RETURNS, TRADING VOLUME AND VOLATILITY IN THE STOCK MARKET OF MAURITIUS

B. M. Nowbutsing[1]
University of Mauritius, Republic of Mauritius
Email: b.nowbutsing@uom.ac.mu

S. Naregadu[2]
Ernst and Young, Republic of Mauritius.
Email: sunju.naregadu@mu.ey.com

ABSTRACT
This paper examines the trading volume and return and volatility relationship on the Stock Exchange of Mauritius (SEM). Thirty-six stocks, six constructed indices and the SEMDEX has been used to test the validity of the Mixture of Distributions Hypothesis where volume is taken as a proxy for the rate of informal arrival. To achieve our objectives several versions of the Autoregressive Conditional Heteroscedasticity (hereafter ARCH) family is adopted namely the simple ARCH model, GARCH and GJR-TGARCH. Analysis has also been done to include a risk component in the models by using ARCH-in-mean models. Further, two conditional mean equations, the random walk and the AR (1) have been employed. Very weak evidence of a positive relationship between trading volume and volatility has been found, therefore support of the Mixture-of-Distributions hypothesis and the Sequential Information Arrival hypothesis cannot be found on the SEM.

Key Words: Volatility, ARCH, GARCH, GJR-TGARCH

JEL: G14, G15

[1] B. M. Nowbutsing holds a PhD. degree in Economics and is with the Department of Economics and Statistics, Faculty of Social Studies and Humanities, University of Mauritius, Reduit, Republic of Mauritius. Telephone: (00230) 403 7712.
[2] S. Naregadu holds a B.Sc (Hons) degree in Economics and Finance and is with Ernst and Young, Level 20, Newton Tower, Sir William Newton Street, Port Louis, Republic of Mauritius, Telephone (00230) 2024777.

I. INTRODUCTION

An understanding of the relationship between returns, volatility and volume is crucial for the appreciation of the microstructure of financial markets. It helps to comprehend the role of information in the price formation of stocks, with volume and volatility providing measures of significance of information reflected in the market. It might eventually lead to better volatility forecasting, further exploration of this relation is worth pursuing. Granger and Poon (2003) comment '*the volume-volatility research may lead to a new and better way for modeling returns distributions*'. In the light of these arguments, it will be instructive to examine the returns, volatility and trading volume relationships.

Market folklore suggests that trading volume is positively related to stock return volatility. In the literature, the informational content of volume has been analyzed through two main informational hypotheses namely the Mixture of Distributions Hypothesis and the Sequential Arrival of Information Hypothesis. Researchers found relationships running from returns to volume and vice-versa in stock markets. Irrespective of the approach, the consensus in the volume-volatility literature to date is that a strong link exists between contemporaneous trading volume and conditional volatility (Girard and Biswas 2007). This goes against the weak form of the Efficient Market Hypothesis of Fama (1965) which says that abnormal returns cannot be made by using past information, which trading volume forms part of. However, support is found among chartists and technical analysts who rely on patterns of prices, returns and trading volume to devise their trading strategies.

This paper analyse the relationship between return, volatility and trading volume using data from the Stock Market of Mauritius (SEM). It can be argued that an increase in price induce investors to trade more, thereby increasing trading volume. Conversely, we can hypothesise that an increase in trading volume can lead to an increase in price. Such a study has never been carried out on the Stock Exchange of Mauritius (hereafter SEM). The analysis has been done using 36 listed companies on the official market, industry-wise and as the market as a whole. To achieve our objectives several versions of the Autoregressive Conditional Heteroscedasticity (hereafter ARCH) family is adopted namely the simple ARCH model, GARCH and GJR-TGARCH. Analysis has also been done to include a risk component in the models by using ARCH-in-mean models. Further, two conditional mean equations, the random walk and the AR (1) have been employed.

II. A BRIEF LITERATURE REVIEW

We concentrate on the informational models such as Mixture-of-Distributions Hypothesis (MDH) and the Sequential Flow of Information Hypothesis (SIAH). The MDH was pioneered by Clark (1973) and was later extended by Epps and Epps (1976), Tauchen and Pitts (1983), Lamoureux and Lastrapes (1990) and Andersen (1996). It implies strong positive contemporaneous but no causal linkage between return variability and trading volume, whereas returns levels and trading volume features no interactions. It shows that the time series of market returns is not drawn from a single probability distribution but rather from a mixture of conditional distributions with varying degrees of efficiency in generating the expected return Girard and Biswas (2007).

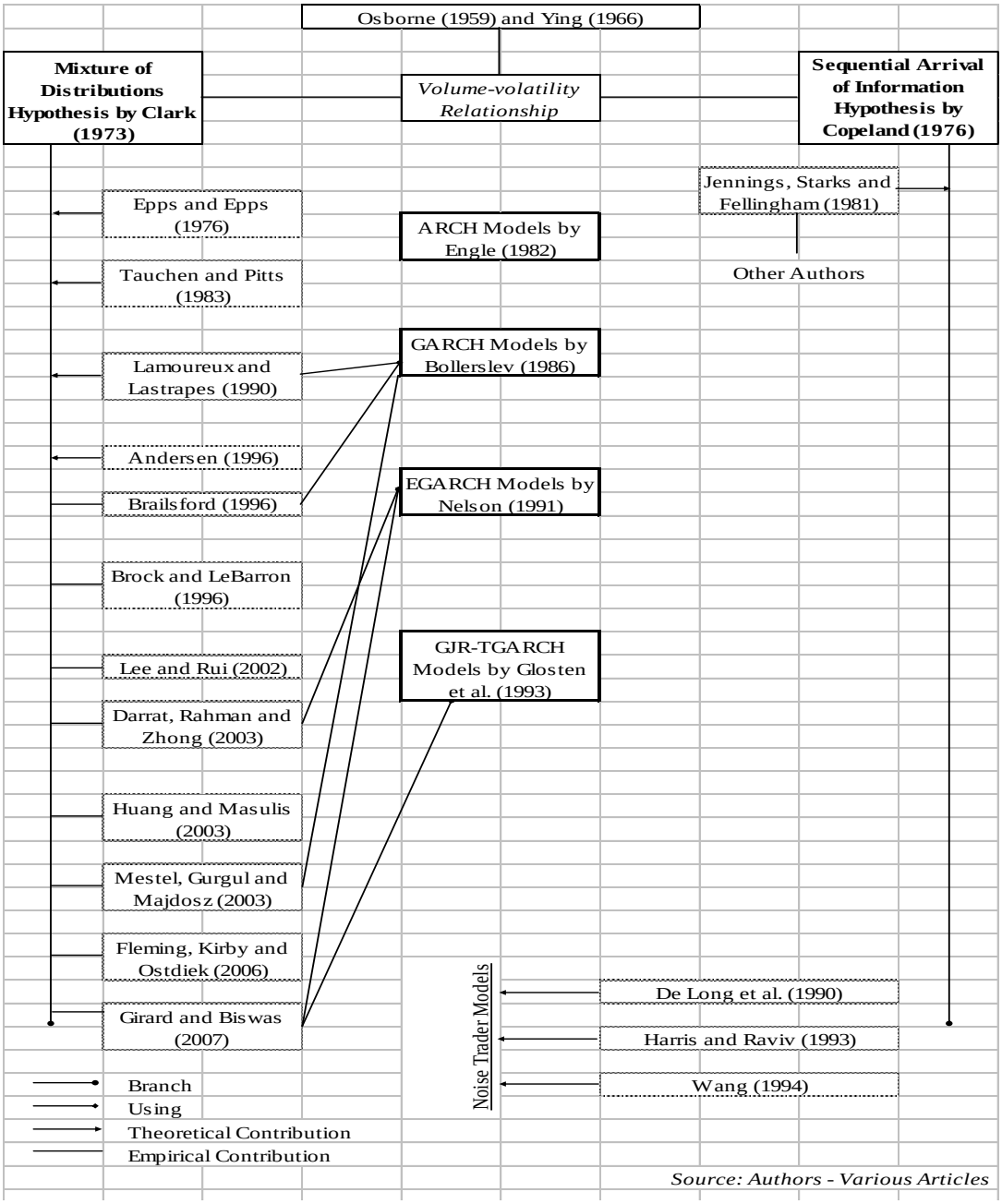
Stock returns and trading volume are related due to their joint dependence on the rate of information flow called the underlying common mixing variable. The model suggests using volume data as a proxy for this subordinated stochastic (information) process. This implies that price and volume change simultaneously in response to new information. As such, the shift to a new equilibrium is immediate and there will be no intermediate partial equilibrium. This hypothesis has also been used to explain the presence of Autoregressive Conditional Heteroscedasticity (ARCH) effects.

On the other hand, the SIAH find its roots in the work of Copeland (1976) and Jennings, Starks and Fellingham (1981). One important implication of this model is the existence of positive contemporaneous as well as causal relations between price volatilities and trading activities. Unlike the MDH, the SIAH assumes that new information is disseminated sequentially to traders, and informed traders cannot infer the presence of informed traders perfectly. Informed traders take positions and adjust their portfolios accordingly, resulting in a series of sequential equilibria before a final equilibrium is attained. This sequential dissemination of information from trader to trader is correlated with the number of transactions. Consequently, new arrival of information to the market results not only in price movements but also a rise in trading volume. Further, a rise in information shocks generates increases in both trading volume and price movements.

Figure I show the major contributions by various authors, both empirically and theoretically, over the years following the development of ARCH class of models. In the model of Clark (1973), daily price change is the sum of a random number of within-day price changes. The variance of the daily price change is thus a random variable with a mean proportional to the mean number of daily transactions. He postulated that transaction volume is

related positively to the variability of price change as result of the positive relationship between volume and within-day transactions.

Figure 1: Theoretical and Empirical Contribution



It is known that the ARCH process has been shown to provide a good fit for many financial time series data. An appealing explanation for the presence of ARCH is based upon the hypothesis that daily returns are generated by a mixture of distributions, in which the rate of information arrival is the stochastic mixing variable. The ARCH process might capture the time series properties of this mixing variable. Lamoureux and Lastrapes (1990) examine the validity of this explanation for 20 daily US stocks. Empirically, they exploited the implication of the mixture model that the variance of daily price is heteroscedastic, i.e. positively related to the rate of information arrival. They found that the ARCH effect disappeared when volume is included as an explanatory variable in the conditional variance equation.

Within the MDH, other contributors include Brailsford (1996); Brock and LeBarron (1996); Darrat, Rahman and Zhong (2003); Lee and Rui (2002); Huang and Masulis (2003); Mestel, Gurgul and Majdosz (2003), Fleming, Kirby and Ostdiek (2006); Girard and Biswas (2007) among others.

Within the SIAH, Jennings, Starks and Fellingham (1981), show that (generally) when the trader is a pessimist, the trading volume is less than when the trader is an optimist. Since prices decrease with a pessimistic seller and increase with an optimistic buyer, it follows that volume is low when prices decrease and high when prices increase. The development of the above-mentioned model centers on differences in the costs of taking various market positions. Short positions are assumed more costly than long positions. In such a market, investors with short positions would be less responsive to price changes.

III. THE DATA

The data set comprises of daily closing prices and trading volume for stocks of 36 companies traded on SEM and is available on http://www.abrl.net. The list of companies is provided in the Appendix, Table A.1. The sample period is from the January 3, 2002 to December 31, 2008, making up 1755 observations.

The main market index on the official market is the SEMDEX. The SEMDEX is a broad-based index of prices of all listed shares and each stock is weighted according to its share in the total market capitalization.

$$SEMDEX = \frac{Current\ Mkt\ Value\ of\ all\ listed\ shares}{Base\ Mkt\ Value\ of\ all\ listed\ shares} x\,100$$

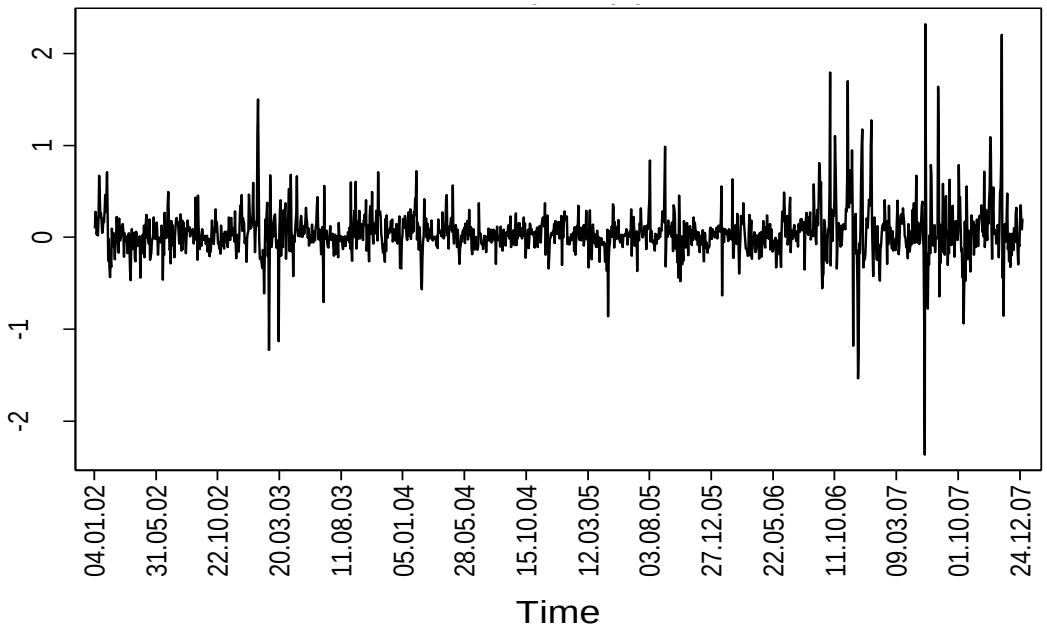
Thus, changes in the SEMDEX are dominated by changes in the prices of shares with relatively higher market capitalization. In its computation, the current value of SEMDEX is expressed in relation to a base period, which is

chosen as July 5, 1989, with an index value of 100. The base value of listed shares is adjusted to reflect new listings, rights issues and other capital restructurings. Daily returns are used in the empirical investigations. Market returns are calculated as follows:

$$RSEMDEX_t = LOG(SEMDEX_t / SEMDEX_{t-1});$$

Where $RSEMDEX_t$ =Return on *SEMDEX* at time *t*.

Figure 2: Returns on SEMDEX



In the SEM, companies are grouped into six main sectors namely Banking and Insurance, Commerce, Industry, Investment, Leisure and Hotels and Sugar Sector. We constructed indices for the six sectors. The same principle behind the SEMDEX has been kept to calculate these indices, except that the base date has changed to the January 3, 2002.

The leisure and hotels industry consisted of three companies namely Automatic Systems Ltd (ASL), New Mauritius Hotels Ltd (NMH) and Sun Resorts Ltd (SUN). To calculate the index of the Leisure and Hotel sector (HOTEX), we adopted the following formula.

$$HOTEX_t = \frac{(PASL_t \ x\ No.of\ shares_t) + (PNMHL_t \ x\ No.of\ shares_t) + (PSUN_t \ x\ No.of\ shares_t)}{(PASL_b \ x\ No.of\ shares_b) + (PNMHL_b \ x\ No.of\ shares_b) + (PSUN_b \ x\ No.of\ shares_b)} *100$$

where $PASL_t$ denotes price of Automatics Systems Ltd at time *t*, $PNMHL_t$ denotes price of New Mauritius Hotels at time *t* and $PSUN_t$ denotes price of Sun Resorts Ltd at time *t*. The subscripts b price of the company at the base time, that is, on January 3, 2002. Likewise, the 5 other indices were constructed:

BANKEX = Banking and Insurance Sector
COMMEX = Commerce
INDUSTEX = Industry
INVESTEX = Investment
SUGEX = Sugar Sector

To calculate trading volume in a sector, volume of shares transacted of firms in that particular industry were simply summed. Adjustments were done in case of corporate actions such as rights issues, bonus issues and share buy-back programmes.

Likewise, individual stock returns are computed by:

$$RCOMPANY_t = LOG(PCOMPANY_t / PCOMPANY_{t-1})$$

Where $RCOMPANY_t$ =Return on a company's stock at time t.

$PCOMPANY$ = Prices of a company's stock at time t and t-1 respectively.

For e.g. the formula to calculate return on *ASL* stocks is:

$$RASL_t = LOG(PASL_t / PASL_{t-1})$$

IV. EMPIRICAL METHODOLOGY

Two models have been chosen for the mean equation. Firstly, r_t is expressed as a random walk,

$$r_t = \mu + \varepsilon_t$$

where r_t is the realized return of the stock, expressed as a random walk with ε_t of mean zero and conditional variance σ_t^2. Secondly,

$$r_t = \mu + ar_{t-1} + \varepsilon_t$$

The ar_{t-1} term allows for possibility of autocorrelation of order 1, as argued by Scholes and Williams (1977) as well as Lo and MacKinlay (1988). This can be induced by discontinuous trading in the stocks making up an index. The Scholes and Williams model suggests an MA(1) form for index returns, while the Lo and MacKinlay model suggests an AR(1) form, which

we adopt. As a practical matter, there is little difference between an AR(1) and an MA(1) when the AR and MA coefficients are small and the autocorrelations at lag one are equal, since the higher-order autocorrelations die out very quickly in the AR model. As Lo and MacKinlay noted, however, such simple models do not adequately explain the short-term autocorrelation behavior of the market indices, and no fully satisfactory model yet exists[3].

Most random walk tests, particularly on emerging stock markets, remain inconclusive, e.g. Osei (2002). This is because thin trading presumably induces positive serial correlation in index returns and slightly negative first order autocorrelation in individual security returns, based on observed on observed transaction prices Atchison et al. (1987), Ekechi (1989), for example found that for the NSE stocks, the prices of infrequently traded shares deviate more from the random walk than the prices of the more actively traded shares. It is also believed that the serial correlation, (especially higher order serial correlation) evident on emerging markets is symptomatic of infrequent trading and thus the slow adjustment of prices to information e.g. Bekaert and Harvey (2002). Miambo, Biekpe and Smit (2003) found a positive relationship between the duration of non-trading and the return magnitudes and took this to suggest that returns following a period of non-trading tend to reflect information arriving in the market over a period longer than a day. Thin trading, does not explain all the observed autocorrelation. Part of it is attributed to other factors or inefficiencies in the pricing process.

In addition, when the conditional variance term was added in the mean equations:

$$r_t = \mu + \lambda\sqrt{h_t} + \varepsilon_t$$

$$r_t = \mu + ar_{t-1} + \lambda\sqrt{h_t} + \varepsilon_t$$

We chose not to detrend volume because no major happenings occurred so that the number of traders increased on the SEM. There was no clear indication that the number of traders increased on the stock exchange of Mauritius during the 2002-2007 period.

To verify the main hypothesis, an unrestricted GARCH model (with trading volume) was compared against a restricted GARCH model (without trading volume). Thus, we follow the same methodology of Lamoureux and Lastrapes (1990).

For both mean equations, the unrestricted and restricted versions of the conditional variances were:

[3] Stated in Nelson (1991).

GARCH (1,1):

Unrestricted: $h_t = \omega + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + vol_t$

Restricted: $h_t = \omega + \alpha \varepsilon^2_{t-1} + \beta h_{t-1}$

GJR-TGARCH (1,1):

Unrestricted: $h_t = \omega + \alpha_1 \varepsilon_{t-1} + \alpha_2 \varepsilon^2_{t-1} D^-_{t-1} + \beta h_{t-1} + vol_t$

Restricted: $h_t = \omega + \alpha_1 \varepsilon_{t-1} + \alpha_2 \varepsilon^2_{t-1} D^-_{t-1} + \beta h_{t-1}$

The main variation in the models is that we have augmented the conditional variances with contemporaneous trading volume. Its significance will indicate its influence on volatility.

V. ECONOMETRIC ANALYSIS AND FINDINGS

Our econometric analysis follows the following steps: (1) testing for stationarity (2) autocorrelation (3) testing for the ARCH effect (4) analyzing the volume – volatility effect in the simple ARCH – GARCH setting and (5) analyzing the volume – volatility effect in the asymmetric GARCH.

Table 1: Augmented Dickey Fuller Unit Root Test for Individual Daily Indices, Return on Indices and Volume of Indices

Variable	test statistic*	Variable	test statistic*	Variable	test statistic*
SEMDEX	3.264 (1.000)	BANKEX	2.933 (1.000)	COMMEX	1.220 (0.9961)
RSEMDEX	-23.196 (0.000)	RBANKEX	-24.767 (0.000)	RCOMMEX	-24.965 (0.000)
VOLALL	-25.955 (0.000)	VOLBANKEX	-27.152 (0.000)	VOLCOMMEX	-27.473 (0.000)
INDUSTEX	-0.725 (0.8401)	INVESTEX	0.012 (0.9595)	HOTEL	3.864 (1.000)
RINDUSTEX	-27.278 (0.000)	RINVESTEX	-22.635 (0.000)	RHOTEX	-24.411 (0.000)
VOLINDUSTEX	-26.294 (0.000)	VOLINVESTEX	-26.913 (0.000)	VOLHOTEX	-25.720 (0.000)
SUGEX	-0.367 (0.9155)				
RSUGEX	-24.613 (0.000)				
VOLSUGEX	-26.232 (0.000)				

1% critical value: -3.430; 5% critical value: -2.860; 10% critical value: -2.570
** figures in brackets are Mackinon approximate p-value for Z (t)*

A. Testing for Stationary

To check for stationarity in prices, returns and volume, a *confirmatory data analysis* is adopted. This is the joint use of unit-root tests, the Augmented Dickey-Fuller (ADF) test /Phillips-Peron (PP) test and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test.

As can be deduced from Table 1, most of the variables are stationary at 1% critical value. In fact, only six variables out of 21 are not stationary. Referring to table III, the KPSS test at 1% critical value, for return on indices has not rejected the H_0, that is return on indices are stationary. This tally with the results of the ADF test.

Table 2: KPSS Test for Return on Indices

	RSEMDEX	RBANKEX	RCOMMEX	RINDUSTEX	RINVESTEX	RHOTEX	RSUGEX
Lag order	Test statistic	Test statistic	Test statistic	Test statistic	Test statistic	Test statistic	Test statistic
0	0.15	0.0773	0.0717	0.115	0.101	0.139	0.174
1	0.117	0.0665	0.065	0.109	0.0818	0.122	0.147
2	0.105	0.0623	0.0613	0.109	0.0729	0.114	0.137
3	0.0982	0.0602	0.0582	0.114	0.0681	0.11	0.134
4	0.0946	0.0594	0.0556	0.117	0.0651	0.109	0.132
5	0.0926	0.0593	0.0538	0.119	0.0636	0.109	0.13
6	0.0917	0.0603	0.0528	0.117	0.0629	0.109	0.127
7	0.091	0.0612	0.0519	0.116	0.0628	0.11	0.123
8	0.0897	0.0619	0.0512	0.115	0.0628	0.109	0.119
9	0.0883	0.0623	0.0503	0.114	0.0635	0.109	0.115
10	0.0875	0.0624	0.0497	0.114	0.0641	0.108	0.113
11	0.0871	0.0624	0.0494	0.114	0.0652	0.109	0.112
12	0.0867	0.0622	0.0491	0.115	0.0664	0.109	0.111
13	0.0866	0.0621	0.0492	0.116	0.0677	0.11	0.11
14	0.0867	0.0618	0.0495	0.116	0.0689	0.111	0.109
15	0.0866	0.0614	0.0499	0.117	0.0697	0.111	0.108
16	0.0867	0.0612	0.0503	0.118	0.0702	0.112	0.107
17	0.0869	0.0613	0.0505	0.119	0.0707	0.113	0.107
18	0.0873	0.0617	0.051	0.12	0.0713	0.113	0.106
19	0.0877	0.062	0.0514	0.121	0.0717	0.114	0.106
20	0.088	0.0622	0.0518	0.122	0.0723	0.114	0.106
21	0.0882	0.0625	0.0521	0.124	0.0729	0.113	0.106
22	0.0885	0.0627	0.0526	0.125	0.0735	0.112	0.106
23	0.0888	0.0629	0.053	0.127	0.0739	0.112	0.106

Critical value for H_0: rsemdex is trend stationary
10%:0.119; 5%: 0.146; 1%: 0.216

The KPSS has rejected H0 up-to the 20th for most of the indices (Table 2). This confirms that the indices in their level form are non-stationary. This is the essence of the CDA test - to confirm non-stationarity when the ADF test is unable to do it.

Table 3: KPSS Test on Indices

	SEMDEX	BANKEX	COMMEX	INDUSTEX	INVESTEX	HOTEX	SUGEX
Lag order	Test statistic	Test statistic	Test statistic	Test statistic	Test statistic	Test statistic	Test statistic
0	24.2	22.2	13.5	15.9	19	22.9	22.1
1	12.1	11.2	6.78	7.98	9.51	11.5	11.1
2	8.11	7.47	4.53	5.33	6.35	7.67	7.38
3	6.09	5.62	3.41	4	4.77	5.77	5.54
4	4.88	4.51	2.73	3.21	3.82	4.63	4.44
5	4.08	3.77	2.28	2.67	3.19	3.87	3.7
6	3.5	3.25	1.96	2.3	2.74	3.32	3.17
7	3.07	2.85	1.72	2.01	2.4	2.92	2.78
8	2.74	2.54	1.54	1.79	2.14	2.6	2.47
9	2.47	2.29	1.39	1.61	1.93	2.34	2.23
10	2.25	2.09	1.26	1.47	1.76	2.14	2.03
11	2.07	1.92	1.16	1.35	1.61	1.96	1.86
12	1.91	1.78	1.08	1.24	1.49	1.82	1.72
13	1.78	1.66	1	1.16	1.39	1.69	1.6
14	1.66	1.55	0.938	1.08	1.3	1.58	1.49
15	1.56	1.46	0.882	1.01	1.22	1.49	1.4
16	1.47	1.38	0.833	0.956	1.15	1.4	1.32
17	1.39	1.31	0.789	0.904	1.09	1.33	1.25
18	1.32	1.24	0.75	0.858	1.03	1.26	1.18
19	1.26	1.18	0.715	0.816	0.981	1.2	1.13
20	1.2	1.13	0.683	0.778	0.936	1.15	1.07
21	1.15	1.08	0.654	0.743	0.895	1.1	1.03
22	1.1	1.04	0.627	0.712	0.858	1.05	0.982
23	1.06	0.999	0.603	0.683	0.823	1.01	0.943

Critical value for H_0: rsemdex is trend stationary
10%:0.119; 5%: 0.146; 1%: 0.216

B. Autocorrelation

Before choosing the mean equation, we shall carry out the autocorrelation test on SEMDEX returns which will confirm which type of model we should use. Stock returns over time should be independent of one another because new information is transmitted to the market in a random, independent fashion,

and security prices adjust rapidly to such new information. Autocorrelation tests of independence measure the significance of positive or negative correlation of returns over time. If the correlations of daily stock returns are insignificant for the different lags, these may indicate weak-form market efficiency. Our autocorrelation test reveals that SEMDEX is autocorrelated of order 1.

C. Testing the ARCH Effect

Table 4 shows the ARCH-LM test for arch effects in SEMDEX over the sample period. Both the F-statistic and the LM-statistic are very significant, suggesting the presence of ARCH in the SEMDEX returns and confirming the results of the graphical methods employed above.

Table 4: ARCH-LM Test for returns on SEMDEX

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.042074	0.007911	5.31844	0.0000
RESID^2(-1)	0.428485	0.025869	16.5638	0.0000
RESID^2(-2)	-0.110413	0.028145	-3.92303	0.0001
RESID^2(-3)	0.070838	0.02823	2.509272	0.0122
RESID^2(-4)	-0.006237	0.028145	-0.2216	0.8247
RESID^2(-5)	0.029793	0.025869	1.151679	0.2496
R-squared	0.164277			
Adjusted R-squared	0.161478			
F-Statistic	58.69534			
Prob(F-Statistics)	0.000000			

D. Tests for use of Asymmetric Models

We have carried out diagnostic tests for asymmetries in volatility, known as the Sign and Size Bias tests, which were introduced by Engle and Ng (1993), to substantiate the use of GJR-TGARCH models. Our results (not shown) substantiate the use of the GJR-TGARCH model.

E. Simple GARCH models

Table 5 shows the result for the simple GARCH model, results for the restricted model are reported in bold. For both the unrestricted and restricted models, the ARCH and GARCH coefficients were highly significant, except for INVESTEX for which the GARCH terms were insignificant. Out of the six indices, four displayed a positive value for the volume, which is the expected sign. It should be noted that the coefficients of volume are very small in value and only two were significant at 1% level. Looking at volatility persistence, it can be seen that when both the restricted and unrestricted equations were completed, the sum of $\alpha + \beta$ was in the majority of cases less than one, indicating that shocks do not take too long to die in the equations. For HOTEX, the volatility persistence was greater than one; this indicates that the effect of shocks on volatility increases with time, which is quite improbable. In addition, the difference between the $\alpha + \beta$ for unrestricted and restricted equations was very small, confirming that volume indeed contribution to volatility is almost null. The log-likelihood, which changed only marginally when volume was, added in the conditional variance equations, also confirms the above results.

Table 5: Volume-Augmented GARCH (1, 1) and GARCH (1,1) – Indices

Stock	Constant	Vol	Constant	ARCH L1	GARCH L1	LL	Vol. Per
SEMDEX	0.0380*	1.64E-08	-3.9300*	0.5840*	0.2055*	173.725	0.790
	0.0381*		**0.0198***	**0.5841***	**0.2052***	**173.594**	**0.789**
BANKEX	0.0300*	8.77E-08*	-2.2000*	0.5277*	0.0395**	-792.846	0.567
	0.0301*		**0.1168***	**0.4793***	**0.0636***	**-817.526**	**0.543**
COMMEX	**0.0221***		**0.0246***	**0.3466***	**0.4638***	**-254.581**	**0.810**
INDUSTEX	0.0215*	-9.49E-08	-3.6975*	0.0985*	0.5881*	-166.039	0.687
	0.0215*		**0.0249***	**0.0991***	**0.5856***	**-166.085**	**0.685**
INVESTEX	0.0126	-3.55E-07*	-2.0659*	0.5154*	0.0048	-728.195	0.520
	0.0121		**0.1211***	**0.5012***	**0.0039**	**-730.059**	**0.505**
HOTEX	0.0191*	9.40E-07	-5.8558*	0.1580*	0.8478*	-465.03540	1.00580
	0.0193*		**0.0027***	**0.1577***	**0.8476***	**-465.352**	**1.005**
SUGEX	0.0049	1.41E-06	-3.1629*	0.1455*	0.6681*	-906.286	0.814
	0.0048		**0.0417***	**0.1443***	**0.6758***	**-907.104**	**0.820**

** indicates significance at 1%; ** indicates significance at 5%*

When the conditional variance was added in the mean equations, the unrestricted models showed that volume was insignificant (Table 6). The ARCHM was positive, except for INVESTEX, this indicates the positive premium which must be paid to investors for risk-taking. However, it was significant only for BANKEX and INVESTEX. Under this specification also, the $\alpha + \beta$ of HOTEX was above one, and INVESTEX joined it. Again, it was noted that the Log-likelihood changed negligible when volume was removed from the unrestricted model.

Table 6: Volume-Augmented GARCH (1, 1) – M and GARCH (1, 1) – M INDICES

Stock	Constant	ARCHM	Vol	Constant	ARCH L1	GARCH L1	LL	W	Chi2	Vol. Per
SEMDEX	**0.0355***	**0.0580**		**0.0198***	**0.5832***	**0.2066***	**173.762**	**0.35**	**0.55**	**0.7898**
BANKEX	**-0.0053**	**0.2044***		**0.1330***	**0.4809***	**-0.0317**	**-810.195**	**13.5**	**0**	**0.4492**
COMMEX	0.0080	0.1772	-1E-07	-3.6439*	0.3677*	0.4348*	-253.369	1.84	0.175	0.8025
	0.0084	**0.1730**		**0.0259***	**0.3653***	**0.4385***	**-253.567**	**1.76**	**0.19**	**0.8038**
INDUSTEX	**0.0479****	**-0.3683**		**0.0244***	**0.0950***	**0.5938***	**-165.582**	**2.03**	**0.15**	**0.6888**
INVESTEX	0.0010	0.0220	2E-07	-6.3139*	0.1689*	0.8641*	-457.863	0.22	0.64	1.033
HOTEX	0.0102	0.1092	-9E-07	-5.8795*	0.1584*	0.8480*	-463.145	2.57	0.109	1.0064
	0.0102	**0.1097**		**0.0027***	**0.1581***	**0.8479***	**-463.454**	**2.59**	**0.11**	**1.006**
SUGEX	-0.0393***	0.2445**	1E-06	-3.1160*	0.1495*	0.6536*	-903.128	5.7	0.017	0.8031
	-0.0382***	**0.2371****		**0.0435***	**0.1481***	**0.6631***	**-904.075**	**5.61**	**0.02**	**0.8112**

** indicates significance at 1%; **indicates significance at 5% and ***indicates significance at 10%*

Table 7: Volume Augmented AR (1) GARCH (1, 1) and AR (1) GARCH (1, 1) – INDICES

Stock	L1	Constant	Vol	Constant	ARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
SEMDEX	0.3052*	0.0265*	1E-08	-3.9982*	0.5029*	0.2562*	208.994	103.87	0	0.7591
	0.3052*	**0.0265***		**0.0185***	**0.5028***	**0.2560***	**208.906**	**103.83**	**0**	**0.7588**
BANKEX	**0.1931***	**0.0287***		**0.1154***	**0.3664***	**0.1046***	**-807.241**	**24.6**	**0**	**0.471**
COMMEX	0.2022*	0.0197*	-1E-07	-3.7186*	0.3502*	0.4596*	-239.105	56.03	0	0.8098
	0.2021*	**0.0198***		**0.0240***	**0.3473***	**0.4639***	**-239.229**	**56**	**0**	**0.8112**
INDUSTEX	0.1025*	0.0198**	-9E-08	-3.6808*	0.1017*	0.5784*	-161.935	7.04	0.008	0.6801
	0.1027*	**0.0198****		**0.0253***	**0.1022***	**0.5760***	**-161.972**	**7.04**	**0.008**	**0.6782**
INVESTEX	**0.1876***	**0.0135**		**0.1275***	**0.3597***	**-0.0017**	**-720.701**	**23.53**	**0**	**0.358**
HOTEX	0.1677*	0.0156**	-4E-06*	-5.4438*	0.1600*	0.8448*	-448.138	38.05	0	1.0048
	0.1684*	**0.0157****		**0.0027***	**0.1520***	**0.8521***	**-450.275**	**38.72**	**0**	**1.0041**
SUGEX	0.1198*	0.0053	1.36E-06	-3.2024*	0.1391*	0.6795*	900.823	9	0.0027	0.8186
	0.1204*	**0.0053**		**0.0402***	**0.1383***	**0.6860***	**-901.563**	**9.36**	**0.0022**	**0.8243**

* indicates significance at 1%; **indicates significance at 5% and ***indicates significance at 10%

When the conditional variance term was added in the AR (1) mean models (Table 8), the ARCHM term was positive, except in 3 cases, confirming the results of above. However, the number of times it was significant remain very low. The coefficient of volume was positive in 4 cases out of 6 but was statistically significant only in 1 case, for BANKEX. The log-likelihood behaved similar to what was previously noted, except for INVESTEX. There was a significant improvement in the LL when volume was included in the regression, this may be interpreted as an indication that volume influences volatility. But the coefficient of volume in the conditional variance model remained insignificant and the volatility persistence, expected to fall (as per Lamoureux and Lastrapes 1990), rose and hit beyond one. Overall, it can be concluded that with the no volume-volatility relationship exists on the SEM when using the constructed indices.

Table 8: Volume-Augmented AR (1) GARCH (1, 1)-M and AR (1) GARCH (1,1)-M-INDICES

Stock	L1	Constant	ARCHM	Vol	Constant	ARCH LI	GARCHL1	LL	W	Chi2	Vol. Per.
SEMDEX	0.3105*	0.0314*	-0.13136	1.11E-08	-3.9994	0.0544*	0.256*	209.571	114.26	0	0.7604
	0.3106*	**0.0316***	**-0.1336**		**0.0184***	**0.5041***	**0.2562***	**209.504**	**114.45**	**0**	**0.7603**
BANKEX	0.1084*	0.0009	0.1832*	6.42E-08*	-2.0945	0.4785*	-0.0192	-780.999	29.4	0	0.4593
	0.1249*	**-0.0106**	**0.2423***		**0.1336***	0.423*	-0.0207	-803.936	29.44	0	0.4023
COMMEX	0.2022*	0.0058	0.1922	-1.29E-07	3.6091*	0.3904*	0.4041*	-237.876	77.57	0	0.7945
	0.2044*	**0.0063**	**0.1867**		**0.0267***	**0.3862***	**0.4105***	**-238.064**	**76.52**	**0**	**0.7967**
INDUSTEX	**0.0995***	**0.0277**	**-0.1112**		**0.0249***	0.0100*	0.5833*	-161.932	6.7	0.035	0.5933
INVESTEX	0.1338*	0.0014	0.0280	1.52E-07	-6.3607*	**0.1583***	**0.8713***	**-450.085**	**26.9**	**0**	**1.0296**
	0.1802*	**0.0058**	**0.0536**		0.1262*	0.3601*	0.0066	-720.446	22.72	0	0.3667
HOTEX	0.1639*	0.0094	0.0803	-7.82E-07	-5.8972*	0.1523*	0.8525*	-448.965	41.06	0	1.0048
	0.1641*	**0.0094**	**0.0807**		**0.0027***	**0.1521***	**0.8524***	**-449.239**	**41.69**	**0**	**1.0045**
SUGEX	0.1147*	-0.0365	0.2350**	1.43E-06	-3.1589*	0.1430*	0.6663*	-898.129	13.3	0.0013	0.8093
	0.1155*	**-0.0354**	**0.2282****		**0.0419***	**0.1419***	**0.6742***	**-898.977**	**13.17**	**0.0014**	**0.8161**

** indicates significance at 1%; **indicates significance at 5% and ***indicates significance at 10%*

The company-wise regressions results are summarized below (detailed results are presented in the Appendix: Table A.3 – A.6):

Table 9: Summary of Regressions (Company Wise)

	GARCH	GARCH-M	AR(1)-GARCH	AR(1)-GARCH-M
No. of Reg.	19	18	22	15
Significant	9	12	14	10
Positive	12	11	16	11
Positive and Significant	7	8	11	9

For some companies, the relationship between volume and volatility is positive and significant. However, the small value of the coefficients (see Appendix) indicates that the nexus is weak. In some cases, the relationship is found to be negative and significant. Tauchen and Pitts (1983) examined this possibility. They suggest that both volatility and trading volume are determined by new information flow rates to the market, traders' response to new information arrival and the number of active traders. As a result, in thinly traded and highly volatile emerging markets, infrequent trading can cause prices to deviate from fundamentals.

The negative relationship between volume and volatility for the emerging markets is supported by the SIAH of Copeland (1976) and Jennings, Starks and Fellingham (1981). Indeed, it is more likely that in emerging markets, dissemination of information is asymmetric and initially only well-informed traders take positions. After a series of intermediate transient equilibria, a final equilibrium is reached resulting in lower volatility (Girard and Biswas 2007). It was noted that the coefficient of the GARCH term was negative. This is considered a violation of the non-negativity constraints of GARCH models.

F. Asymmetric GARCH models – GJR TGARCH

The most important feature here is the asymmetry in the modeling the distribution of returns, captured in the GJR-TGARCH by the coefficient of TGARCH L1 (Table 10).

Table 10: Volume – Augmented TGARCH (1, 1) and TGARCH (1, 1) - INDICES

Stock	Constant	Vol	Constant	ARCH L1	TGARCH L1	GARCH L1	LL	Vol. Per
SEMDEX	**0.0398***		**0.0201***	**0.4594***	**0.2136***	**0.2053***	**175.907**	**0.665**
BANKEX	0.0331* **0.0332***	8.51E-08*	-2.2637* **0.1104***	0.2705* **0.2468***	0.5206* **0.4674***	0.0699* **0.0901***	-784.330 **-809.420**	0.340 **0.337**
COMMEX	0.0259* **0.0260***	-1.02E-07	-3.8082* **0.0220***	0.1718* **0.1707***	0.2777* **0.2768***	0.5055* **0.5079***	-245.000 **-245.110**	0.677 **0.679**
INDUSTEX	**0.0255***		**0.0137***	**-0.0091****	**0.1331***	**0.7650***	**-145.479**	**0.756**
INVESTEX	0.0184* **0.0183***	1.45E-07	-5.8785* **0.0028***	0.0058 **0.0058**	0.2118* **0.2119***	0.8786* **0.8787***	-395.304 **-395.448**	0.884 **0.885**
HOTEX	0.0241* **0.0242***	-1.16E-06	-5.8122* **0.0029***	0.1066* **0.1064***	0.0747* **0.0744***	0.8520* **0.8527***	-459.446 **-459.817**	0.959 **0.959**
SUGEX	0.0172 **0.0171**	1.39E-06	-3.4017* **0.0335***	0.0186* **0.0200***	0.1673* **0.1663***	0.7384* **0.7396***	-890.564 **-891.293**	0.757 **0.760**

* indicates significance at 1%; **indicates significance at 5% and ***indicates significance at 10%

Asymmetry is found to be uniformly present in the indices since TARCH term is found to be consistently positive and statistically significant. This result is consistent with that expected by the leverage effect and confirms the results of the sign and bias test of Engle and Ng (1993) previously carried out.

From table 10, in the GJR-TGARCH (1, 1) and VA (1, 1) GJR-TGARCH (1, 1), all coefficients were statistically significant, except for SUGEX where the constant in the mean equation was statistically insignificant and for INVESTEX where the ARCHL1 was insignificant. Again, the coefficients of trading volume are insignificant, except for BANKEX, albeit its coefficient is very small.

When the risk component was added in the mean equation, only one coefficient was statistically significant, either the ARCHM or the constant (see Table 11). Again trading volume was significant only for BANKEX. When the AR (1) was added to both models, again trading volume was significant only for BANKEX, but still very small (see Table 12). Results from table 12 also show little support for trading volume in the conditional variance equations.

The second finding from table is that the volatility persistence coefficient is marginally reduced as compared to when volume was excluded from the variance equation. This is consistent with the results of Girard and Biswas (2007). Thus, the inclusion of trading volume in conditional volatility does not reduce volatility persistence.

Overall, it can be said that trading volume does not play a significant role in the volatility of returns, confirming results of the simple GARCH models above.

Table 11: Volume – Augmented TGARCH (1,1) – M and TGARCH (1,1) – M – Indices

Stock	Constant	ARCHM	Vol	Constant	ARCH L1	TGARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
SEMDEX	0.0329*	0.1572	1.77E-08	-3.9293*	0.4325*	0.2605*	0.2128*	177.051	2.26	0.133	0.6453
	0.0332*	**0.1542**		**0.0199***	**0.4324***	**0.2604***	**0.2122***	**176.900**	**2.17**	**0.14**	**0.6446**
BANKEX	0.0038	0.1879*	6.72E-08*	-2.1726*	0.3000*	0.5327*	0.0031	-777.616	18.46	0	0.3031
	-0.0048	**0.2336***		**0.1221***	**0.2595***	**0.4876***	**0.0142**	**-801.640**	**16.81**	**0**	**0.2737**
COMMEX	-0.0004	0.3490*	-1.23E-07	-3.7301*	0.1745*	0.3431*	0.4673*	-241.337	7.09	0.008	0.6418
	-0.0001	**0.3453***		**0.0237***	**0.1732***	**0.3418***	**0.4706***	**-241.511**	**6.95**	**0.008**	**0.6438**
INDUSTEX	0.0452**	-0.2848	-4.50E-07	-4.3069*	-0.0099*	0.1257	0.7722*	-144.335	1.35	0.246	0.7623
	0.0447*	**-0.2782**		**0.0137***	**-0.0092****	**0.1280***	**0.7653***	**-144.877**	**1.35**	**0.245**	**0.7561**
INVESTEX	0.0048	0.2050	1.45E-07	-6.0784*	0.0054	0.2252*	0.8850*	-391.075	14.68	1E-04	0.8904
	0.0047	**0.2058***		**0.0023**	**0.0054***	**0.2254***	**0.8851***	**-391.184**	**14.89**	**1E-04**	**0.8905**
HOTEX	0.0113	0.1646**	-1.19E-06	-5.8632*	0.1019*	0.0856*	0.8547*	-455.967	5.89	0.015	0.9566
	0.0112	**0.1655****		**0.0028***	**0.1017***	**0.0854***	**0.8544***	**-456.329**	**5.96**	**0.015**	**0.9561**
SUGEX	-0.0247	0.2374**	1.39E-06	-3.4153*	0.0251*	0.1695*	0.7375*	-887.846	5.28	0.022	0.7626
	-0.0247	**0.2369****		**0.0330***	**0.0260***	**0.1690***	**0.7390***	**-888.555**	**5.33**	**0.021**	**0.765**

** indicates significance at 1%; **indicates significance at 5% and ***indicates significance at 10%*

Table 12: Volume – Augmented TGARCH (1, 1) and AR (1) TGARCH (1, 1) – Indices

Stock	L1	Constant	Vol	Constant	ARCH L1	TGARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
SEMDEX	0.3164*	0.0304*	1E-08	-3.9674*	0.3572*	0.2779*	0.2457*	213.412	103.32	0	0.6029
	0.3165*	**0.0305***		**0.0191***	**0.3570***	**0.2781***	**0.2455***	**213.341**	**103.26**	**0**	**0.6025**
BANKEX	0.1743*	0.0359*	8E-08	-2.2466*	0.2110*	0.3854*	0.1023*	-777.161	25.76	0	0.3133
	0.1873*	**0.0346***		**0.1113***	**0.1996***	**0.3448***	**0.1206***	**-800.494**	**28.2**	**0**	**0.3202**
COMMEX	0.1788*	0.0246*	-8E-08	-3.9184*	0.1574*	0.2480*	0.5462*	-231.635	35.78	0	0.7036
	0.1789*	**0.0247***		**0.0197***	**0.1563***	**0.2472***	**0.5488***	**-231.698**	**35.87**	**0**	**0.7051**
INDUSTEX	**0.0675****	**0.0256***		**0.0138***	**-0.0108***	**0.1341***	**0.7643***	**-142.838**	**5.16**	**0.0231**	**0.7535**
INVESTEX	**0.1563***	**0.0195*****		**0.1204***	**0.1662***	**0.4782***	**0.0215**	**-714.529**	**13.82**	**0.0002**	**0.1877**
HOTEX	0.1727*	0.0211*	-1E-06	-5.8391*	0.0974*	0.0851*	0.8566*	-443.081	43.48	0	0.954
	0.1729*	**0.0211***		**0.0028***	**0.0973***	**0.0848***	**0.8564***	**-443.420**	**43.92**	**0**	**0.9537**
SUGEX	0.0939*	0.0187	1E-06	-3.4388*	0.0187*	0.1629*	0.7462*	-886.359	6.78	0.0092	0.7649
	0.0950*	**0.0186**		**0.0323***	**0.0200***	**0.1620***	**0.7472***	**-887.015**	**7.12**	**0.0076**	**0.7672**

** indicates significance at 1%; **indicates significance at 5% and ***indicates significance at 10%*

The company-wise regressions results are summarized below (detailed results are presented in the Appendix. Table A. 7 – A.10):

Table 13: Summary Regressions TGARCH (Company Wise)

	TGARCH	TGARCH-M	AR(1)-TGARCH	AR(1)-TGARCH-M
No. of Reg.	17	13	13	12
Significant	10	8	7	7
Positive	12	10	10	9
Positive and Significant	8	7	6	6

For some companies, the relationship between volume and volatility is positive and significant. However, the small value of the coefficients (see Appendix) indicates that the nexus is weak.

VI. CONCLUSION

Overall, it was seen that it should not be possible to use trading volume in designing trade strategies. Therefore on the stock exchange of Mauritius, investors are less likely to have a significant edge over other investors if they incorporate trading volume in their analysis. It was discovered that trading volume is not a significant component of volatility like it is in other emerging market. This may be a sign of maturity of the SEM indicating it is weak form efficient. Nevertheless, this is least probable.

It has also been discovered that bad news affect volatility more that good news, through the significance of the asymmetric terms in the conditional variances. This may be indicative to investors who may want to reduce the amount of risk in their portfolios if the asymmetric GARCH models are used in forecasting.

It has been discovered that the returns data exhibit properties, such as volatility pooling, which are best-modeled using ARCH models like in other countries. In addition, it was found that asymmetric GARCH models are well. This should be used as a reference to encourage companies to use forecast from these models for risk management purposes.

It has also been discovered that stock returns can be predicted using the previous day's returns based on autocorrelation analysis. This may indicate weak-form efficiency of the Stock Exchange of Mauritius and can be seen as an opportunity for investors. However, Sannassee and Soobaroyen (2000) show that the SEM do no exhibit weak-form efficiency. However, they

argue that informational efficiency should also take into consideration the qualitative issues pertaining to the market before any conclusion may be reached.

As it was discussed stock prices do not follow random walks, this means that they may to some extent be predictable. Biekpe and Miambo (2005) also rejected the Random Walk Hypothesis on the Stock Exchange of Mauritius, irrespective of the method used to measure returns. They show that there is insignificant nontrading-induced autocorrelation in all the stocks. Therefore, the deviation from the random walk by the stocks on the Mauritius Market is not necessarily due to thin trading, but other pricing inefficiencies. It has also been discovered that the macroeconomy is associated with stock market volatility. As it has been seen, if there are plans by a government to stimulate the economy this should be reflected in the stock market and not surprise investors. A relationship running from the stock market to the macroeconomy can also exist.

Company-wise it can be seen that the two most efficiently priced stocks on the SEM are NMHL and SUN. This is perhaps the tourism sector is experiencing a boom according the Central Statistics Office and which makes trading and information flow better. Only these two were able to run all the 8 models to which their data were applied. Company wise it was also discovered that some returns are positively skewed, this may be indicate investors that the probability of making a profit is higher than making a lost. It is often believed that emerging stock markets are inherently informationally inefficient Sannassee and Soobaroyen (2000) due to thin trading and slow adjustments of prices to new information. These inefficiencies normally give rise to serial correlations in share prices and stock returns.

This paper has investigated the relationship returns, volatility and trading volume on the Stock Exchange of Mauritius. Thirty-six listed stocks, six constructed indices and the SEMDEX have been used to test the validity of the Mixture-of-Distributions Hypothesis (MDH) when volume is taken as a proxy for the rate of information arrival. The empirical results show that no support for the MDH can be found on the stock market of Mauritius, that is trading volume does not affect volatility and returns and vice-versa. These empirical results can help better understand the microstructure of the SEM and of emerging stock markets in general. However, since the Mauritian stock market is thin when compared to more developed markets, additional comparable investigations with respect to other markets are desirable.

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Table A.1: Official Market – List of Companies

No.		*Codes*	*Date of Listing*	*Data availability*	*Decision*
	BANKING AND INSURANCE				
1	Mauritian Eagle Insurance Co. Ltd.	MEI	16 Dec 1993	03 Jan 02 - 31 Dec 08	OK
2	Mauritius Commercial Bank Ltd.	MCB	05 Jul 1989	03 Jan 02 - 31 Dec 08	OK
3	Mauritius Leasing Co. Ltd.	MLC	19 Nov 1990	27 Feb 04 - 31 Dec 08	Remove
4	Mauritius Union Assurance Ltd.	MUA	14 Dec 1993	03 Jan 02 - 31 Dec 08	OK
5	State Bank of Mauritius Ltd.	SBM	30 Jun 1995	03 Jan 02 - 31 Dec 08	OK
6	Swan Insurance Company Ltd.	SWAN	19 Dec 1990	03 Jan 02 - 31 Dec 08	OK
	COMMERCE				
7	Companies des Magasins Populaires Ltd.	CMPL	6 Mar 1991	03 Jan 02 - 31 Dec 08	OK
8	Harel Mallac & Co. Ltd.	HML	20 Feb 1991	03 Jan 02 - 31 Dec 08	OK
9	Innodis	HWF	28 Feb 1996	03 Jan 02 - 31 Dec 08	OK
10	Ireland Blyth Ltd.	IBL	17 Aug 1994	03 Jan 02 - 31 Dec 08	OK
11	Rogers & Co. Ltd.	ROGE	27 Jun 1990	03 Jan 02 - 31 Dec 08	OK
12	Shell Mauritius Ltd.	SHEL	13 Nov 1991	03 Jan 02 - 31 Dec 08	OK
	INDUSTRY				
13	Gamma Civic Ltd.	GCL	30 Nov 1994	03 Jan 02 - 31 Dec 08	OK
14	Phoenix Breweries Ltd.	PBL	10 Jun 1993	03 Jan 02 - 31 Dec 08	OK
15	Mauritius Chemical Fertilizers Ltd.	MCFI	13 Dec 1989	03 Jan 02 - 31 Dec 08	OK
16	Mauritius Oil Refineries Ltd.	MOR	21 Feb 1990	03 Jan 02 - 31 Dec 08	OK
17	Mauritius Stationery Manufacturers Ltd.	MSM	05 Jul 1989	03 Jan 02 - 31 Dec 08	OK
18	Plastic Industry (Mtius) Ltd.	PIM	15 Jul 1993	03 Jan 02 - 31 Dec 08	OK
19	United Basalt Products Ltd.	UBP	05 Jul 1989	03 Jan 02 - 31 Dec 08	OK
	INVESTMENT				
20	British American Investment Co. (Mtius) Ltd		07 Jul 2003	07 Jul 03 - 31 Dec 08	Remove
21	Belle-Mare Holding Ltd.	BMHL	07 Mar 1994	03 Jan 02 - 31 Dec 08	OK
22	Caudan Development Ltd.		29 Jul 2002	29 Jul 02 - 31 Dec 08	Remove
23	Fincorp Investment Ltd.	FINC	31 Aug 1994	03 Jan 02 - 31 Dec 08	OK
24	General Investment & Development Co. Ltd.	GIDC	04 Jul 1990	03 Jan 02 - 31 Dec 08	OK
25	Liberty Investment Trust Ltd.	LIT	22 Jun 1993	03 Jan 02 - 31 Dec 08	OK
26	Mauritius Development Investment Trust	MDIT	05 Jul 1989	03 Jan 02 - 31 Dec 08	OK
27	National Investment Trust Ltd.	NIT	29 Jul 1993	03 Jan 02 - 31 Dec 08	OK
28	Promotion and Development Ltd.	PAD	17 Jan 1996	03 Jan 02 - 31 Dec 08	OK
29	P.O.L.I.C.Y. Limited	POL	08 Dec 1992	03 Jan 02 - 31 Dec 08	OK
30	United Docks Ltd.	UTDL	27 Nov 1991	03 Jan 02 - 31 Dec 08	OK
	LEISURE AND HOTELS				
31	Automatic Systems Ltd.	ASL	12 Oct 1994	03 Jan 02 - 31 Dec 08	OK
32	New Mauritius Hotels Ltd.	NMHL	12 Jun 1996	03 Jan 02 - 31 Dec 08	OK
33	Naiade Resorts		23 Nov 2005	23 Nov 05 - 31 Dec 08	Remove
34	Sun Resorts Ltd.	SUN	26 Jan 1993	03 Jan 02 - 31 Dec 08	OK
	SUGAR				
35	Harel Frères Ltd.	HARF	20 Feb 1991	03 Jan 02 - 31 Dec 08	OK
36	Mon Desért Alma Ltd.	MDA	17 Jan 1990	03 Jan 02 - 31 Dec 08	OK
37	Mount Sugar Estates Co. Ltd.	MOUN	27 Feb 1991	03 Jan 02 - 31 Dec 08	OK
38	Mon Trésor Mon Désert Ltd.	MTMD	05 Jul 1989	03 Jan 02 - 31 Dec 08	OK
39	Savannah S.E Co. Ltd.	SAVA	24 Jan 1990	03 Jan 02 - 31 Dec 08	OK
	TRANSPORT				
40	Air Mauritius Ltd.	AIRM	17 Feb 1995	03 Jan 02 - 31 Dec 08	OK

Source: SEM Handbook 2003, Factbook 2004 & 2008 and www.arbl.net

Table A.2: Augmented Dickey-Fuller Unit Roof test for Individual Daily price, Return and Volume (36 Companies)

	test statistic*		**test statistic***		**test statistic***
PMEI	-1.392 (0.5860)	PMCB	-0.636 (0.8626)	PMUA	-1.635 (0.4647)
RMEI	-28.829 (0.0000)	RMCB	-28.227 (0.0000)	RMUA	-26.519 (0.0000)
VOLMEI	-26.312 (0.0000)	VOLMCB	-27.033 (0.0000)	VOLMUA	-25.978 (0.0000)
PSBM	1.653 (0.9980)	PSWAN	-1.431 (0.5671)	PCMPL	-1.536 (0.5156)
RSBM	-25.201 (0.0000)	RSWAN	-20.31 (0.0000)	RCMPL	-26.858 (0.0000)
VOLSBM	-27.303 (0.0000)	VOLSWAN	-26.873 (0.0000)	VOLCMPL	-27.10 (0.0000)
PHML	-1.653 (0.4554)	PHWF	-1.594 (0.4865)	PIBL	-0.360 (0.9166)
RHML	-24.175 (0.0000)	RHWF	-29.413 (0.0000)	RIBL	-26.93 (0.0000)
VOLHML	-25.958 (0.0000)	VOLHWF	-27.428 (0.0000)	VOLIBL	-27.203 (0.0000)
PROGE	3.135 (1.000)	PSHEL	-1.088 (0.7198)	PGCL	2.396 (0.9990)
RROGE	24.990 (0.0000)	RSHEL	-25.576 (0.0000)	RGCL	-27.990 (0.0000)
VOLROGE	26.023 (0.0000)	VOLSHEL	-27.085 (0.0000)	VOLGCL	-21.847 (0.0000)
PMCFI	-1.271 (0.6423)	PMOR	-2.235 (0.1939)	PMSM	-0.494 (0.8931)
RMCFI	-25.856 (0.0000)	RMOR	-27.380 (0.0000)	RMSM	-25.543 (0.0000)
VOLMCFI	-26.027 (0.0000)	VOLMOR	-27.071 (0.0000)	VOLMSM	-25.922 (0.0000)
PPBL	-0.444 (0.9026)	PPIM	-1.447 (0.5596)	PUBP	-2.507 (0.1138)
RPBL	-25.966 (0.0000)	RPIM	-28.697 (0.0000)	RUBP	-28.739 (0.0000)
VOLPBL	-22.288 (0.0000)	VOLPIM	-27.471 (0.0000)	VOLUBP	-27.056 (0.0000)
PBMHL	-2.688 (0.0761)	PFINC	-0.781 (0.8247)	PGIDC	0.063 (0.9634)
RBMHL	-26.703 (0.0000)	RFINC	-25.663 (0.0000)	RGIDC	-23.078 (0.0000)
VOLBMHL	-25.028 (0.0000)	VOLFINC	-27.431 (0.0000)	VOLGIDC	-27.374 (0.0000)
PLIT	0.146 (0.9691)	PMDIT	-2.520 (0.1107)	PNIT	0.683 (0.9895)
RLIT	-24.209 (0.0000)	RMDIT	-27.780 (0.0000)	RNIT	-25.350 (0.0000)
VOLLIT	-27.286 (0.0000)	VOLMDIT	-24.184 (0.0000)	VOLNIT	-23.686 (0.0000)
PPAD	-0.394 (0.9111)	PPOL	0.465 (0.9838)	PUTDL	-1.493 (0.5369)
RPAD	-23.855 (0.0000)	RPOL	-25.965 (0.0000)	RUTDL	-24.495 (0.0000)
VOLPAD	-26.224 (0.0000)	VOLPOL	-26.687 (0.0000)	VOLUTDL	-27.304 (0.0000)
PASL	-1.730 (0.4159)	PNMHL	2.929 (1.0000)	PSUN	1.671 (0.9981)
RASL	-26.845 (0.0000)	RNMHL	-25.871 (0.0000)	RSUN	-25.219 (0.0000)
VOLASL	-27.244 (0.0000)	VOLNMHL	-24.963 (0.0000)	VOLSUN	-27.484 (0.0000)
PHARF	-3.396 (0.0111)	PMDA	0.117 (0.9672)	PMOUN	-0.776 (0.8262)
RHARF	-27.045 (0.0000)	RMDA	-26.510 (0.0000)	RMOUN	-21.271 (0.0000)
VOLHARF	-23.751 (0.0000)	VOLMDA	-27.227 (0.0000)	VOLMIOUN	-26.567 (0.0000)
PMTMD	-2.422 (0.1355)	PSAVA	-0.893 (0.7903)	PAIRM	-2.174 (0.2157)
RMTMD	-26.093 (0.0000)	RSAVA	-23.601 (0.0000)	RAIRM	-26.117 (0.0000)
VOLMTMD	-26.533 (0.0000)	VOLSAVA	-27.423 (0.0000)	VOLAIRM	-21.851 (0.0000)

1% critical value: -3.430; 5% critical value: -2.860; 10% critical value: -2.570
** figures in brackets are Mackinon approximate p-value for Z (t)*

Table A.3: Volume Augmented GARCH (1,1)

Stock	Constant	Vol	Constant	ARCH L1	GARCH L1	LL	Vol. Per.
03 MUA	-0.01910	-0.00391	-2.57837	0.06769	0.90420	-1,776.773	0.972
	[0.3480]	[0.000]	[0.000]	[0.000]	[0.000]		
05 SWAN	0.03188	-0.00002	-5.63090	0.05018	0.93486	-667.270	0.985
	[0.001]	0.7850	[0.000]	[0.000]	[0.000]		
06 CMPL	0.0227	0.00013	-2.8850	0.0611	0.7214	-1,045.637	0.783
	[0.106]	[0.000]	[0.000]	[0.000]	[0.000]		
08 HWF	-0.01650	7.21e-08	-3.92332	0.09057	0.80209	-732.320	0.893
	[0.089]	[0.752]	[0.000]	[0.000]	[0.000]		
09 IBL	0.33330	4.2e-0.6	-2.08070	0.35477	0.41781	-1,345.579	0.773
	[0.035]	[0.000]	[0.000]	[0.000]	[0.000]		
12 GCL	0.03080	0.00001	-4.55956	0.04194	0.91047	-974.880	0.952
	[0.015]	[0.000]	[0.000]	[0.000]	[0.000]		
14 MOR	0.01340	7.01e-07	-1.51436	0.04682	0.36044	-1,373.385	0.407
	[0.457]	[0.543]	[0.000]	[0.000]	[0.000]		
16 PBL	0.00614	-0.00582	-4.70195	0.03197	0.94918	-950.340	0.981
	[0.554]	[0.000]	[0.000]	[0.000]	[0.000]		
17 PIM	0.00864	-0.04936	-6.00231	0.00410	0.98664	-999.836	0.991
	[0.493]	[0.599]	[0.000]	[0.000]	[0.000]		
18 UBP	0.00617	0.00011	-2.20196	0.05376	-2.09e-07	-807.147	0.054
	[0.602]	[0.000]	[0.000]	[0.000]	[0.754]		
19 BMHL	0.00641	0.00006	-1.92130	0.27238	0.83037	-2,403.329	1.103
	[0.350]	[0.579]	[0.000]	[0.000]	[0.000]		
20 FINC	0.01452	-3.5e-08	-4.00074	0.18095	0.86175	-1,789.796	1.043
	[0.413]	[0.989]	[0.000]	[0.000]	[0.000]		
21 GIDC	0.01426	-0.00510	-5.88118	0.03489	0.96695	-1,234.629	1.002
22 LIT	0.02405	0.00001	-4.09682	0.03945	0.84241	-622.009	0.882
	[0.004]	[0.000]	[0.000]	[0.000]	[0.000]		
26 POL	0.01756	-4.6e-07	-6.02615	0.03840	0.96051	-1,491.845	0.999
	[0.246]	[0.952]	[0.000]	[0.000]	[0.000]		
29 NMHL	0.00860	1.20e-06	-2.56967	0.58239	0.29309	-968.497	0.875
	[0.387]	[0.77]	[0.000]	[0.000]	[0.000]		
30 SUN	0.00468	4.62e-09	-4.65913	0.28415	0.75405	-752.155	1.038
	[0.546]	[0.995]	[0.000]	[0.000]	[0.000]		
34 MTMD	-0.01262	2.80e-06	-2.24043	0.08386	0.70838	-1,572.108	0.792
	[0.499]	[0.000]	[0.000]	[0.000]	[0.000]		
36 AIRM	0.00945	0.00001	-3.39511	0.37671	0.63213	-1,251.673	1.009
	[0.192]	[0.000]	[0.000]	[0.000]	[0.000]		

Table A.4: Volume Augmented GARCH (1,1) - M

Stock	Constant	ARCHM	Vol	Constant	ARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
03 MUA	-0.01757	-0.00327	-0.00391	-2.57968	0.06777	0.90422	-1,776.767	0	0.9613	0.97199
04 SBM	0.03305	0.04902	2.24e-0.8	-2.26786	0.33548	0.44611	-1,215.959	0.58	0.4479	0.78159
	[0.143]	[0.448]	[0.730]	[0.000]	[0.000]	[0.000]				
05 SWAN	0.01816	0.11747	-0.00002	-5.61663	0.05071	0.93401	-665.718	3.2	0.0734	0.98472
	[0.134]	[0.073]	[0.776]	[0.000]	[0.000]	[0.000]				
08 HWF	-0.03408	0.12400	7.24e-08	-3.92851	0.09074	0.80263	-731.709	1.05	0.3061	0.89337
	[0.090]	[0.306]	[0.758]	[0.000]	[0.000]	[0.000]				
09 IBL	0.05087	-0.05518	3.99e-0.6	-2.09585	0.34682	0.42694	-1,344.847	1.05	0.3058	0.77376
	[0.041]	[0.306]	[0.000]	[0.000]	[0.000]	[0.000]				
16 PBL	-0.01014	0.08917	-0.00617	-4.69920	0.03178	0.94938	-949.997	0.49	0.4848	0.98116
	[0.706]	[0.485]	[0.000]	[0.000]	[0.000]	[0.000]				
18 UBP	-0.02752	0.04769	-0.05459	-2.00234	0.11942	0.80024	-1,227.000	0.45	0.5011	0.91966
	[0.077]	[0.501]	[0.000]	[0.000]	[0.000]	[0.000]				
22 LIT	-0.02697	0.40553	0.00001	-4.15366	0.03722	0.85062	-618.748	5.36	0.0206	0.88784
	[0.262]	[0.021]	[0.000]	[0.000]	[0.000]	[0.000]				
23 MDIT	-0.01419	-0.00137	-0.00043	-3.86706	0.28532	0.85445	-1,317.360	0	0.9601	1.13978
	[0.088]	[0.960]	[0.001]	[0.000]	[0.000]	[0.000]				
24 NIT	0.00631	0.07830	8.62e-07	-2.94877	0.16425	0.70283	-1,210.096	0.55	0.4596	0.86708
	[0.829]	[0.460]	[0.001]	[0.000]	[0.000]	[0.000]				
25 PAD	0.04123	-0.00641	7.46e-06	-3.99353	0.08624	0.88120	-1,475.016	0.02	0.8978	0.96743
	[0.093]	[0.898]	[0.000]	[0.000]	[0.000]	[0.000]				
26 POL	0.02320	-0.01644	-4.8e-07	-6.01978	0.03852	0.96037	-1,491.799	0.08	0.7728	0.99889
	[0.386]	[0.773]	[0.953]	[0.000]	[0.000]	[0.000]				
29 NMHL	-0.01839	0.14123	1.83-06	-2.44951	0.65162	0.20984	-962.098	21.39	0	0.86146
	[0.124]	[0.000]	[0.002]	[0.000]	[0.000]	[0.000]				
30 SUN	0.00138	0.02884	2.75e-10	-4.65946	0.28536	0.75370	-751.816	0.61	0.435	1.03906
	[0.879]	[0.435]	[0.1000]	[0.000]	[0.000]	[0.000]				
32 MDA	-0.14840	0.34840	0.00006	-3.16671	0.02204	0.90123	-1,704.360	3.97	0.0463	0.92327
	[0.069]	[0.046]	[0.000]	[0.000]	[0.000]	[0.000]				
34 MTMD	-0.05738	0.09815	2.58e-06	-2.23472	0.08520	0.70653	-1,571.575	1.05	0.30640	0.79173
	[0.241]	[0.306]	[0.000]	[0.000]	[0.000]	[0.000]				
35 SAVA	-0.10042	0.12690	-0.00001	-2.98960	0.05133	0.87841	-1,748.567	4.49	0.0341	0.92974
	[0.026]	[0.034]	[0.832]	[0.000]	[0.000]	[0.000]				
36 AIRM	-0.00816	0.09663	0.00001	-3.11215	0.47515	0.54829	-1,245.536	670.76	0	1.02343
	[0.254]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				

Table A.5: AR (1) Volume – Augmented GARCH)

Stock	L1	Constant	Vol	Constant	ARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
03 MUA	0.05681	-0.01824	-0.00395	-2.53969	0.06518	0.90361	-1,774.967	1.92	0.1662	0.96879
	[0.166]	[0.395]	[0.000]	[0.000]	[0.000]	[0.000]				
04 SBM	0.25668	0.01614	2.54e-0.8	-1.54476	0.49996	0.01091	-1,202.685	78.66	0	0.51086
	[0.000]	[0.102]	[0.590]	[0.000]	[0.000]	[0.662]				
05 SWAN	0.00882	0.03169	-0.00002	-5.63235	0.05010	0.93499	-667.369	0.05	0.82	0.98508
	[0.820]	[0.001]	[0.778]	[0.000]	[0.000]	[0.000]				
06 CMPL	0.04168	0.02252	0.00013	-2.88543	0.06082	0.72172	-1,045.240	0.06	0.8101	0.78254
	[0.810]	[0.109]	[0.000]	[0.000]	[0.000]	[0.000]				
08 HWF	-0.05468	-0.01745	6.80e-08	-3.96027	0.08862	0.80774	-731.290	1.55	0.2134	0.89636
	[0.213]	[0.071]	[0.773]	[0.000]	[0.000]	[0.000]				
09 IBL	0.01580	0.03475	4.12e-0.6	-2.10040	0.34024	0.43050	-1,345.427	0.19	0.6604	0.77074
	[0.660]	[0.027]	[0.000]	[0.000]	[0.000]	[0.000]				
12 GCL	0.42308	0.02866	0.00001	-4.54387	0.04221	0.90949	-969.765	1.72	0.1892	0.95170
	[0.189]	[0.024]	[0.000]	[0.000]	[0.000]	[0.000]				
14 MOR	-0.04173	0.01425	7.02e-07	-1.50662	0.04763	0.35523	-1,372.332	1.04	0.3071	0.40285
	[0.307]	[0.432]	[0.545]	[0.000]	[0.000]	[0.0001]				
16 PBL	0.05838	0.00575	-0.00600	-4.71511	0.03148	0.94986	-948.489	3.16	0.0757	0.98134
	[0.076]	[0.587]	[0.000]	[0.000]	[0.000]	[0.000]				
21 GIDC	0.10125	0.01363	-0.21999	-5.85856	0.03464	0.96757	-1,228.826	13.6	0.0002	1.00221
	[0.000]	[0.262]	[0.880]	[0.000]	[0.000]	[0.000]				
22 LIT	0.07443	0.02269	0.00001	-4.12085	0.03912	0.84555	-620.406	2.79	0.0951	0.88468
	[0.095]	[0.008]	[0.000]	[0.000]	[0.000]	[0.000]				
23 MDIT	0.15701	-0.00797	1.32e-06	-5.23542	0.24296	0.85626	-1,301.722	29.32	0	1.09923
	[0.000]	[0.499]	[0.000]	[0.000]	[0.000]	[0.000]				
24 NIT	0.03534	0.02673	8.52e-07	-2.97547	0.16441	0.70746	-1,209.431	0.74	0.3908	0.87187
	[0.391]	[0.039]	[0.001]	[0.000]	[0.000]	[0.000]				
25 PAD	0.14006	0.03659	7.36e-06	-4.01746	0.08255	0.88396	-1,464.608	19.31	0	0.96652
	[0.000]	[0.022]	[0.000]	[0.000]	[0.000]	[0.000]				
26 POL	0.00403	0.01706	-4.72e-07	-6.02664	0.03844	0.96051	-1,489.924	0.03	0.8725	0.99895
	[0.872]	[0.264]	[0.953]	[0.000]	[0.000]	[0.000]				
27 UTDL	0.06386	-0.00545	6.87e-06	-1.67704	0.56246	0.18858	-1,322.957	1.66	0.1982	0.75104
	[0.198]	[0.660]	[0.000]	[0.000]	[0.000]	[0.000]				
29 NMHL	0.12582	0.01115	1.10-06	-2.62352	0.52867	0.33235	-963.054	16.6	0	0.86102
	[0.000]	[0.272]	[0.126]	[0.000]	[0.000]	[0.000]				
30 SUN	0.04767	0.00426	2.96e-08	-4.67705	0.28191	0.75680	-750.545	5.54	0.0185	1.03871
	[0.019]	[0.586]	[0.965]	[0.000]	[0.000]	[0.000]				
31 HARF	0.15076	0.06352	-0.00030	2.20073	0.58014	0.15745	-3,712.902	3.24	0.0719	0.73760
	[0.072]	[0.297]	[0.000]	[0.000]	[0.000]	[0.000]				
32 MDA	0.01280	0.03102	0.00007	-3.27864	0.01897	0.91060	-1,708.473	0.11	0.7413	0.92958
	[0.741]	[0.121]	[0.000]	[0.000]	[0.000]	[0.000]				
34 MTMD	0.02034	-0.01213	2.81e-06	-2.24651	0.08297	0.71027	-1,571.416	0.27	0.6053	0.79324
	[0.605]	[0.516]	[0.000]	[0.000]	[0.000]	[0.000]				
36 AIRM	0.08632	0.00963	0.00001	-3.38139	0.38152	0.62838	-1,246.240	7.02	0.0081	1.00990
	[0.008]	[0.203]	[0.000]	[0.000]	[0.000]	[0.000]				

Table A.6: Volume Augmented GARCH (1,1) – M

Stock	L1	Constant	ARCHM	Vol	Constant	ARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
04 SBM	0.26388	0.00240	0.04548	6.36e-0.8	-1.52293	0.50983	-0.01013	-1,201.999	103.17	0	0.49970
	[0.000]	[0.869]	[0.185]	[0.020]	[0.000]	[0.000]	[0.440]				
05 SWAN	0.00065	0.01819	0.11736	-0.00002	-5.61573	0.05073	0.93399	-665.851	3.17	0.2046	0.98472
	[0.987]	[0.140]	[0.093]	[0.777]	[0.000]	[0.000]	[0.000]				
06 CMPL	0.04155	0.02962	-0.03173	0.00013	-2.89286	0.06018	0.72393	-1,045.202	0.08	0.9618	0.78412
	[0.812]	[0.506]	[0.863]	[0.000]	[0.000]	[0.000]	[0.000]				
08 HWF	-0.05522	-0.03568	0.12842	6.80e-08	-3.96977	0.08865	0.80886	-730.652	2.87	0.2377	0.89751
	[0.212]	[0.079]	[0.294]	[0.780]	[0.000]	[0.000]	[0.000]				
09 IBL	0.01997	0.05313	-0.05806	3.89e-0.6	-2.11438	0.33282	0.43894	-1,344.644	1.31	0.5197	0.77176
	[0.578]	[0.035]	[0.294]	[0.000]	[0.000]	[0.000]	[0.000]				
12 GCL	0.04189	0.03187	-0.01661	0.00001	-4.54471	0.04220	0.90943	-969.749	1.77	0.4128	0.95163
	[0.197]	[0.230]	[0.870]	[0.000]	[0.000]	[0.000]	[0.000]				
16 PBL	0.05931	-0.01167	0.09596	-0.00639	-4.70829	0.03134	0.95001	-948.092	4.18	0.1236	0.98136
	[0.076]	[0.668]	[0.466]	[0.000]	[0.000]	[0.000]	[0.000]				
21 GIDC	0.09778	-0.00317	0.08847	-0.00513	-5.90240	0.03463	0.96736	-1,227.537	16.41	0.003	1.00198
	[0.000]	[0.850]	[0.091]	[0.635]	[0.000]	[0.000]	[0.000]				
22 LIT	0.06175	-0.02415	0.37494	0.00001	-4.16874	0.03688	0.84256	-617.692	7.79	0.0204	0.87944
	[0.186]	[0.330]	[0.042]	[0.000]	[0.000]	[0.000]	[0.000]				
24 NIT	0.02621	0.00933	0.06646	8.65e-07	-2.97065	0.16483	0.70607	-1,208.984	1.05	0.5921	0.87091
	[0.539]	[0.761]	[0.544]	[0.001]	[0.000]	[0.000]	[0.000]				
25 PAD	0.14150	0.04230	-0.01601	7.36e-06	-4.02066	0.08239	0.88422	-1,464.569	19.35	0.0001	0.96662
	[0.000]	[0.105]	[0.775]	[0.000]	[0.000]	[0.000]	[0.000]				
29 NMHL	0.11474	-0.01900	0.16425	1.95-06	-2.43287	0.65027	0.19935	-957.064	55.91	0	0.84962
	[0.000]	[0.114]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
30 SUN	0.04704	0.00112	0.02783	2.44e-08	-4.67866	0.28295	0.75659	-750.232	8.06	0.0178	1.03953
	[0.055]	[0.907]	[0.540]	[0.972]	[0.000]	[0.000]	[0.000]				
35 SAVA	0.09862	-0.10310	0.13692	-0.00001	-3.06133	0.04691	0.88667	-1,544.954	12.4	0.002	0.93358
	[0.044]	[0.037]	[0.041]	[0.801]	[0.000]	[0.000]	[0.000]				
36 AIRM	0.07821	-0.00680	0.09245	0.00001	-3.11860	0.47602	0.54984	-1,240.994	807.52	0	1.02586
	[0.004]	[0.384]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				

Table A.7: Volume – Augmented TGARCH (1, 1)

Stock	Constant	Vol	Constant	ARCH L1	TGARCH L1	GARCH L1	LL	Vol. Per.
01 MEI	0.03845	-0.00359	0.26192	0.28843	-0.21367	0.42395	-2,542.421	0.712
	[0.480]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
04 SBM	0.04044	2.71e-08	-1.67475	0.19640	0.48648	0.13142	-1,214.051	0.328
	[0.003]	[0.652]	[0.000]	[0.000]	[0.000]	[0.000]		
05 SWAN	0.02426	-0.00001	-5.66231	0.07434	-0.05280	0.94039	-644.753	1.015
	[0.012]	[0.822]	[0.000]	[0.000]	[0.000]	[0.000]		
08 HWF	-0.01159	7.13e-08	-3.88626	0.07001	0.05243	0.79487	-729.513	0.865
	[0.255]	[0.744]	[0.000]	[0.000]	[0.000]	[0.000]		
09 IBL	0.04778	4.21e-06	-2.08499	0.13794	0.39998	0.42017	-1,331.819	0.558
	[0.004]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
10 ROGE	0.03164	5.16E-05	-2.03294	0.08417	0.19079	-0.00036	-842.633	0.084
	[0.003]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
12 GCL	0.02222	1.14E-05	-2.97032	-0.00552	0.23045	0.67670	-974.938	0.671
	[0.064]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
16 PBL	0.02711	-0.00260	-4.96394	-0.00074	0.07855	0.94725	-885.306	0.947
	[0.015]	[0.000]	[0.000]	[0.497]	[0.000]	[0.000]		
20 FINC	0.02395	-0.19390	-4.38188	-0.01252	0.11189	0.95797	-1,724.086	0.945
	[0.097]	[0.858]	[0.000]	[0.000]	[0.000]	[0.000]		
24 NIT	0.01912	8.44e-07	-3.10526	0.23189	-0.12184	0.73117	-1,205.615	0.963
	[0.192]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]		
25 PAD	0.04508	1.11E-05	-1.17610	0.27454	0.21806	0.02409	-1,502.507	0.299
	[0.008]	[0.000]	[0.000]	[0.000]	[0.000]	[0.050]		
26 POL	0.03153	-5.77e-07	-5.83997	0.00764	0.05073	0.96177	-1,470.348	0.969
	[0.043]	[0.931]	[0.000]	[0.000]	[0.000]	[0.000]		
27 UTDL	-0.00170	7.04e-06	-1.67096	0.39655	0.35127	0.17868	-1,320.526	0.575
	[0.895]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
29 NMHL	0.01847	1.00e-06	-2.67353	0.33138	0.48442	0.32393	-956.781	0.655
	[0.093]	[0.166]	[0.000]	[0.000]	[0.000]	[0.000]		
30 SUN	0.01402	7.35e-08	-4.95243	0.10377	0.19370	0.81040	-735.760	0.914
	[0.116]	[0.913]	[0.000]	[0.000]	[0.000]	[0.000]		
32 MDA	0.02599	7.93E-05	-3.50561	0.02580	-0.01662	0.92654	-1,705.040	0.952
	[0.213]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
36 AIRM	0.01975	1.22E-05	-3.40157	0.29216	0.16240	0.63384	-1,247.257	0.926
	[0.031]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		

Table A.8: Volume – Augmented TGARCH (1, 1) – M

Stock	Constant	ARCHM	Vol	Constant	ARCH L1	TGARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
04 SBM	0.00798	0.11532	3.69-08	-1.62415	0.16994	0.61487	0.09037	-1,211.761	3.36	0.0668	0.26032
	[0.728]	[0.067]	[0.416]	[0.000]	[0.000]	[0.000]	[0.000]				
05 SWAN	0.01789	0.05556	-0.000014	-5.65117	0.07358	-0.05167	0.93988	-644.278	1.04	0.3081	1.01346
	[0.121]	[0.308]	[0.822]	[0.000]	[0.000]	[0.000]	[0.000]				
09 IBL	0.05698	-0.03023	4.13-06	-2.08801	0.13829	0.38901	0.42252	-1,331.552	0.39	0.5299	0.56081
	[0.010]	[0.530]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
18 UBP	-0.03193	0.12651	-0.03370	-2.32859	-0.00250	0.22350	0.8418672	-1,174.884	4.22	0.0399	0.83937
	[0.012]	[0.040]	[0.000]	[0.000]	[0.035]	[0.000]	[0.000]				
20 FINC	0.02216	0.02296	4.12e-08	-5.12514	-0.01280	0.13927	0.94514	-1,719.772	2.49	0.1149	0.93234
	[0.172]	[0.115]	[0.993]	[0.000]	[0.000]	[0.000]	[0.000]				
21 GIDC	0.00469	0.09660	-0.16057	-5.88259	-0.00381	0.05599	0.97301	-1,187.004	8.79	0.003	0.96919
	[0.675]	[0.003]	[0.843]	[0.000]	[0.000]	[0.000]	[0.000]				
22 LIT	-0.02671	0.40426	0.00001	-4.14712	0.03643	0.00183	0.84963	-618.741	4.82	0.0281	0.88606
	[0.268]	[0.028]	[0.000]	[0.000]	[0.000]	[0.687]	[0.000]				
24 NIT	0.00589	0.05189	8.52e-07	-3.09975	0.22928	-0.11821	0.73007	-1,205.340	0.27	0.6049	0.95935
	[0.843]	[0.605]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]				
25 PAD	0.04802	0.02439	7.56e-06	-4.32741	0.01505	0.09962	0.90323	-1,445.242	0.32	0.572	0.91828
	[0.025]	[0.572]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
28 ASL	0.02311	-0.02274	0.0000104	-2.68984	0.03886	0.02684	0.77265	-1,368.766	0.08	0.7817	0.81152
	[0.488]	[0.782]	[0.000]	[0.000]	[0.000]	[0.024]	[0.000]				
29 NMHL	-0.01531	0.18990	1.68e-06	-2.57239	0.36854	0.60182	0.24781	-947.634	25.76	0	0.61635
	[0.204]	[0.000]	[0.007]	[0.000]	[0.000]	[0.000]	[0.000]				
30 SUN	0.00550	0.08111	7.20e-08	-4.86453	0.10987	0.22038	0.79754	-733.800	5.27	0.0217	0.90741
	[0.550]	[0.022]	[0.910]	[0.000]	[0.000]	[0.000]	[0.000]				
36 AIRM	-0.00084	0.09842	0.0000107	-3.17317	0.37329	0.16064	0.56815	-1,242.639	436.45	0	0.94144
	[0.931]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				

Table A.9: AR (1) Volume – Augmented TGARCH (1, 1)

Stock	L1	Constant	Vol	Constant	ARCH L1	TGARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
04 SBM	0.27099	0.03050	2.61e-08	-1.60328	0.23484	0.57851	0.03885	-1193.40	86.80	0.00000	0.27369
	[0.000]	[0.008]	[0.591]	[0.000]	[0.000]	[0.000]	[0.182]				
05 SWAN	0.01395	0.02383	-0.000014	-5.66904	0.07406	-0.05269	0.94075	-644.821	0.13	0.7196	1.01482
	[0.720]	[0.013]	[0.826]	[0.000]	[0.000]	[0.000]	[0.000]				
07 HML	0.12643	0.01204	0.000015	-5.40257	0.00852	0.01221	0.97339	-1,289.052	25.56	0	0.98191
	[0.000]	[0.490]	[0.280]	[0.000]	[0.000]	[0.000]	[0.000]				
09 IBL	0.02720	0.04945	4.06e-06	-2.10657	0.13111	0.39041	0.43356	-1,331.779	0.73	0.3937	0.56467
	[0.394]	[0.003]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
16 PBL	0.04257	0.02787	-0.0027	-4.98092	-0.00096	0.07940	0.94771	-883.739	3.19	0.074	0.94675
	[0.074]	[0.013]	[0.000]	[0.000]	[0.382]	[0.000]	[0.000]				
21 GIDC	0.11192	0.02491	1.31-07	-6.14648	-0.00672	0.05706	0.9726	-1,188.394	15.28	0.0001	0.96588
	[0.000]	[0.028]	[0.984]	[0.000]	[0.000]	[0.000]	[0.000]				
22 LIT	0.07430	0.02274	0.0000124	-4.11380	0.03888	0.00077	0.84455	-620.405	2.73	0.0984	0.88343
	[0.098]	[0.000]	[0.000]	[0.000]	[0.000]	[0.872]	[0.000]				
23 MDIT	0.05835	0.02591	1.25e-06	-4.83033	0.00095	0.52383	0.84182	-1,205.555	6.15	0.0132	0.84277
	[0.013]	[0.009]	[0.000]	[0.000]	[0.768]	[0.000]	[0.000]				
24 NIT	0.03687	0.01839	8.54e-07	-3.12225	0.23370	-0.12318	0.73267	-1,205.214	0.94	0.332	0.96637
	[0.332]	[0.209]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]				
25 PAD	0.12940	0.05488	7.43e-06	-4.34080	0.01326	0.09949	0.90468	-1,435.491	27.01	0	0.91793
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
27 UTDL	0.06832	-0.00215	7.04e-06	-1.66821	0.38947	0.35318	0.17839	-1,319.785	2.01	0.1558	0.56786
	[0.156]	[0.866]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
29 NMHL	0.10112	0.02041	7.12e-07	-2.73173	0.31183	0.43288	0.36182	-952.652	9.54	0.002	0.67366
	[0.002]	[0.066]	[0.235]	[0.000]	[0.000]	[0.000]	[0.000]				
30 SUN	0.08024	0.01572	-3.36e-07	-6.35012	0.00400	0.09828	0.94225	-726.465	15.61	0.0001	0.94625
	[0.000]	[0.052]	[0.978]	[0.000]	[0.077]	[0.000]	[0.000]				

Table A.10 - AR (1) Volume – Augmented TGARCH (1, 1) - M

Stock	L1	Constant	ARCHM	Vol	Constant	ARCH L1	TGARCH L1	GARCH L1	LL	W	Chi2	Vol. Per.
04 SBM	0.27109	0.00693	0.08773	4.78e-08	-1.57619	0.25320	0.64067	0.00499	-1,191.802	104.32	0	0.25819
	[0.000]	[0.685]	[0.040]	[0.130]	[0.000]	[0.000]	[0.000]	[0.830]				
08 HWF	-0.05991	-0.03246	0.14113	6.64e-08	-3.94099	0.06798	0.05309	0.80288	-727.568	3.51	0.1731	0.87086
	[0.173]	[0.106]	[0.251]	[0.776]	[0.000]	[0.000]	[0.000]	[0.000]				
09 IBL	0.03841	0.06227	-0.04143	3.91e-06	-2.11554	0.12865	0.37753	0.43985	-1,331.348	1.95	0.377	0.56850
	[0.230]	[0.006]	[0.390]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
12 GCL	0.03582	0.02678	0.01802	0.000013	-4.57103	0.02141	0.03498	0.91343	-967.216	1.3	0.5227	0.93485
	[0.264]	[0.324]	[0.873]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
16 PBL	0.04269	0.02829	-0.00266	-0.00268	-4.98013	-0.00097	0.07939	0.94769	-883.739	3.19	0.2028	0.94672
	[0.078]	[0.133]	[0.978]	[0.000]	[0.000]	[0.396]	[0.000]	[0.000]				
20 FINC	-0.06962	0.02031	0.02688	-3.27e-08	-5.29937	-0.01380	0.13082	0.95022	-1,710.186	32.45	0	0.93643
	[0.000]	[0.220]	[0.074]	[0.995]	[0.000]	[0.000]	[0.000]	[0.000]				
22 LIT	0.06221	-0.02451	0.37695	0.000012	-4.17389	0.03751	-0.00148	0.85336	-617.685	7.48	0.0238	0.89087
	[0.181]	[0.325]	[0.051]	[0.000]	[0.000]	[0.000]	[0.744]	[0.000]				
24 NIT	0.03349	0.00814	0.04059	8.59e-07	-3.11991	0.23148	-0.12058	0.73236	-1,204.046	1.12	0.5717	0.96384
	[0.393]	[0.786]	[0.694]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
25 PAD	0.13063	0.05544	-0.00168	7.43-06	-4.33971	0.01324	0.09949	0.90464	-1,435.493	27.59	0	0.91788
	[0.000]	[0.012]	[0.971]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
26 POL	-0.00370	0.02098	0.03097	-5.82e-07	-5.88638	0.00730	0.05113	0.96241	-1,468.201	0.33	0.847	0.96970
	[0.880]	[0.399]	[0.567]	[0.933]	[0.000]	[0.000]	[0.000]	[0.000]				
29 NMHL	0.05239	-0.01437	0.18838	1.64e-06	-2.57454	0.38092	0.55103	0.25243	-945.878	31.78	0	0.63336
	[0.115]	[0.236]	[0.000]	[0.007]	[0.000]	[0.000]	[0.000]	[0.000]				
30 SUN	0.04493	0.00638	0.07402	1.05e-07	-4.94705	0.10329	0.20918	0.80856	-732.407	14.43	0.0007	0.91185
	[0.090]	[0.515]	[0.090]	[0.856]	[0.000]	[0.000]	[0.000]	[0.000]				