	0.854	0.968	0.908	0.996	0.99	0.978	0.998	0.977
2011-2015	0.792	0.899	0.999	0.978	0.967	0.978	0.998	0.977
2012-2016	0.919	0.955	0.501	0.815	0.891	0.969	0.269	0.75
2013-2017	0.792	0.272	0.214	0.982	0.952	0.971	0.367	0.939
2014-2018	0.728	0.863	0.356	0.878	0.972	0.965	0.389	0.821
2015-2019	0.845	0.531	0.132	0.418	0.111	0.802	0.356	0.871
2016-2020	0.445	0.923	0.517	0.589	0.008	0.902	0.136	0.856

The diagnostic test is presented in table 5 for DOW. The results reveal no evidence of serial correlation since the probabilities of Q statistics is higher than the 5% significant level. Heteroscedasticity test is implemented in establishing a constant variance of the homoscedasticity of error terms of the fitted GARCH models. F-statistics probability values (P-Value) are greater than 0.05; thus, the ARCH (1) tests show that there is no sign of conditional heteroscedasticity in the residuals.

5. Results and Discussion

Recent empirical studies on stock market efficiency and calendar anomalies portray a transition from erstwhile absolute efficiency to recent adaptive efficiency framework. As a result of their unique features and limited studies on AMH, the current study explores changing day-of-the-week effects in frontier

markets. The findings suggest that the DOW anomalies conform to the time-changing behaviour. This study confirms weekend effect reported by Onyuma (2009) in Kenya but also shows that the effects changes over time. This study shows that DOW is not persistent in BRVM, contradicting Tachiwou (2010) who reported DOW effect in absolute form Côte d'Ivoire. Our findings support Alagidede and Panagiotidis (2009) who found absence of DOW effects in Ghana as well as Kalidas, Mbululu and Chipeta (2013) who showed that South Africa, Zambia, Botswana, Nigeria, and Morocco displayed changing DOW effect using sub-period analyses.

The lack of support for day-of-the-week effects in Ghana and BRVM, a regional stock exchange serving Benin, Burkina Faso, Guinea Bissau, Cote d'Ivoire, Mali, Niger, Senegal and Togo, could be traceable to limited liquidity and other features of frontier markets. In addition, the absence of weekend effect suggests that short selling activities, a well-known reason for weekend effect, is limited in Ghana and BRVM. Short sheller want to cover their short position in order to avoid the exposure to risks engendered by new information on non-trading days (Saturday and Sunday), thereby driving up prices and returns on Friday. Our findings also imply limited activities of the institutional investors who usually practice short shelling. Furthermore, it can be deduced that mood have no significant effect on investors in Ghana and BRVM because where weekend effects are found, they are sometimes attributed to investors' optimism on Friday and pessimism on Monday.

The changing behaviour shown in Kenya and Botswana supports the adaptive market hypotheses and similar studies such as Obalade and Muzindutsi (2019a&b). Particularly, the findings portend positive Wednesday and Thursday effects in Kenya as well as positive Thursday and Friday effects in Botswana during certain period or windows. This suggests that possible argument for DOW effects, such as the investors' psychology (mood) and short selling might hold in Kenya and Botswana, albeit in a changing version.

6. Conclusion

The study used rolling GARCH models to estimate Ghana stock exchange (GSE), Nairobi securities exchange (NSE), Botswana stock exchange (BSE) and Bourse Régionale des Valeurs Mobilières (BRVM) stock indices return for 2000:1-2020:7 periods. On the one hand, the presence of DOW effects in the Ghana and Bourse Régionale des Valeurs Mobilières stock market cannot be substantiated given its absence in virtually all the windows. On the other hand, the DOW effects

are adaptive in Nairobi and Botswana stock exchanges. The observed DOW effect in Kenya and Botswana stock markets is not an all-or-nothing phenomenon. From these findings, this study concludes that changing DOW effect in the AMH context cannot be generalised in African frontier markets. From the AMH viewpoint, the investors must be able to determine the market conditions that generate this effect for them to be exploitable as it is not present all the time. Hence, the investors must take changing behaviour into consideration in these markets. Besides, the fact that most of the windows are not associated with significant DOW effect suggests that the anomalies must be treated with cautions in in Bourse Régionale des Valeurs Mobilières and Ghana as not more than four of the 17 windows display DOW effects, casting doubt on the persistence and exploitability of the calendar effects in these markets. BRVM is a regional stock exchange serving Benin, Burkina Faso, Guinea Bissau, Cote d'Ivoire, Mali, Niger, Senegal and Togo; hence day-of-the-week effects in most frontier African markets cannot be validated. There is a need to examine the profitability of adaptive trading strategy for the DOW effect in Botswana and Kenya which is outside the scope of this study.

References

Abounoori, E., Shahrazi, M., & Rasekhi, S. (2012). An investigation of forex market efficiency based on detrended fluctuation analysis: A case study of Iran. *Physica A: Statistical Mechanics and its Applications*, 391(11), 3170-3179.

Abrahamson, A., & Creutz, S. (2018). Stock market anomalies: the day of the week effect. [online], Available at: https://diva-portal.org/smash/get/diva2:1212006/fulltext01.pdf. [Accessed on 03 March 2020].

Adaramola, A.O., & Adekanmbi, K.O. (2020). Day-of-the-week effect in Nigerian Stock Exchange: Adaptive Market Hypothesis Approach. *Investment Management and Financial Innovations*, 17(1), 97-108.

Akhter, T., & Yong, O. (2019). Adaptive market hypothesis and momentum effect: Evidence from Dhaka stock exchange. *Cogent Economics & Finance*, 7(1).

Alagidede, P., & Panagiotidis, T. (2009). Calendar anomalies in the Ghana stock exchange. *Journal of Emerging Market Finance*, 8(1), 1-23.

Borges, M.R. (2009). Calendar Effects in Stock Markets: Critique of Previous Methodologies and Recent Evidence in European Countries. *Research Unit on Complexity and Economics*, WP 37/2009/DE/UECE.

Brooks, C. (2019). *Introductory economics for finance*. Cambridge University Press: United Kingdom.

Brooks, C., & Persand, G. (2001). Seasonality in Southeast Asian stock markets: Some new Evidence on day-of-the-week effects. *Applied Economics Letters*, 8(3), 155-158.

Charfeddine, L., Khediri, K.B., Aye, G.C. & Gupta, R. (2018). Time-varying efficiency of developed and emerging bond markets: Evidence from long-spans of historical data. *Physica A: Statistical Mechanics and its Applications*, 505(C), 632–647.

Chatzitzisi, E., Fountas, S., & Panagiotidis, T. (2019). Another look at calendar anomalies. *The Quarterly Review of Economics and Finance*, 31, 1-34.

Fama, E.F. (1970). Random walks in stock market prices. *Journal of Finance*, 25(2), 383–417.

FTSE, Russell. (2014). *Frontier markets accessing the next frontier*. London Stock Exchange Group plc: London.

FTSE, Russell. (2019). *FTSE classification of equity markets*. London Stock Exchange Group plc: London.

Ferrouhi, E.M., Kharbouch, O., Aguenaou, S., & Naeem, M. (2021). Calendar anomalies in African stock markets. *Cogent Economics & Finance*, 9(1), 1-17, 1978639, DOI: 10.1080/23322039.2021.1978639

Ghazani, M.M., & Ebrahimi, S.B. (2019). Testing the adaptive market hypothesis as an evolutionary perspective on market efficiency: Evidence from the crude oil prices. *Finance Research Letter*, 30, 60-68.

Gökbulut, R.I., & Pekkaya, M. (2014). Estimating and forecasting volatility of financial markets using asymmetric GARCH models: An application on Turkish financial markets. *International Journal of Economics and Finance*, 6(4), 23-35.

Kalidas, S., Mbululu, D., & Chipeta, C. (2013). Changing Patterns in The Day-Of-The-Week Effects in African Stock Markets. *International Business and Economic Research Journal*, 12(10), 1157-1174.

Khursheed, A., Naheem, M., Ahmed, S., & Mustafa, F. (2020). Adaptive market hypothesis: An empirical analysis of time–varying market efficiency of cryptocurrencies. *Cogent Economics and Finance*, 8(1), 1-15. DOI: 10.1080/23322039.2020.1719574

Konstantinidis, A., Katarachia, A., Borovas, G., & Voutsa, M.E. (2012). From efficient market hypothesis to behavioural finance: Can behavioural finance be the new dominant model for investing? *Scientific Bullentin – Economic Sciences*, 11(2), 16-26.

Lakonishok, J., & Maberly, E. (1990). The weekend effect: Trading patterns of individual and institutional Investors. *Journal of Finance*, 45(1), 231-243.

Latif, M., Arshad, S., Fatima, M., & Farooq, S. (2011) Market efficiency, market anomalies, causes, evidences, and some behavioural aspects of market anomalies. *Research Journal of Finance and Accounting*, 2(9), 1-13.

Lo, A.W. (2004). The adaptive market hypothesis. *Journal of Portfolio Management*, 30(5), 15-29.

Lo, A.W. (2005). Reconciling efficient markets with behavioral finance: The adaptive market hypothesis. *Journal of Investment Consulting*, 7(2), 21-44.

Lo, A.W. (2017). *Adaptive markets: Financial Evolution at the Speed of Thought*. Princeton University Press: New Jersey.

Malkiel, B.G. (2003). The efficient market hypothesis and its critics. *Journal of Economic Perspective*, 17(1), 59-82.

Mazviona, B.W., Mah, G., Choga, I. (2021). Panel Analysis of Calendar Anomalies in the South African Stock Market. *AUDOE*, 17(3), 250-273.

Obalade, A.A. (2019). Adaptive Market Hypothesis and Calendar Anomalies in Selected African Stock Markets (Doctoral dissertation), University of KwaZulu-Natal, Durban, South Africa.

Obalade, A.A., & Muzindutsi, P.F. (2019a). Time-varying Calendar Anomaly in African Stock Markets: Application of GARCH Models. *Journal of Global Business and Technology*, 15(2), 1-16.

Obalade, A.A., & Muzindutsi P.F. (2019b). Calendar anomalies, market Regimes, and the adaptive market hypothesis in African stock markets. *Central European Management Journal*, 27(4), 71-94.

Onyuma, O.S. (2009). Day-of-the-week and month-of-the-year effect on the Kenyan stock market returns. *Eastern Africa Social Science Research Review*, 25(2), 53-74.

Pandey, F., & Samanta, A. (2016). An empirical analysis of January effect–evidence from Indian Market. *International Journal of Innovative Research and Development*, 5(7), 187-197.

Paradza, A. (2015). The efficient market hypothesis in developing economies: An investigation of the Monday effect and the January effect on the Zimbabwe stock exchange post of multi-currency system (2009-2013): The GARCH approach analysis (Master's Thesis), Wits Business School, South Africa.

Ramirez, S.C., Arellano, P.L., & Rojas, O. (2015). Adaptive market efficiency of agricultural commodity futures contracts. *Contaduría y Administración*, 60, 389-401.

Rosini, L., & Shenai, V. (2020). Stock returns and Calendar Anomalies on the London Stok Exchange in the dynamic perspective of the adaptive market hypothesis: A study of FTSE 100& FTSE 250 indices over a ten-year periods. *Quantitative Finance and Economics*, 4(1), 121-141.

Tachiwou, A.M. (2010). Day-of-the-week-Effects in West African regional stock market. International Journal of Economics and Finance, 2(4), 167-173.

Urquhart, A., & McGroarty, F. (2014). Calendar effects, market conditions and the Adaptive Market Hypothesis: Evidence from long-run U.S. data. *International Review of Financial Analysis*, 35, 154-166.

Wong, W., Agarwal, A., & Wong, N. (2006). The Disappearing Calendar Anomalies in the Singapore Stock Market. *Labore Journal of Economics*, 11(2), 123-139.