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Time-varying world integration of the African stock markets: a Kalman filter approach

Abstract

The paper examines the time-varying world integration of African stock markets. The authors analyze the daily returns of Morgan Stanley Capital International (MSCI)/International Finance Corporation (IFC) return indices for eleven African countries from May 2002 to May 2011. The adjusted pricing error from an equilibrium international asset pricing model is used as market integration measure. The Kalman filter technique was employed to capture the time-varying degree of market integration and allows for dynamic change in global risk premium.

The paper observed that African stock markets are yet to be fully integrated into global markets and the level of integration has increased after the 2008/2009 financial crisis limiting the diversification opportunities Africa stocks offer for global investors.

Keywords: financial integration, Kalman filter, capital asset pricing model.
JEL Classification: G12, G14, G15.

Introduction

The understanding of stock markets integration has received considerable attention in the academic and practitioners literature due to its importance for academics, practitioners and policymakers. The implications from theory suggest that integrated markets allow capital to flow freely to where highest returns can be generated; thereby, easing the accessibility of foreign capital. Investors and fund managers dwell on global stock market integration information for investment opportunities internationally to diversify their portfolios and to improve risk-adjusted returns. The improvement in global stock markets integration reduces diversification opportunities for investors but susceptible to global financial crisis. The inference from Obstfeld (1995), Bracker, Dockino and Koch (1999), Stulz (1999) and Alagidede (2009) imply that integration allows for international risk sharing, which can affect long-term economic growth by altering resource allocation and savings rates. High degree of market segmentation increases the level of risk, and inevitably affects the local cost of capital; affecting business financing and, hence, economic growth (Bekaert, 1995; Bekaert & Harvey, 1995; and Kim and Singal, 2000). Stock market integration has been considerably studied in an attempt to look at how various markets integrate and are mostly centred on the developed markets[1].

There is enough evidence in support of the view that developed stock markets are highly integrated (Quan & Huyghebaert, 2006; Alagidede, 2009; Berger, Pukthuanthong, & Jimmy Yang, 2011). The emerging stock markets have garnered the attention of researchers due to a number of factors such as the significant economic and financial development, being source of diversification for international investors (Alagidede, 2009), ongoing financial integration processes across the continents, for example Africa (Agyapong & Adam, 2013) and the response of African stock markets to the recent Global Financial Crisis. The available literature documents that emerging stock markets are moderately less correlated with developed markets and may offer significant diversification benefits for the international investors (Bekaert & Harvey, 1995; and Yeoh, Hooy & Arsad, 2010; Neaime, 2012). In spite of the growing importance of Africa financial markets, owing to the significant economic and financial development, there is still inadequate evidence on the extent of integration of African markets with the global equity market. The two most recent studies, Alagidede (2009) and Agyei-Ampomah (2011), both documented divergent findings. The latter using global market indices observed that Africa markets are segmented while the former reported that the Africa stock markets are less integrated but not completely isolated from the rest of the world proxy by the markets of Brazil, Mexico, India, Japan, the United Kingdom and the United States. However, the contagious effects suffered by most African stock markets from the global financial crisis seem not to support these findings (see Arieff, 2010). Apart from Tunisia whose Tunindex made a gain of 0.42% between July, 2008 and February, 2009; all major African stock markets saw the value of their indices dropping in proportion similar to the major global stock indices like Dow Jones Industrial (USA), CAC 40 Index (France) and Nikkei 225 Index (Japan) (Kasekende, Ndikumana & Rajhi, 2009). The case of Egypt and Nigeria were alarming; the

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[1] See Sharma and Seth (2012) for details of a synthesis of stock market integration studies.

market indices of Egypt and Nigeria lost more than 50% of their values between the same periods. These revelations suggest that African stock markets could be integrated with the rest of the world and therefore further investigation is required. It should be noted that the previous studies relied on static assumptions, which do not consider the time-varying nature of the underlying fundamentals. And since integration is a process, static models subsume structural stability and will reject integration if the integration is in the process. Again, the studies either examine market correlation, long-run cointegration or volatility transmission to indirectly infer the stock market integration hypothesis, which does not really comply with the definition of market integration as implied by Bekaert and Harvey (1995). That is, a stock market is completely integrated with the world stocks if its assets have the same expected return as the assets with identical risk levels listed in major global markets.

This paper, therefore, examines the degree of African stock market integration with the rest of the world from the viewpoint of adjusted pricing error from an equilibrium international asset pricing model. Our study is unique in the sense that we estimate stochastically time varying coefficients to allow for dynamic structural change to model unobserved deterministic or stochastic causes of parameter changes. This allows the data to reveal shifts or the transitional dynamics in the integration process.

The rest of the paper is structured as follows: Section one looks at the market integration measure and estimation technique. Data sources and properties are discussed in Section two. Estimation of the market integration is presented in Section three and concluded in Final Section.

1. The measure for market integration and estimation

The Capital Asset Pricing Model (CAPM) by Sharpe (1964) and Lintner (1965) describes the expected market rate of return of a specific asset in relation to the expected risk. The Sharpe-Lintner version of CAPM postulates a stable linear relationship between the expected excess return and non-diversifiable risk of holding financial asset. We followed Yeoh, Hooy and Arsad (2010) to extend the domestic CAPM to international settings, and write a single factor international CAPM (ICAPM) as:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i (R_{w,t} - R_{f,t}) + \mu_{i,t}, \quad (1)$$

where $R_{i,t}$ and $R_{w,t}$ are the returns for i^{th} market portfolio and world portfolio respectively; $R_{f,t}$ is the international risk free rate; t is the time and μ_{it} is the residual. Under the hypothesis of stock market integration, a_i represents the pricing error instead of it being a measure of stock selection skills and market timing by mutual fund manager as in CAPM. In the case of complete integration, we expect a_i to be equal to zero. Following Levine and Zervos (1998), adjusted market integration index (MII) is constructed as:

$$MII_i = -\left|\hat{\alpha}_i\right| \ \forall \ MII \le 0, \quad (2)$$

where the upper bound of adjusted market integration index, zero, signifies perfect integration with global stock market.

1.1. Kalman filter. As argued by Adam, Agyapong and Gyamfi (2010), and Adom (2013), static models like equation 1 does not allow the data to reveal shifts or the transitional dynamics in the estimated relationship. In particular, a static model for market integration may not be plausible from economic and financial viewpoint because market integration is more of a process than an event. We therefore formulate time varying ICAPM with time varying parameters as follows:

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_{i,t} (R_{w,t} - R_{f,t}) + \mu_{i,t}, \quad (3)$$

where $a_{i,t}$ and $\beta_{i,t}$ are the time varying parameters. To obtain the estimate of these time varying parameters, we formulate the following state space models:

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_{i,t} (R_{w,t} - R_{f,t}) + \mu_{i,t}, \quad (4)$$

$$\alpha_{i,t} = \alpha_{i,t-1} + \psi_{i,t}, \quad (5)$$

$$\beta_{i,t} = \beta_{i,t-1} + \eta_{i,t}. \quad (6)$$

Equation (4) is the measurement or observation equation, equations (5) and (6) are the state or transition equations. The $\mu_{i,t}$, $\psi_{i,t}$ and $\eta_{i,t}$ are error term that are assumed to be normally distributed with zero mean and constant variance; serially uncorrelated and independent of each other. Kalman filter[1] is employed to estimate the time varying coefficients. The time varying adjusted market integration index is specified as:

$$MII_{i,t} = -\left|\hat{\alpha}_{i,t}\right| \ \forall \ MII \le 0. \quad (7)$$

In this case, dynamics of the integration process may be traced over time.

2. Data source and properties

The data employed in this study are the daily indices for ten African stock markets: Botswana,

[1] For detail discussion of Kalman filter specification and estimation procedure, see Inglesi-Lotz (2011), and Kleeman (1996).

Cote d'Ivoire, Egypt, Ghana, Kenya, Mauritius, Morocco, Namibia, Nigeria, South Africa, Tunisia and Zimbabwe. The indices were obtained from Morgan Stanley Capital International (MSCI). The MSCI All-Country World Index is used as a proxy for the global portfolio. All indices were obtained from DataStream. The daily yields on the US three-month Treasury bill rate are used as the international risk free rate extracted from IMF-IFS database. All the indices were in US dollars and cover the period between 31/05/2002 and 02/05/2011. The continuous compounded returns of the indices with $P_{i,t}$ as the price index of market i at time t, $R_{i,t}$, is calculated as follows:

$$R_{i,t} = ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right)x100. \quad (8)$$

Figure 1 (see Appendix) shows the graphical representations of natural logarithms form of each of the stock market series. It is clear from Figure 1 that the African exchanges closely followed the global market, all experienced upward trend from 2002 till mid 2007 except Ghana which experienced some downward trend from the ending of 2004 to early 2006. The impact of the 2008 global financial crisis can be seen around 2008/2009 as in Figure 1. Almost all the exchanges of Africa like the global index experienced a sharp downward spike except Tunisia which saw its price index appreciated. The degree of intensity varies from country to country; Nigeria for example was badly hit and recovery thereafter is relatively slow compared to the global recovery. In general, all the markets seem to show upward trend after 2009.

Table 1 presents the summary statistics of stock returns of the market used in this study. The arithmetic mean of the returns of Africa stocks are generally higher than the global average and growth in the returns are also high for African stocks. The growth rate of global stock over the period is 0.013% which is less than half the least growth rate recorded among African stocks, which is 0.028% for Nigeria. The implication is that gains from holding Africa stocks are higher than the global average and that Africa stocks behave differently from the global market. However, the standard deviation, skewness and Kurtosis show that the daily distributions of the Africa stocks were not different from the global stock distribution. The correlation coefficients between Africa stocks and global All-index shows weak correlation except South Africa, indicating possible segmentation of Africa stocks from that of the world.

Table 1. Summary statistics of stock return from 2002 to 2011

Market	Arithmetic mean	Geometric mean	Std. dev.	Skewness	Kurtosis	Correlation coefficient with MSCI All-Index	Observations
Botswana	0.027	0.032	1.134	1.503	59.724	0.219	2264
Cote d'Ivoire	0.071	0.058	1.165	6.344	75.923	-0.01	2264
Egypt	0.086	0.081	1.866	-0.881	11.084	0.209	2264
Ghana	-0.013	0.033	0.957	-2.013	40.718	-0.003	2264
Kenya	0.050	0.050	2.805	1.208	469.725	0.029	2264
Mauritius	0.075	0.080	1.350	0.218	14.424	0.132	2264
Morocco	0.053	0.053	1.200	-0.380	6.862	0.287	2264
Namibia	0.047	0.048	1.266	1.235	37.130	0.335	2264
Nigeria	-0.001	0.028	1.493	-0.245	6.207	-0.002	2264
South Africa	0.053	0.041	2.033	-0.430	8.086	0.674	2264
Tunisia	0.043	0.029	1.043	0.217	10.675	0.216	2264
MSCI world index	0.018	0.013	1.149	-0.474	12.375	1.000	2264

3. Estimation of the market integration

We begin the investigation by first estimating the time invariant ICAPM for all the countries considered in this study from Ordinary Least Squares (OLS). The static OLS estimates are presented in Table 2. The significance of all the $\beta's$ at 5% significance level except Ghana, which is significant at 10%; and absence of autocorrelation implies that ICAPM is well specified for the dataset. The market integration indexes in column six of Table 2 shows that Africa stock markets are quietly integrated with world market. The integration level varies with Nigeria having the least integration index and surprisingly followed by Tunisia because of its behavior during the global financial crisis. Another interesting finding is that of Egypt as less integrated with the world among the countries studied. These surprises are not supported by the extent of contagious effect of the global financial crisis and prices behavior over time relative to global index and are difficult to explain because of time-invariant nature of the index. We proceed to estimate the time-varying market integration index which reveals the transition in the integration.

Table 2. Results of static regression and market integration index

Market	α	β	R^2	DW-statistic	$MII_i = -\lvert\hat{\alpha}_i\rvert$
Botswana	0.031 (0.179)	0.170 (0.000)**	0.030	2.025	-0.031
Cote d'Ivoire	0.063 (0.022)	0.099 (0.027)**	0.003	2.013	-0.063
Egypt	0.089 (0.019)	0.268 (0.000)**	0.027	1.896	-0.089
Ghana	0.039 (0.129)	0.108 (0.056)*	0.003	1.918	-0.039
Kenya	0.075 (0.071)	0.881 (0.000)**	0.062	1.572	-0.075
Mauritius	0.081 (0.003)	0.131 (0.000)**	0.013	1.788	-0.081
Morocco	0.050 (0.029)	0.239 (0.000)**	0.056	1.618	-0.050
Namibia	0.048 (0.082)	0.308 (0.000)**	0.065	2.026	-0.048
Nigeria	0.020 (0.642)	0.689 (0.000)**	0.047	2.256	-0.020
South Africa	0.039 (0.219)	1.030 (0.000)**	0.371	2.274	-0.039
Tunisia	0.035 (0.173)	0.196 (0.000)**	0.046	1.807	-0.035

The Kalman filter models for each country are estimated and adjusted time-varying market integrated index is constructed. The index for each country is visually displayed in Figure 2. The numerical results are not reported because of the size but available upon request.

Figure 2 (see Appendix) shows varying integration paths of the markets considered in this study. Generally, the market integration index of all the countries fluctuated between -0.5 and 0, indicating that African markets have never been completely isolated from the rest of the world from 2002-2011. However, the degree of integration varies from country to country at each point in time as depicted by each graph. South Africa, Morocco, Nigeria and Namibia have shown to be much integrated with the world stock markets with low integration index and persistent integration path over the period under consideration. The integration index compared to the findings of Yeoh, Hooy & Arsad (2010) shows that the big shots in African stock markets are less integrated with the world than those of Asia such as Malaysia.

One interesting finding is that almost all the markets in Africa were moving closer to the world equity market prior to 2008/2009 financial crisis except Tunisia. This probably explains why the contagious effects were severe for most African countries except Tunisia (see Kasekende, Ndikumana & Rajhi, 2009). The integration deepened after the crisis and African stock markets seem to be more integrated with the world equity market. It should be noted that economic events bring about structural changes which remove inefficiencies in global equity markets. It is therefore not surprising that Africa stock markets have further integrated into the global stock market to limit the diversification opportunity for global investors.

Conclusions

In this study, we have examined the degree of Africa stock markets integration with the world stock markets from 2002-2011. The study departed from previous studies which relied on static models that measured integration as market correlation and volatility transmission by using adjusted pricing error from an equilibrium international asset pricing model as market integration measure and time-varying Kalman filter technique.

Though, we observed that African stock markets are yet to be fully integrated with global markets, it has never been completed disconnected from the global stock market. The level of integration has increased after the 2008/2009 financial crisis limiting the diversification opportunities Africa stocks offer for global investors.

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Appendix

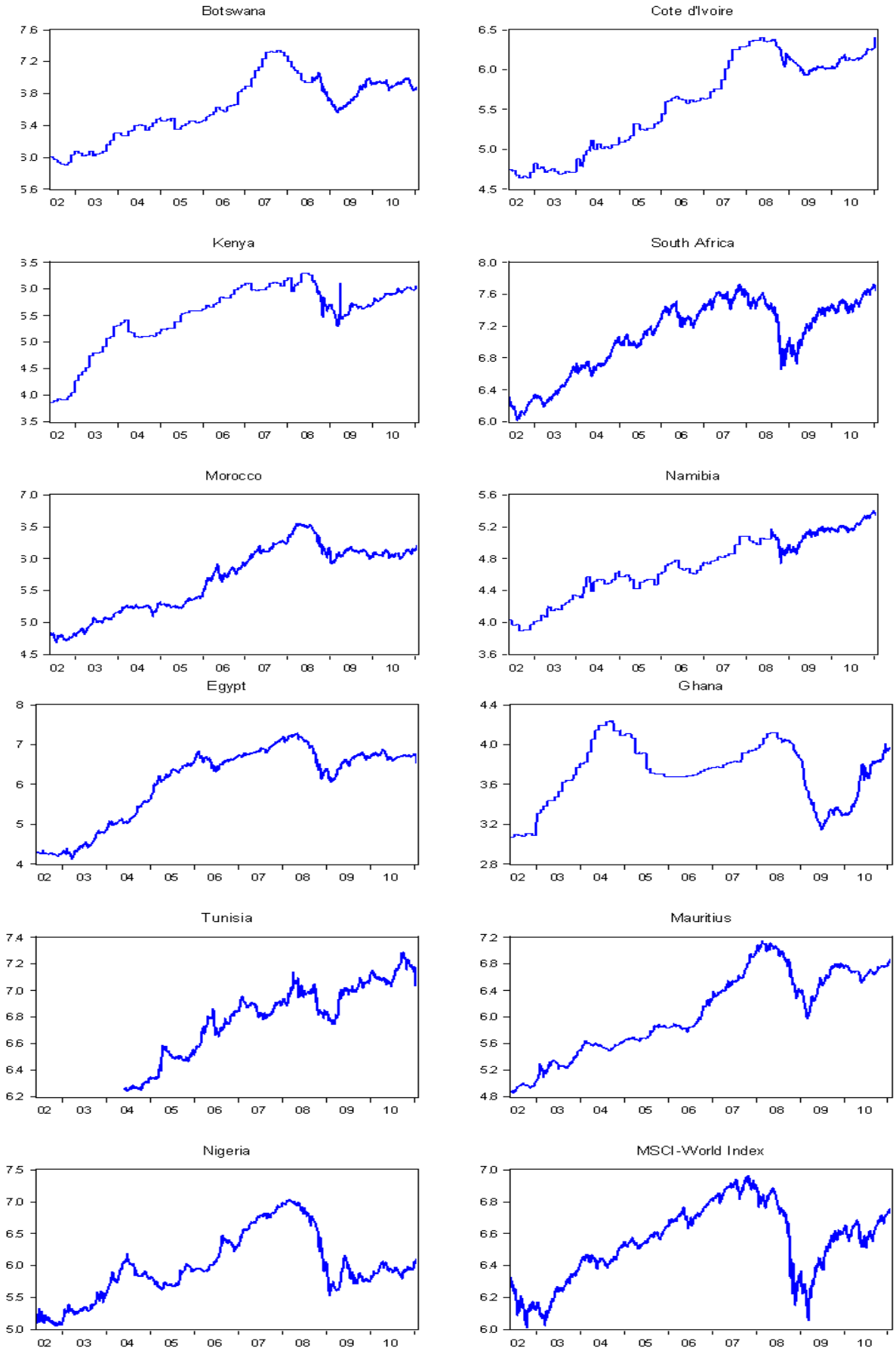

Fig. 1. Logarithms of daily stock prices

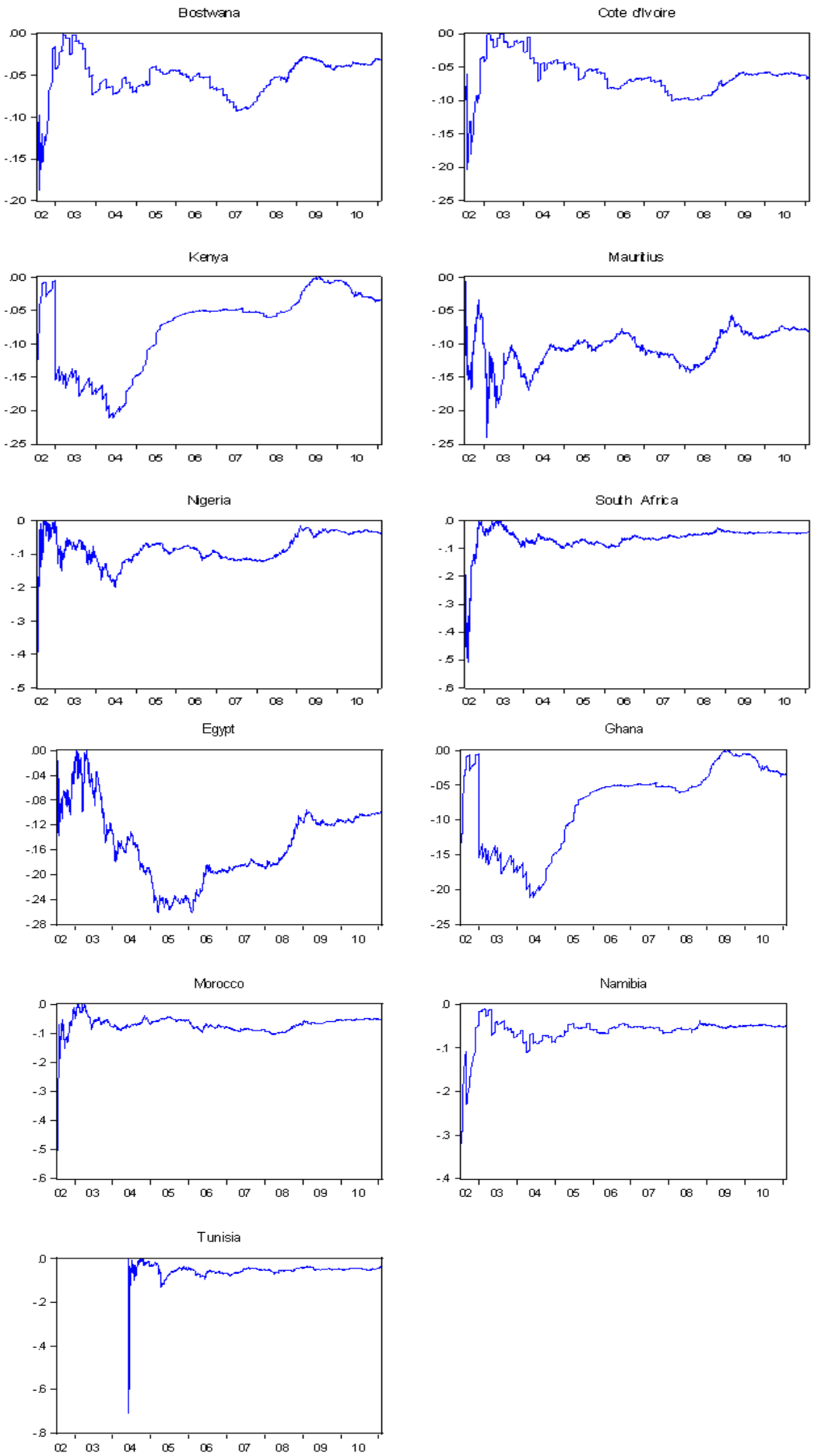

Fig. 2. Time-varying market integration index