

Interdependence of African Stock markets

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Abstract: The term of stock market interdependence represents a broad area of research in financial economics, which encompasses many aspects of the interrelationships across equity markets. the purpose of this study is to investigate this issue based on eight African stock markets, over an 11 years period from 2004 to 2014, which cover the recent global financial crisis. To this end, we analyzed the long- and short-run relationships among the stock markets by employing a multivariate cointegration framework, and VECM approach. The results show that, the African stock markets are interdependent in both regional and international level; this interdependence varies over time, as it is more pronounced in post-crisis period. The pricing securities in each market is determined by both local and global factors, as the change in asset price in each market is affected by lagged change in its own index in previous days as well as by the lagged change in the price index of other markets. The existence of such interdependence indicates that the potential for diversifying risk by investing in the African region is limited.

Keywords: Interdependence, African stock markets, Johansen cointegration tests, VECM approach

Jel classification: C22, G01, G15, F36

Introduction

The international stock market interdependence has grown during the last three decades, and it attracts the attention of researchers especially after the 1987 global stock market crash. The increased interdependence is mainly due to recent economic developments among countries at a regional and international level including relaxation of capital control measures (Masih & Masih, 2002); the introduction of new financial products such as country funds (Phylaktis & Ravazzolo, 2005) (Diamandis, 2009); developments in trading system technologies (Maghyereh, 2006); improved policy coordination (Diamandis, 2009); improvements in communication (Alkulaib & A., 2009). These developments have resulted in the speedy dissemination of information among markets, reduced transaction costs and improved access to different markets for foreign investors.

The researchers pay attention to the issue of stock market interdependent for two reasons. First, if stock markets are interdependent this tends to limit the potential gain from the diversification, in other words, cointegration among the markets has implications for long-run diversification potential by providing information about whether markets tend to move together over time. Second, the existence of cointegration would suggest that prices are predictable based on historical price information from own and other markets, which violate the efficient market hypothesis (Granger, 1986).

Several studies on interdependence of various groups of national stock markets have used tests of cointegration see for example (Kasa, 1992), (Chung & Liu, 1994), (Richards, 1995), (Ewing, Payne, & Sowell, 2001) and (Darrat & Zhong, 2005). To investigate possible linkages or comovement between selected stock markets we use Johansen cointegration tests, in addition to the long-run analysis, short-run relationships among the markets are investigated by estimating the VECM for the markets. If the stock markets under study are interdependent, they can be expected to be highly correlated, this tend to limit the benefits from international diversification.

1. Model and Data

2.1. Model specification

Recent advances in time series analysis allows investigation of the interaction among the stock market using the methods of cointegration, means, if the stock markets are cointegrated in econometric sense, we infer they are interdependent in economic sense. Prior studies of the interdependence among various groups of national stock markets have used tests of cointegration among such markets, see for example (Kasa, 1992) who suggested that the stock markets that are cointegrated have a long-run relationship.

The cointegration framework is adopted to analyze the joint movements of the variables in the long-run. The basic idea behind the cointegration is that for all components of vector time series process $X_t = (x_{1t}, x_{2t}, \dots, x_{nt})$ have a unit root, or X_t is multivariate I(1) process, there may exist linear combinations, these linear combinations may then be interpreted as long-run relations between the component of X_t or in economic terms as static equilibrium relations.

Let be a vector of n stock market indices which are individually non-stationary and are integrated of the same order e.g. I(1). A VAR (k) model (Kasa, 1992), (Tsay, 2002) can be written as follow:

$$X_t = \mu + A_1 X_{t-1} + A_2 X_{t-2} + \dots + A_k X_{t-k} + \varepsilon_t \quad (1)$$

The vector autoregressive model with Gaussian error can be written as vector error correction model (VECM) of the following form:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-1} + \varepsilon_t \quad (2)$$

Where X_t is a $n \times 1$ vector of I(1) stock index series, $t=1,2,3,\dots,T$ and ε_t white noise is assumed to be i.i.d. process. We refer to the term ΠX_{t-1} as error correction term, which play a key role in the cointegration study.

$$\Gamma_j = -\sum_{i=1}^j A_i, \quad j = 1, 2, \dots, k-1, \quad (3)$$

$$\Pi = -I + \sum_{i=1}^K A_i \quad (4)$$

A_i is a $n \times n$ coefficient matrix, and I is the identical matrix

The reason for doing this is that now all the long-run information in the X_t process is summarized by the long-run impact matrix Π , and Γ is an $n \times n$ coefficient matrix representing the short-term dynamics. Π contains the long-term equilibrium relationship information between the X variables, it

known as the long-run matrix and its rank r , the rank r determine the number of stationary linear combination of X_t (the number of cointegrating vectors). In sum, Johansen's procedure essentially designed to determine the rank of a matrix Π . Π can be of full rank (the rank of Π equals the number of variables (n)), this imply the absence of any stochastic trends¹ whatsoever in the data, and all the stock price series are stationary in levels contrary to the original $I(1)$ specification, means that the ECM is not informative and one can study X_t directly. Π could have rank zero, in which case Eq. (2) reduces to a standard VAR in first differences, and there are no combinations which are stationary and there are no cointegrating vectors. For $0 < r < n$, there exist r cointegrating relationships among the elements of X_t , or equivalently r cointegrating vectors (i.e. the equation (2) can be rewritten to allow for intercept as well as a linear trend). In that case, Π can be decomposed into the product of two $n \times r$ matrix α and β as $\alpha\beta'$. Then, we can write the process for X_t in Eq. (2) as follow:

$$\Delta x_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \alpha\beta' x_{t-1} + \varepsilon_t \quad (5)$$

This model reflects a dynamic equilibrium relation, in which the $\beta'x_t$ is stationary and the columns of β are the cointegrating vectors of x_t , the series are linked together over time by the long-run relation in β , ensuring that the series never move too far apart. Whereas α is the adjustment matrix, or in other words, α are the error-correction parameters and take into account the speed of adjustment. The presence of cointegrating vectors supports the application of a dynamic VECM that depicts the feedback process and speed of adjustment for short run deviation towards the long run equilibrium and reveals short run dynamics in any variables relative to others.

2.2. Data description and preliminary analysis

In this study we use daily closing price indices of the stock markets of eight African countries, together with the stock market price indices of the Japan, UK and US which represent three developed stock markets. The eight African stock markets indices are: Egypt (EGX30), Kenya (NASI), Mauritius (SEMDEX), Morocco (MADEX), Nigeria (NSE_ASI), South

¹ n represent the number of variables . in this case it is 11

Africa (FTSE/JSE), Tunisia (TUNIDEX), Zambia (LASI), these indices are largely accepted as benchmark indices for the eight stock markets. Furthermore, the choice of these markets was determined mainly by the availability of data, the relatively large size of these markets in the region and the financial and economic linkages between these markets. The three developed market indices are S&P 500(US), FTSE 100(UK), N225(Japan). Data cover the period from June 1, 2004 to April 30, 2014, by using daily data in this study; we can capture more information than with weekly or monthly data, such as some interactions that may last only a few days. Since the data come from different countries, it is unavoidable to have different holidays for each market. We could overcome this problem by taking the holiday closing price as being the same as the previous day. Hence the sample for each country contains all days of the week except weekend. The data are obtained from (ASEA, 2014), (Yahoo, 2014) and from (Bloomberg, 2014). In this study we take the whole period (2004-2014), and in order to examine the impact of 2008 global financial crisis, our full sample is divided into two sub-samples of pre-crisis period covering June 1, 2004 to August 30, 2008 and post-crisis period covering September 16, 2008 to April 30, 2014. The periods were chosen with consideration of the evidence that September 14, 2008 was known as the day when Lehman Brothers declared their bankruptcy. In order to assess the robustness of the empirical results, all tests are conducted for the overall period and for each of the two sub-periods using daily data.

Figure 1 and 2: show the time plot of the price series of the selected stock markets for the entire sample period. Visual inspection of the graph indicates that generally the indices move together. In the period between mid-2004 to the beginning of 2008 all the indices experienced a large fluctuation as we see there are a multiple increase and decrease states till they reached the maximum value around mid-2008. Since then, influenced by the world financial crisis all stocks exhibited a sharp decline till they reached the minimum value. Then since the mid-2009 the series also depict similar movement and are trending upwards.

Figure 1: Stock price indices from 2004 to 2014 (African stock indices)

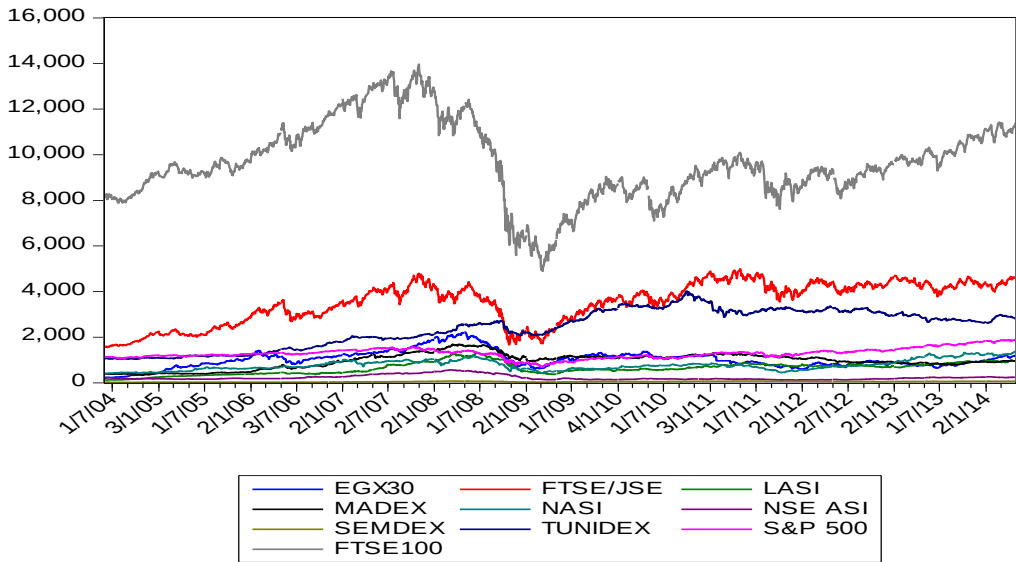
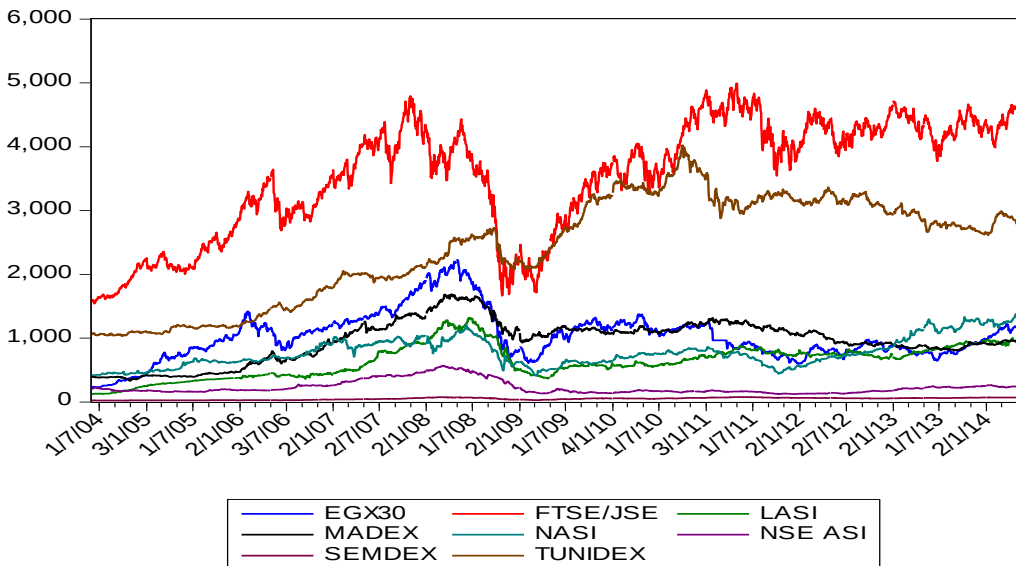


Figure 2: Stock price indices from 2004 to 2014 (All indices)



3. Empirical Results

3.1. Cointegration test

In this section, we answer the following questions: are the African stock markets indices cointegrated among themselves and with the developed markets indices? If so, how many cointegrating relationships are there? Is degree of interdependence varying across periods? To this end, we distinct two models, model 1 includes all African stock markets to investigate the cointegration relation between African stock markets; while the second

model includes all African markets and the stock market of Japan, UK and US this designed to investigate the long run cointegrating relation between African and international stock markets. To detect the number of cointegrating relationship between the variables, we rely on the $\lambda_{\max}$ and λ_{trace} statistics. The $\lambda_{\max}$ statistic tests the null hypothesis that the number of cointegrating vectors is r^2 against the alternative of $r + 1$ cointegrating vectors. The λ_{trace} statistic tests the null hypothesis that the number of cointegrating vectors is less than or equal to r against the same alternative ($r + 1$) cointegrating vectors.

Table 1 reports results for the entire period from June 2004 to April 2014 whereas table 2 and 3 show results for the two sub-periods from June 2004 to August 2008 and from September 2008 to April 2014, respectively. The first two columns in these tables show the number of cointegrating vectors investigated while the next four columns report the trace test and maximum eigenvalue test values and the critical values for these tests.

The results of table below (table1) confirm that: in model 1, since the $\lambda_{\text{trace}}(0)$ and $\lambda_{\max}(0)$ exceed the critical value at 5% level of significance we reject the null hypothesis that the stock indexes of the eight countries in Africa are not cointegrated ($r = 0$) against the alternative of one or more cointegrating vector. So, in the entire period both tests indicate that the African stock markets have one cointegrating vector. For model 2, both the trace statistics and eigenvalue indicate the existence of two cointegrating vectors between our selected markets. So, we can conclude that for the entire period the eight African stock price indexes share one long-term equilibrium relationship among themselves and two long-run equilibrium relationships with foreign markets. These results confirm that, the African markets are interdependent in both regional and global level.

The results documented in the table (2) indicate that in model 1, the λ_{trace} statistics indicate one cointegrating vector while the $\lambda_{\max}$ test statistics show no evidence of cointegrating vector³; this suggest in the period pre-crisis, African markets share one long-run equilibrium relationship among

² The rank of estimated matrix Π is r , representing the number of cointegration vectors,

³ In the case of conflict between trace test and maximum eigenvalue test the trace is more appropriate to evaluate the results

themselves. In model 2, both the trace statistics and eigenvalue test lead to the rejection of the null hypothesis of none cointegrating vectors against the alternative hypothesis of (one or more cointegrating vectors) at 5% level of significance. So, we can conclude that for the pre-crisis period there is one long-term equilibrium relationship among African stock markets, while these stocks share two long-term equilibrium relationships with foreign markets.

Table 1: Cointegration test results for entire period, 2/06/2004 to 30/04/2014

Cases	Null hypothesis H_0	Alternative hypothesis H_A	Trace test		Maximum eigenvalue test	
			Statistic λ_{trace}	5% critical value	Statistic λ_{max}	5% critical value
Model 1 : African markets	$r = 0$	$r = 1$	183.78*	159.52	79.94*	52.36
	$r \leq 1$	$r = 2$	103.83	125.61	34.69	46.23
	$r \leq 2$	$r = 3$	69.14	95.75	26.13	40.07
	$r \leq 3$	$r = 4$	43.01	69.81	17.12	33.87
	$r \leq 4$	$r = 5$	25.88	47.85	10.05	27.58
	$r \leq 5$	$r = 6$	15.82	29.79	8.59	21.13
	$r \leq 6$	$r = 7$	7.23	15.49	5.46	14.26
	$r \leq 7$	$r = 8$	1.76	3.84	1.76	3.84
Model 2: All selected markets	$r = 0$	$r = 1$	395.43*	285.14	238.91*	70.53
	$r \leq 1$	$r = 2$	256.52*	239.23	90.35*	64.51
	$r \leq 2$	$r = 3$	166.16	197.37	35.56	58.43
	$r \leq 3$	$r = 4$	130.61	159.53	34.04	52.36
	$r \leq 4$	$r = 5$	96.55	125.61	25.51	46.23
	$r \leq 5$	$r = 6$	71.03	95.75	20.30	40.07
	$r \leq 6$	$r = 7$	50.73	69.82	19.39	33.87
	$r \leq 7$	$r = 8$	31.34	47.85	11.48	27.58
	$r \leq 8$	$r = 9$	19.86	29.79	10.74	21.13
	$r \leq 9$	$r = 10$	9.12	15.49	9.01	14.26
	$r \leq 10$	$r = 11$	0.11	3.84	0.11	3.84

*Note: Critical values are based on MacKinnon-Haugh-Michelis (1999); * denotes significance of the test statistic at the five per cent level.*

Table 2: Cointegration test results for pre-crisis period, 2/06/2004 to 28/08/2008

Cases	Null hypothesis H_0	Alternative hypothesis H_A	Trace test		Maximum eigenvalue test	
			Statistic λ_{trace}	5% critical value	Statistic λ_{max}	5% critical value
Model 1: African markets	$r = 0$	$r = 1$	160.49*	159.52	50.20	52.36
	$r \leq 1$	$r = 2$	110.28	125.61	32.39	46.23
	$r \leq 2$	$r = 3$	77.89	95.75	24.68	40.07
	$r \leq 3$	$r = 4$	53.21	69.82	22.10	33.87
	$r \leq 4$	$r = 5$	31.1	47.85	11.77	27.58
	$r \leq 5$	$r = 6$	19.32	29.79	10.95	21.13
	$r \leq 6$	$r = 7$	8.37	15.49	7.90	14.26
	$r \leq 7$	$r = 8$	0.46	3.84	0.46	3.84
Model 2: All selected markets	$r = 0$	$r = 1$	414.68*	285.14	170.99*	70.53
	$r \leq 1$	$r = 2$	242.28*	239.23	57.47	64.51
	$r \leq 2$	$r = 3$	184.81	197.37	47.72	58.43
	$r \leq 3$	$r = 4$	137.07	159.53	33.83	52.36
	$r \leq 4$	$r = 5$	103.24	125.62	24.53	46.23
	$r \leq 5$	$r = 6$	78.71	95.75	21.24	40.07
	$r \leq 6$	$r = 7$	57.23	69.82	19.26	33.87
	$r \leq 7$	$r = 8$	37.97	47.85	18.68	27.58
	$r \leq 8$	$r = 9$	19.29	29.79	11.27	21.13
	$r \leq 9$	$r = 10$	8.01	15.49	6.07	14.26
	$r \leq 10$	$r = 11$	1.95	3.84	1.95	3.84

*Note: Critical values are based on MacKinnon-Haugh-Michelis (1999); * denotes significance of the test statistic at the five per cent*

The results reported in the table below indicate that the λ_{trace} and λ_{max} statistics are higher than their critical values at the five per cent level of significance; so, the null is rejected by both tests and three cointegrating vector is detected during the second sub-period (post-crisis) among the African stock market indices as well as with foreign markets. In the long run the markets have a relationship, which suggests that there may be less diversification benefits for international investors. The results reported in this table confirm that interdependence among African markets has increased after the global financial crisis, as the markets show more linkages after September 2008.

Table 3 Cointegration test results for post-crisis period, 16/09/2008 to 30/04/2014

Cases	Null hypothesis H_0	Alternative hypothesis H_A	Trace test		Maximum eigenvalue test	
			Statistic λ_{trace}	5% critical value	Statistic λ_{max}	5% critical value
Model 1 : African markets	$r = 0$	$r = 1$	254.18*	159.52	104.67*	52.36
	$r \leq 1$	$r = 2$	149.51*	125.61	46.03	46.23
	$r \leq 2$	$r = 3$	103.46*	95.75	42.96*	40.07
	$r \leq 3$	$r = 4$	60.51	69.82	31.77	33.87
	$r \leq 4$	$r = 5$	28.73	47.85	13.35	27.58
	$r \leq 5$	$r = 6$	15.37	29.79	9.15	21.13
	$r \leq 6$	$r = 7$	6.21	15.49	5.21	14.26
	$r \leq 7$	$r = 8$	1.03	3.84	1.03	3.84
Model 2: All selected markets	$r = 0$	$r = 1$	401.71*	285.14	129.01*	70.53
	$r \leq 1$	$r = 2$	272.69*	239.23	74.925*	64.51
	$r \leq 2$	$r = 3$	197.76*	197.37	56.49	58.43
	$r \leq 3$	$r = 4$	141.26	159.53	41.16	52.36
	$r \leq 4$	$r = 5$	100.1	125.61	27.52	46.23
	$r \leq 5$	$r = 6$	72.57	95.75	24.14	40.07
	$r \leq 6$	$r = 7$	48.43	69.82	18.31	33.87
	$r \leq 7$	$r = 8$	30.12	47.85	13.47	27.58
	$r \leq 8$	$r = 9$	16.64	29.79	11.41	21.13
	$r \leq 9$	$r = 10$	5.23	15.49	5.21	14.26
	$r \leq 10$	$r = 11$	0.025	3.84	0.025	3.84

*Note: Critical values are based on MacKinnon-Haugh Michelis (1999); * denotes significance of the test statistic at the five per cent level*

3.2. ECM Results

The results of the Johansen's multivariate cointegration test indicate that our selected markets move together in the long-run. However, during a longer period a fundamental or non-fundamental shock may disrupt the equilibrium. When the variables are cointegrated, the short-term deviation from the long-run equilibrium will feed back on the variation in the dependent variable in order to force the movement toward the long-run equilibrium. To investigate the relationships of the African equity markets

in more depth, the VECM is examined⁴; the VECM is employed to examine both short- and long-run relationships among the markets for the entire period and for the two sub-periods. The significance of different explanatory variables gives the short-term effect, whereas the long-run relationship is concluded through the significance of the coefficient of lagged error correction term (ECT_{t-1}). This lagged ECT contains the long-term information since it is derived from the long-run cointegrating relationship; the ECT is included as one of the independent variables in the general model. Its coefficient can be interpreted as the speed of adjustment toward equilibrium state.

The results of VECM for the entire period as well as the two sub period are reported in following tables for each market in the system; table 4 gives the results of the entire period, while table 6 and 7 show the results of first and second sub-period respectively. The results of VECM show that each country in the system is expressed as equations. The equations provide the response of each market stock index in the system to the lagged change in its own values as well as the lagged change in the price index of other stock markets.

➤ **Entire period results**

The visual inspection of t-statistic values in the table 4 reveals that in the short run, the changes in the equity index for each market is affected by lagged change in its own index in previous days as well as lagged change in price index of the other equity markets, these results mean that, the news affecting pricing securities in each market are not purely domestic in nature but are global. For example The price change in Egypt stock index is positively affected by the lagged change in its own index in previous days as well as by the lagged changes in the equity index of Morocco, South Africa, Zambia, this means that if there is an increase in the price index in previous days in these markets the Egyptian stock index goes up; in addition, the increase in Egypt stock index in previous days cause a continuous increase in this market stock price for a quite long time. In other

⁴ The appropriate VECM model associated with the cointegration analysis was analysed with the same restrictions imposed as the cointegration system.

hand, the lagged change in stock price index of US and Japan have a significant and negative impact on Egypt equity index this in turn means that when the stock price increase in US and Japan it will be followed by decline in the Egyptian stock price index. These lagged price changes may be employed to predict the current price changes in the first market through any error correction which may exist in order to bring the market into equilibrium over the long term. This indicates that the Individual equity market indices are becoming responsive to both regional and global influences, and the potential benefits from international risk diversification may have gradually diminished between these studied markets. The changes in price index in each of African stock market is significantly and positively affected by the lagged changes in its own index, this means that the market decline is followed by market decline for some time and the market increase is followed by market advance for some period of time.

The results show that most of the negative relationships are observed between African countries with the developed markets, while the positive relationships are found in the case of the African stock markets among themselves. The positive relationship between the price changes in the case of the African stock markets among themselves might be due to the fundamental causes including trade and financial linkages among these countries' economies and to common shocks, as the African countries have increased the cooperation and the trade among themselves since 1990s. If for example, Egypt exports significant part of its production of cars to South Africa, a shock to South Africa (that causes decrease in demand for cars) will negatively affect the revenues of automobile industry in Egypt and thus the prices of automobile related stocks in Egypt will decline. The negative relationship in the price changes between the stock indices of African markets and those of developed markets is due to the investors behavior (such as speculation, the investors' expectations about future profitability of underlying firms), as the investor around the world always considers the African stock markets as an opportunity for diversifying their portfolio to gain more return at lower risk.

Table 4: VECM results for entire period, 2/06/2004 to 30/04/2014

Regressors		Equation for the Price for each stock market (dependent market)							
Index	Lag	EGX30	FTSE/JSE	LASI	MADEX	NASI	NSE_ASI	ΔEMDEX	TUNIDEX
ΔEGX30	1	0.131* [6.31]	0.194* [2.71]	0.007 [1.35]	0.041* [3.35]	0.023** [2.17]	0.003 [1.22]	0.0004 [0.61]	0.051** [2.25]
	2	0.058* [2.78]	0.095 [1.43]	0.002 [1.21]	0.024*** [1.91]	0.014 [1.37]	0.001 [0.87]	0.0017 [1.03]	0.007 [1.17]
ΔFTSE/ JSE	1	0.02** [2.14]	0.099* [3.09]	0.019** [1.94]	0.003 [0.926]	0.0053 [1.11]	0.003** [2.12]	0.0012 [0.71]	0.0042 [0.69]
	2	0.033* [3.48]	0.033 [1.39]	0.003 [0.892]	0.007 [1.31]	0.0048 [0.99]	0.001 [0.89]	0.004 [1.36]	0.019*** [1.91]
ΔLASI	1	0.007 [0.77]	0.305** [2.23]	0.049** [2.39]	-0.024 [-1.02]	0.005 [0.92]	0.0002 [0.25]	0.0013 [0.97]	0.013 [1.31]
	2	0.069*** [1.783]	0.112 [1.28]	0.085* [4.17]	0.026 [1.11]	0.031 [1.47]	0.0062 [1.14]	0.002*** [1.78]	0.061 [1.38]
ΔMAD- EX	1	0.086** [2.41]	0.256** [2.07]	0.016 [0.875]	0.225* [10.47]	0.046** [2.49]	0.014* [2.92]	0.0017 [1.41]	0.018 [0.96]
	2	0.037 [1.02]	-0.078 [-1.36]	0.044** [2.36]	0.055** [2.52]	0.014 [1.26]	0.004 [0.83]	0.004 [1.58]	0.067*** [1.67]
ΔNASI	1	0.036 [0.922]	0.136 [1.01]	0.024 [1.23]	0.049** [2.12]	0.303* [14.9]	0.0036 [0.97]	0.0018 [1.39]	0.021 [0.97]
	2	0.025 [0.621]	0.171 [1.23]	0.048** [2.31]	0.028 [1.16]	0.03*** [1.68]	0.0081 [1.48]	0.0017 [1.29]	0.068 [1.54]
ΔNSE_ ASI	1	-0.012 [-0.84]	-0.056 [-1.52]	0.108 [1.41]	0.07 [1.17]	0.025 [1.23]	0.341* [16.7]	0.002 [0.86]	-0.231 [-1.40]
	2	-0.072 [-1.46]	0.989** [1.82]	0.029 [1.02]	0.078 [1.28]	0.043 [0.93]	0.128* [5.99]	0.003 [0.78]	0.051 [1.09]
ΔSEM- DEX	1	0.075 [1.22]	0.094 [1.39]	0.038 [1.12]	-0.545 [-1.48]	0.139 [1.43]	0.184** [2.21]	0.189* [9.31]	0.043 [1.36]
	2	0.018 [0.617]	0.031 [1.14]	0.736** [2.28]	-0.029 [0.77]	0.079 [1.12]	0.068 [1.12]	-0.067 [-0.97]	0.184** [2.14]
ΔTUNI- DEX	1	0.142 [1.51]	0.015 [1.32]	0.02** [2.03]	0.017 [1.52]	0.006 [0.96]	0.0031 [1.19]	0.0013** [2.12]	0.128* [5.92]
	2	0.115 [1.27]	0.109 [1.61]	0.012 [1.16]	0.014 [1.23]	0.003 [0.77]	0.0037 [1.39]	0.001 [1.54]	0.048** [2.23]
ΔN225	1	-0.191* [-2.97]	-0.004 [-1.35]	-0.047** [-2.29]	-0.054** [-2.28]	0.004 [1.48]	-0.0005 [0.92]	-0.0036* [-2.71]	0.003 [0.79]
	2	-0.038 [-1.05]	-0.009 [-1.19]	-0.025 [1.32]	-0.003 [-1.58]	0.007 [0.89]	0.008*** [1.66]	-0.0042* [-3.42]	0.002 [0.95]
ΔFTSE- 100	1	-0.069 [-1.31]	-0.065* [-3.64]	0.003 [0.89]	-0.016** [-2.19]	-0.003 [-1.12]	-0.0015 [1.02]	0.004** [2.59]	-0.024* [-4.18]
	2	-0.063 [-1.15]	-0.055* [-2.93]	0.0016 [0.961]	-0.0034 [-1.26]	-0.005** [-2.03]	0.009 [1.24]	0.002 [1.17]	-0.002 [-1.11]
ΔS&P500	1	-0.312* [-9.82]	0.735* [5.88]	0.032** [1.96]	0.12* [6.34]	0.056* [3.43]	0.0012 [0.81]	0.0052* [4.97]	0.187* [5.37]
	2	-0.087** [-2.37]	0.526* [4.13]	0.012 [1.23]	0.028 [1.31]	0.051* [2.68]	0.006 [1.128]	0.001 [0.87]	0.022 [1.23]
ECT(-1)		-0.085*** [-1.88]	-0.014 [-1.29]	-0.024 [-1.51]	-0.073** [-2.11]	-0.003 [-0.87]	-0.016 [-1.46]	-0.129* [-2.85]	-0.004 [-0.81]

Note: Each column gives the Dependent variable (dependent market), while the row give the independent variable (regressor) at different lag (1and 2).

*The value in [] provides the t-statistics. *, **, *** indicate the significance at 1%, 5% and 10% respectively. The different notifications mean as follow: EGX30: Egypt, FTSE/JSE: South Africa, LASI: Zambia, MADEX:*

Morocco, NASI: Kenya, NSE_ASI: Nigeria, SEMDEX: Mauritius, TUNIDIEX: Tunisia, FTSE100: UK, N225: Japan and S&P500: US. The Δ : means difference., The horizontal and vertical variables are at first difference Δ .

The African stock markets move together in the long-run, and the disequilibrium in price caused by fundamental or non-fundamental shock is adjusted by the markets to restore the long-run equilibrium relationship. As it is evident from the results the coefficient of ECT has a correct sign (negative) and significant for three cases, i.e. these three markets have long-run relationship with the other markets and the adjustment to a long-run relationship is present between Egypt, Mauritius and Morocco with the other markets. Another explanation for the Coefficient of the error correction component (ECT) is about 8.5%, 7.3% and 12.9% of the disequilibrium in price in short-run is corrected in one day in the market of Egypt, Morocco and Mauritius respectively.

The results in the table below, indicate the overall significance of our (VECM), first the value of R^2 for all cases are quite important, so we can say that our models are good fit for all cases. Second the F-statistic value is significant since the probability is zero, means that the independent variables are jointly significant in influencing the dependent variables. Finally, the diagnostic check⁵ of the residual confirms that there is no serial correlation in our models; and our models are homoscedastic which is desired, the check of normality indicate that our residual is normally distributed, this confirm the overall significance of the models.

⁵ For brevity, we didn't report the results.

Table 5: Diagnostic check for model appropriateness for Entire sample period

Country Index	Egypt EGX30	S.Africa FTSE/JSE	Zambia LASI	Morocco MADEX	Kenya NASI	Nigeria NSE_AS I	Mauritius SEMDE X	Tunisia TUNIDE X
R-squared Adj. R ²	0.1692 0.1425	0.1456 0.1182	0.1015 0.0802	0.115 0.0865	0.226 0.2011	0.2441 0.2198	0.1365 0.1087	0.1984 0.1726
F-statistic	8.002	6.991	3.379	5.006	10.116	13.27	6.255	4.850
Prob. (F-stat)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
No. obs.	2527	2527	2526	2527	2527	2526	2526	2527
No. Parameter	17	12	13	10	13	9	15	16

➤ Pre-crisis period results

The results of the following table (table 6) indicate that the individual equity market indices respond to both regional and global influences; as it is evident from the results that, the change in asset price in each market is significantly affected by lagged change in its own index in previous days as well as by the lagged change in the price index of at least three of the other markets. For example, the contemporaneous changes in the equity market of South Africa is positively influenced by the lagged value of its own performance in previous day as well as with lagged price change of equity index of Mauritius, Nigeria, Tunisia, UK and US and Zambia; this means that when there is an increase/decline in the price index in previous days in these markets the South Africa stock index goes up/goes down, in addition, the increase/ recession in South Africa stock index in previous days cause a continuous increase/recession in this market stock price for a quite long time. The results also show that the changes in price index in each of African stock market is positively affected by the lagged changes in its own index, this means that in each market, a market decline is followed by market decline for some time and the market increase is followed by market increase for some period of time. These lagged price changes may be employed to predict the current price changes in the first market; this indicates that the potential benefits from international risk diversification may have gradually diminished between these studied markets.

The results also show that the relationship may be positive or negative, but, most of them are positive. The negative relationships are observed between African countries with the developed markets, while the positive are found in the case of the African stock markets among themselves. The positive relationship between the lagged price changes in the other African stock markets on the given market might be the result of the liberalization policies adopted by the African countries recently as well as the increasing in cooperation and trade among these countries. As when the economy of one country does well the economy and stock market of the other countries do well. The negative relationship is due to the investors' behavior and to the difference in the economic and financial structure among these countries.

The disequilibrium in price in short-run is cleared by the market to restore the long-run equilibrium as shown in the results the lagged ECT is significant and negative in three case. The Coefficient of ECT(-1) indicate that about 9.2%, 10.1% and 12.8% of this disequilibrium is corrected in one day in market of Egypt, Morocco and Mauritius respectively.

Table 6: VECM results for pre-crisis period, 2/06/2004 to 28/08/2008

Regressors		Equation for the price for each stock market (dependent market)							
Index of	Lag	EGX 30	FTSE/JSE	LASI	MAD-EX	NASI	NSE-ASI	SEM-DEX	TUNIDEX
EGX30	1	0.126* [3.95]	-0.074 [-1.12]	0.01 [0.86]	0.03*** [1.89]	0.021 [1.21]	0.003 [1.06]	0.008 [1.09]	0.029 [1.51]
	2	0.032 [1.21]	-0.064 [-0.973]	0.004 [0.07]	0.011 [0.94]	0.0019 [0.91]	0.006 [1.26]	0.018** [2.04]	0.03 [1.55]
FTSE/JSE	1	0.063* [3.88]	0.115** [2.41]	0.007 [0.63]	0.002 [0.89]	0.013 [1.45]	0.017* [3.04]	-0.004 [0.86]	0.017*** [1.73]
	2	0.026 [1.57]	0.008 [0.77]	0.011 [1.46]	0.003 [0.93]	0.006 [0.67]	0.003 [1.29]	0.003 [1.16]	0.014 [1.47]
LASI	1	0.025 [0.98]	0.056* [2.88]	0.024 [1.17]	0.042 [1.19]	0.023 [0.65]	0.026 [1.21]	0.003*** [1.68]	0.015 [0.91]
	2	0.12*** [1.88]	0.023 [1.11]	0.107* [3.41]	0.084** [2.38]	0.038 [1.15]	0.031 [1.56]	0.0008 [0.64]	0.014 [0.86]
MAD-EX	1	0.11*** [1.85]	0.014 [0.79]	0.007 [0.95]	0.218* [6.67]	0.048 [1.47]	0.003 [1.13]	0.002 [1.42]	0.039 [1.09]
	2	0.014 [1.22]	0.023 [0.92]	0.05*** [1.84]	0.067** [2.02]	0.007 [0.71]	0.01 [1.48]	0.0006 [0.83]	0.003 [0.71]
NASI	1	0.10*** [1.77]	0.012 [0.71]	0.012 [1.46]	0.084* [2.68]	0.199* [6.34]	0.011 [1.25]	0.002 [1.43]	0.0018 [0.52]
	2	0.048 [1.18]	0.023 [1.33]	0.04*** [1.82]	0.025 [0.83]	0.074** [2.36]	0.006 [1.1]	0.0024 [1.57]	0.028 [0.83]
E - A	1	0.38*** [1.85]	0.061*** [1.74]	0.0016 [0.61]	0.235** [2.12]	0.007 [0.94]	0.361* [11.34]	0.004 [0.82]	0.194 [1.58]

Interdependence of African Stock markets

	2	0.046** [2.12]	0.029 [1.42]	0.014 [1.31]	0.19*** [1.65]	0.016 [1.13]	0.118* [3.47]	0.008 [1.39]	0.26*** [2.02]
SEM- DEX	1	0.017 [1.35]	0.011 [1.48]	0.071 [1.27]	0.014 [0.93]	0.013 [0.93]	0.33*** [1.84]	0.036 [1.15]	0.0038 [1.45]
	2	0.446* [3.75]	0.051** [2.14]	0.119* [3.75]	0.828* [2.86]	0.006 [0.75]	0.059 [1.03]	0.069** [2.15]	0.175* [3.09]
TUNI- DEX	1	-0.038 [-0.78]	0.357** [2.19]	0.012 [0.94]	0.041 [1.39]	0.05*** [1.68]	0.004 [0.84]	0.0004 [0.92]	0.12* [3.68]
	2	0.098*** [1.79]	0.022 [1.36]	0.017 [1.05]	0.014 [1.16]	0.004 [1.03]	0.011 [0.92]	0.002** [1.89]	0.05*** [1.68]
N25	1	-0.013** [-2.53]	-0.001 [-0.72]	-0.015** [-2.31]	-0.04*** [-1.85]	0.01*** [1.75]	-0.0004 [-0.81]	-0.013* [-3.06]	0.004*** [1.67]
	2	-0.002 [-0.16]	-0.005 [-1.25]	-0.003 [1.35]	-0.026 [-1.28]	0.007 [0.75]	-0.0005 [-1.1]	-0.0052 [-0.81]	0.005** [2.24]
FTSE 100	1	-0.012 [-1.45]	0.041*** [1.66]	0.002 [0.44]	-0.001 [-0.93]	-0.02*** [-1.85]	-0.006 [-0.98]	0.003 [1.09]	0.001 [0.72]
	2	-0.004 [-1.08]	-0.014 [-1.33]	0.005 [1.23]	0.007 [1.44]	-0.01*** [-1.71]	-0.015 [-1.13]	0.004 [1.16]	0.004 [0.93]
S&P 500	1	0.378* [6.69]	0.787* [12.43]	-0.057* [-2.13]	0.112* [3.69]	0.017 [1.11]	-0.02** [-2.38]	0.0004 [0.93]	0.133* [3.98]
	2	0.073 [1.12]	0.619* [3.55]	0.003 [0.91]	0.01 [0.82]	0.06*** [1.74]	-0.021** [-2.11]	0.0016 [1.09]	0.027 [0.96]
EC T(-1)		-0.09*** [-1.93]	-0.032 [-1.26]	-0.047 [-1.41]	-0.10*** [-1.79]	-0.013 [-1.13]	-0.006 [-1.01]	-0.128* [-3.09]	-0.009 [1.1]

Note: same as the table 5. The horizontal and vertical variables are at first difference Δ .

➤ Post-crisis period results

The contemporaneous change in equity index in each market is significantly affected by the lagged changes of its own index in previous days as well as lagged price change in the equity index of at least two of the other markets. These results confirm that the information affecting asset pricing in each market are not purely domestic in nature but to considerable extent international. For example, the price change in Morocco stock index is positively affected by its own lagged value as well as lagged changes in the equity index of Egypt, South Africa, Tunisia, and US, this means that these markets move together and in the same trend; furthermore, the increase/recession in Morocco stock index in previous days cause a continuous increase/recession in this market stock price for a some period of time. In other hand, the lagged change in stock index of UK has a significant and negative impact on Morocco equity index this in turn means that when the stock price increase in UK it will be followed by decline in the Morocco stock price index. The results also show that the changes in price index in

each of African stock market is positively affected by the lagged changes in its own index, this means that in each market a market decline is followed by market decline for some time and the market increase is followed by market increase for some period of time. These lagged price changes may be employed to predict the current price changes in the first market; this indicates that the potential benefits from international risk diversification may have gradually diminished between these studied markets

Overall, the results show that the change in asset price in each of African stock market is positively affected by the lagged price change on the other African markets, and negatively affected by the lagged price change in the developed markets. The positive relationship indicate that there are some factors that make the stock price indices to move in the same trend, such as the close trade relationship, the liberalization policies adopted by most of the African markets, and to the possibility of foreign investors to buy equities in locally listed companies, all these factors have increased the investment across the region and capital flow, this led to a similar movement in equities index in African countries (have same trend). The negative relationship is due to the investors' behavior, especially in this period (turbulence caused by crisis) in which the behavior of investors are prevailing the other cause of comovement across markets.

In post-crisis period the disequilibrium in price in short-run is adjusted by the markets to restore the long-run equilibrium in fairly rapid fashion compared to pre-crisis, as shown by the coefficient of ECT is negative and significant for all cases except Kenya. It is observed that, 15.7%, 5.8%, 11.4%, 9.2%, 10.9%, 12.5% and 8.3% of the disequilibrium is adjusted in one day in the market of Egypt, South Africa, Zambia, Morocco, Nigeria, Mauritius and Tunisia respectively.

Interdependence of African Stock markets

Table 7: VECM results for post-crisis period, 16/09/2008 to 30/04/2014

Regressors		Equation for the price for each stock markets (dependent market)							
Index of	Lag	EGX30	TSE/JSE	LASI	MADEX	NASI	NSE_ASI	SEMDEX	TUNIDEX
EGX30	1	0.137* [5.07]	0.039 [1.04]	0.02 [0.93]	0.029*** [1.73]	0.028** [2.09]	0.005 [1.5]	0.0002 [0.31]	0.059 [1.56]
	2	0.073* [2.7]	0.132 [1.25]	0.008 [0.61]	0.038** [2.27]	0.028** [2.06]	0.006 [1.61]	0.0086 [0.89]	0.04 [1.05]
FTSE/JSE	1	0.005 [1.04]	0.073*** [1.65]	0.007 [1.44]	0.009 [1.1]	0.003 [0.46]	0.001 [0.71]	0.005 [1.2]	0.023 [1.47]
	2	0.034* [3.015]	0.068 [1.56]	0.005 [0.79]	0.021* [2.89]	0.004 [0.89]	0.0009 [0.58]	0.004 [1.04]	0.025 [1.59]
LASI	1	0.021 [1.14]	0.013 [0.71]	0.059** [2.21]	0.013 [0.92]	0.005 [0.56]	0.001 [1.06]	0.002 [1.21]	0.008 [0.91]
	2	0.036 [1.44]	0.018 [0.96]	0.025 [1.19]	0.009 [0.72]	0.019 [0.81]	0.01*** [1.78]	0.0019 [1.07]	0.12*** [1.86]
MAD-EX	1	0.064 [1.39]	0.025 [1.44]	0.017 [0.96]	0.202* [6.93]	0.018 [1.12]	0.017* [3.11]	0.003*** [1.87]	0.064 [0.99]
	2	0.098** [2.12]	0.093 [0.91]	0.006 [0.82]	0.007 [1.16]	0.024 [1.29]	0.001 [0.27]	0.0014 [0.89]	0.096 [1.46]
NASI	1	0.042 [1.13]	0.444** [2.13]	0.04*** [1.71]	0.024 [0.71]	0.398* [10.77]	0.008 [1.29]	0.0009 [0.49]	0.041 [0.84]
	2	0.052 [1.34]	0.051 [1.12]	0.046 [1.46]	0.02 [0.54]	0.029 [1.07]	0.007 [1.04]	0.0004 [0.21]	0.102 [1.26]
NSE_ASI	1	0.499** [2.26]	0.274* [2.68]	0.118 [1.29]	-0.169 [-1.21]	0.016 [0.94]	0.265* [9.95]	0.006 [0.76]	0.24 [1.37]
	2	-0.014 [-1.16]	-0.083 [-1.19]	0.25** [2.03]	-0.148 [-1.03]	0.081 [0.95]	0.129* [4.73]	0.009 [1.12]	0.196 [1.16]
SEM-DEX	1	0.26*** [1.71]	0.014 [0.92]	0.054 [1.35]	-0.0547 [-1.16]	0.195 [0.52]	0.16*** [1.87]	0.264* [9.96]	0.025 [0.85]
	2	0.016 [0.90]	0.003 [0.75]	0.019 [0.95]	-0.016 [-0.84]	0.121 [0.71]	0.054 [0.59]	0.021 [0.76]	0.031 [1.22]
TUNI-DEX	1	0.028 [1.37]	0.009 [0.81]	0.013 [1.17]	-0.027** [-2.05]	0.005 [0.46]	0.003 [1.41]	0.006 [0.84]	0.137* [4.73]
	2	0.029 [1.42]	0.033 [1.14]	0.011 [0.98]	0.014 [1.11]	0.008 [0.78]	0.0027 [1.07]	0.009 [1.29]	0.045 [1.55]
N225	1	-0.071* [-3.31]	-0.081 [-1.44]	0.034 [0.91]	0.027 [0.71]	0.157 [0.97]	0.0008 [0.39]	0.001 [0.63]	0.011 [0.93]
	2	-0.002 [-1.06]	-0.041 [-0.92]	0.184 [1.01]	-0.062 [-0.83]	0.271 [1.6]	0.029 [0.71]	0.004 [0.86]	0.024 [1.15]
FTSE100	1	0.007 [1.11]	-0.099* [-3.8]	-0.002 [-0.65]	-0.015* [-3.57]	0.003 [0.41]	-0.0013 [-1.61]	0.001* [3.09]	-0.045* [-4.77]
	2	0.003 [0.89]	-0.086* [-3.14]	-0.002 [-0.91]	-0.013* [-3.02]	0.013 [0.91]	-0.001 [-1.24]	0.002 [0.67]	-0.003 [-0.72]
S&P500	1	0.226* [5.81]	0.619* [5.71]	0.065* [3.07]	0.154* [6.25]	0.062* [3.41]	0.011** [2.39]	0.004* [2.85]	0.236* [4.3]
	2	0.043 [0.91]	0.068* [2.89]	0.015 [0.91]	0.009 [0.92]	0.02 [0.86]	0.003 [0.96]	0.0016 [0.99]	0.011 [0.66]
ECT (t)		-0.157* [-4.43]	-0.058*** [-1.69]	-0.114* [-2.96]	-0.092* [-2.69]	-0.018 [-1.29]	0.109* [2.81]	-0.125* [-5.32]	-0.08*** [-1.81]

Note: same as the table 5. The horizontal and vertical variables are at first difference Δ .

Diagnostic check for the two sub-periods

The diagnostic check of the models for the two sub-periods shows the value of R^2 for all cases are quite important, this imply that our models are good fit for all cases. However, in the second sub-period, we observe a decrease in the value of R^2 for all cases; the plausible explanation is that, in this period there are other factors that explain the stock price fluctuations in addition to our variables. In both sub-periods, the values of F-statistic are significant since the probability is zero; means that all the independent variables are jointly significant at 1% level, and they can influence the dependent variables. Finally, the diagnostic check of the residual confirms that there is no serial correlation in our models; the residual are homoscedastic, and the residual is normally distributed, this confirms the overall significance of the models, in both sub-periods.

Table 8: Diagnostic check for model appropriateness for pre-crisis period

Country Index	EGX30	FTSE/JSE	LASI	MADEX	NASI	NSEASI	SEMDX	TUNIDEX
R-square	0.2413	0.2406	0.1793	0.1838	0.2597	0.2795	0.1685	0.1462
Adj-R ²	0.1815	0.1807	0.1446	0.1694	0.2214	0.2527	0.133	0.1152
F-statistic	4.7915	5.1324	8.3287	5.117	4.015	6.5313	2.4087	4.2364
Prob. (F-stat)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
No. obs.	1074	1074	1073	1074	1074	1074	1072	1074
No. Parameter	10	11	10	14	9	9	14	13

Table 9: Diagnostic check for model appropriateness for post-crisis period

Country Index	EGX30	FTSE/JSE	LASI	MADEX	NASI	NSEASI	SEMDEX	TUNIDEX
R-square	0.1495	0.127	0.1423	0.1054	0.2335	0.2335	0.1746	0.1189
Adj-R ²	0.1289	0.1095	0.1181	0.0837	0.2123	0.2149	0.1546	0.0925
F-statistic	7.2212	5.0888	4.4992	4.8840	12.386	12.587	3.897	2.7594
Prob. (F-stat)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
No.obs.	1440	1440	1440	1440	1440	1440	1440	1440
No. Parameter	13	9	7	12	6	9	7	8

4. Conclusion

In this paper we analyzed the long- and short-run linkages among the stock market indices of the eight African countries (Egypt, Kenya, Mauritius, Morocco, Nigeria, South Africa, Tunisia and Zambia). This analysis was conducted using multivariate cointegration analysis in a VECM with daily stock prices data over an 11 years period from 2004 to 2014. To date the existent studies in this area have focused on developed and emerging markets; the African markets have mostly been ignored. Since the results from studies on developed markets cannot be automatically extracted to emerging and developing markets due to their difference in business and financial environment; so, in this study we focused on the African markets as these markets are recently adopted liberalization policies and the opening to international investment. The empirical finding suggests that:

- (i) The eight African markets have a long-run equilibrium relationships among themselves as well as with the developed stock markets (Japan, UK, US), this means that African stock markets are interdependent in the economic sense, this interdependence might be due to the economic link among the countries as well as to the financial harmonization policies in the region which is the result of the formation of the African Security Exchange Association (ASEA). The degree of interdependence among the markets vary across period, as we found only one cointegrating vector among the African stock markets in pre-crisis period, while in the period post-crisis the African stock markets show three cointegration relationship, this means that the financial crisis had changed the level of market interaction in Africa. The finding is in agreement with previous studies which show that interaction among the markets increased due to the global events see for example, (Bowman & Comer, 2011), (Merici, Kim, Kim, & Merici, 2008).
- (ii) The changes in price in one market is significantly affected by lagged price changes in other markets, this means that, the news affecting asset pricing are not purely domestic in nature but, are global. Overall, the results show that the change in asset price in each of African stock market is positively affected by the lagged price change on the other African markets, and negatively affected by the lagged price change in some of the

developed markets. When there is a short-term disequilibrium in prices, the market adjusts it and restore the long-run equilibrium, as it is evident from the coefficient of ECT (speed of adjustment) has a correct sign (negative) and significant for some cases.

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Interdependence of African Stock markets

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