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CONTAGION AND INTERDEPENDENCE IN AFRICAN STOCK MARKETS

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EVENTS IN EMERGING FINANCIAL MARKETS during the past decade have given rise to a fevered debate about the role of global integration in capital markets. The Mexican peso crisis of 1994, the Asian crisis of 1997 and the subsequent Russian and Brazilian crises of 1998 have provided new data with which to examine the transmission of financial variable movements from one country to another. Are African markets caught up in the same web, or are they more dependent on co-movements with each other?

When emerging markets were first becoming a viable asset class in the early 1990s, Harvey (1995) suggested that part of their initial appeal was their low correlations with developed markets. It was assumed that they would then serve neatly as a hedge in a global portfolio. But as Harvey (1995) also showed, emerging market correlations with developed markets were changing through time, as they became more integrated into the global financial system.

Most of the literature on financial markets and growth has focused on the benefits of global integration. When a market becomes financially integrated, companies can access a large new pool of investors. The cost of equity may decline and more investment projects are then viable. The result is increased growth and employment. Levine (2001) shows that liberalising restrictions on international portfolio flows tends to enhance stock market liquidity, which in turn accelerates economic growth by increasing

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productivity growth. Bekaert, Harvey and Lumsdaine (2002) suggest that global integration seems to be associated with a lower cost of capital, improved credit ratings, real exchange rate appreciation and increased economic growth. They also show that integration relies not only on liberalisation but also on the establishment of country funds and/or American Depository Receipts. This means that integration is highly dependent on increased foreign portfolio flows. To obtain those flows, it is not enough to open the market to international capital flows - it must be made easy for foreign investors to invest.

The downside to increased global integration is an increased exposure to global crises. If a country is highly integrated with global markets, its financial markets may suffer a dramatic downturn that may or may not be related to that country's own sovereign risk. Open capital accounts and increased global market integration then seem to be a mixed blessing. The advantages in relation to the cost of capital and growth are counterbalanced by vulnerability to global economic events. Economic crises usually have damaging effects on economic growth and stability.

The spread of a crisis depends heavily on the degree of financial market integration, *i.e.* that the more integrated markets are, the higher will be the contagious effects of a shock in another country. Countries that are less financially integrated, either by capital controls or the lack of access to international financing, should then be relatively immune to contagion.

At what stage of integration are the least developed of emerging markets, such as those in Africa? As Table 1 shows, African markets, with the exception of South Africa, are relatively small compared to other emerging markets, with a lower volume of transactions and fewer listed companies. In addition, many have low foreign investment ceilings and few have American Depository Receipts or country funds. Given the low level of development in these markets, one might hypothesise that they would not be subject to contagion. But which countries are developed "enough" to be vulnerable to contagion and which are not? In this study we aim to test the extent of market integration

by measuring the degree of contagion between African equity markets and global emerging equity markets. In section 1, definitions and methods of measuring contagion are reviewed. Section 2 discusses the methodology and data. Section 3 reviews results and section 4 concludes.

Table 1. Comparative indicators for emerging financial markets (1997)

Country	Market Capitalisation/GDP[a]		Value Traded/GDP[b]		Turnover Ratio[c]		No. of Listed Companies[d]		Weight in IFCI Ind[e] %
	Rank	Value	Rank	Value	Rank	Value	Rank	Value	
Argentina	6	0.582	18	0.021	21	0.048	16	127	4.87
Brazil	9	0.405	9	0.181	7	0.446	7	459	12.45
Botswana	17	0.208	20	0.010	22	0.047	25	16	-
Chile	4	0.917	13	0.092	16	0.095	12	258	6.13
Colombia	22	0.126	24	0.005	24	0.038	17	126	1.27
Egypt	11	0.343	10	0.133	9	0.361	3	1076	0.90
Ghana	19	0.154	26	0.003	26	0.014	24	22	-
Greece	3	0.984	4	0.844	5	0.604	9	329	2.26
India	13	0.310	2	1.067	3	3.065	1	5937	2.05
Indonesia	18	0.201	12	0.107	12	0.315	11	292	1.84
Kenya	21	0.128	25	0.005	25	0.035	20	57	-
Korea	7	0.420	1	2.612	2	4.448	2	1308	1.91
Malaysia	2	1.309	6	0.655	8	0.446	4	795	5.98
Mauritius	14	0.305	19	0.017	20	0.051	23	40	-
Mexico	16	0.221	14	0.080	11	0.325	15	179	14.37
Morocco	12	0.330	16	0.033	17	0.089	21	53	0.90
Namibia	24	0.111	21	0.008	23	0.044	26	13	-
Nigeria	25	0.098	22	0.006	19	0.073	14	195	-
Pakistan	23	0.119	7	0.598	1	4.869	5	762	0.74
Philippine	5	0.776	11	0.123	14	0.164	13	230	1.25
South Africa	1	1.776	5	0.671	10	0.332	6	616	12.50
Thailand	15	0.262	8	0.206	6	0.529	8	381	0.71
Tunisia	20	0.145	17	0.032	13	0.226	22	44	-
Turkey	10	0.366	3	0.943	4	1.965	10	315	4.69
Venezuela	26	0.069	23	0.006	18	0.088	18	85	1.16
Zimbabwe	8	0.413	15	0.047	15	0.113	19	69	0.06

Source: International Finance Corporation Emerging Stock Markets Factbook 1998

[a] Market Capitalisation/GDP is the market capitalisation at the end of the year divided by GDP for the year

[b] Value traded/GDP is the total value traded for the year divided by the GDP for the year

[c] Turnover ratio is the total value traded for the year divided by the average market capitalisation for the year

[d] Listed companies are the number of listed companies at the end of the year

[e] International Finance Corporation Investibles Index

1. DEFINING AND MEASURING CONTAGION

Contagion is generally defined as the spread of market disturbances from one market to another. Dornbusch, Park and Claessens (2000) separate the causes of contagion into two categories. The first type of contagion is caused by a fundamental spill-over resulting from the normal interdependence among economies. Examples of this type of contagion refer to fundamental trade and financial links between economies.

The second type of contagion cannot be attributed to fundamentals and looks to investor behaviour for an explanation. One example is that of a decline in asset prices causing large capital losses, which in turn induce investors to sell off securities in other emerging markets to raise cash for redemptions. In a similar way, investors who manage portfolios based on benchmark weightings will keep their weightings the same by selling off assets that have increased in value and thus hold too great a proportion of the portfolio. It is this type of behaviour that penalises more liquid markets. It may also be that investors are imperfectly informed or that they assume (correctly or not) that one country has the same problems as another in crisis. They may look at the actions of other investors to reach this conclusion. These information asymmetries, particularly in circumstances of high fixed costs in gathering and processing country-specific information, could lead to "herd behaviour."

Not all economists are agreed on how to measure contagion. The most common definition, and the one that is used in this paper, is that contagion is a situation in which correlations of asset prices increase during a period of turmoil. If there is an increase in the degree of correlation, it suggests that there is a strengthening of transmission mechanisms between the two countries in question. If there is no change in correlation over the period of turmoil, then there is interdependence but not contagion between the two countries. The results of interdependence and contagion during a financial crisis may be the same and perhaps equally damaging, but the causes and the relevant policy implications may

be different. As such, much of the literature on contagion has focused on making a distinction between interdependence and contagion.

The way testing methodologies fit into this definition differs. One approach tests the case where knowledge of a crisis elsewhere increases the probability of a crisis at home. This method then uses conditional probabilities to examine if the likelihood of crisis is higher in a given country when there are crises in one country or several countries. Eichengreen, Rose and Wyplosz (1996) use a probit model to test this approach and find that the probability of a domestic currency crisis increases with a speculative attack elsewhere. De Gregorio and Valdes (2001) use a similar methodology to test spill-overs of three crises and found that the Mexican crisis was the least contagious while the Asian crisis was as contagious as the 1980s crisis. They also find that debt composition and exchange rate flexibility limit the extent of contagion, while capital controls do not seem to prevent it.

Another approach is to examine whether conditional variances of financial variables are related to each other among markets in different countries during the crisis. This approach uses GARCH models to measure the spill-over in volatility - cross market movements in the second moment of asset prices. Park and Song (1999) use this methodology to test contagion during the East Asian crisis and find that the effects of the crisis in Indonesia and Thailand were transmitted to the Korean currency market, but that the Korean crisis was not contagious to them.

What seems to be the most commonly used measure of contagion is the change in the simple correlation coefficient during a period of market turmoil in one country. King and Wadhwani (1990) use this methodology to test for an increase in stock market correlations between the U.S., UK and Japan and find that correlations increase after the US market crash. Calvo and Reinhart (1996) also use this approach to test contagion in stock markets after the Mexican peso crisis. They show an increase in correlations, and therefore evidence of contagion. Frankel and Schmukler (1996) show that the prices of country funds in Latin

America and East Asia displayed a higher correlation than Mexican country funds did.

Forbes and Rigobon (2002) point out, however, that there is a bias with straightforward correlation coefficients due to heteroscedasticity in market returns. An increase in market volatility biases the estimates of cross-market correlation coefficients. After adjusting the correlation coefficient, they show that there was little evidence of contagion between stock markets during the 1987 US stock market crash, the 1994 Mexican peso crisis and the 1997 Asian crisis. The markets were still closely linked. But evidence of contagion - of a *change* in the correlation - was not found.

2. METHODOLOGY AND DATA

(a) Evidence of African Contagion

The purpose of this study is to gain a greater understanding of the relationship between African markets and global emerging equity market returns, as well as the relationships between African equity market returns. The narrow definition of contagion - a significant increase in correlation coefficients over a period of financial turmoil - is used. The adjusted correlation coefficient is calculated as per Forbes and Rigobon (2002). This approach is the most straightforward and the exercise allows us to measure not only contagion but also the existing interdependencies between global emerging markets. Our method, however, differs slightly from the Forbes and Rigobon (2002) approach. Their test statistics on determining contagion (based on the t-test) were estimated using estimated sample variances. Our test statistics, on the other hand, use exact t-tests based on actual sample correlation coefficients.

Applying the Forbes and Rigobon (2002) adjustment to the correlation coefficients, this study will measure contagion among African markets during the 1997 Asian crisis. Specifically, a case study of the Hong Kong crash on October 17, 1997 is used. The Hong Kong crash is often used as a case study because it appeared to have a widespread impact on global markets, beyond

emerging Asia. It was after this crisis that questions about the connection between investor behaviour and contagion intensified. The Hong Kong index is measured by the Hong Kong Hang Seng index.

For contagion measurement, daily data on market indices for eight African countries are used and rolling two-day averages of daily returns are calculated to allow for differing open market times. Where possible, the local benchmark index for each country is taken. The indices are converted to dollars using daily exchange rates. Using local currency data would have been an option, but Forbes and Rigobon (2002) have shown in their analysis that using dollar and local indices have similar results. The tranquil period is defined as January 2, 1997 to October 17, 1997 and the crisis period is from October 20, 1997 to November 28, 1997. To assess the relationships between African market, a lower weekly frequency and a longer time period is used to capture long term relationships.

In the first test, the log difference of all variables are examined for stationarity using the Augmented Dickey-Fuller (1979) test. The log difference of all series were stationary at the 10 per cent level, as seen in Table 2.

Table 2. Augmented Dickey-Fuller unit root tests for African stock market Indices. Results for log differences

	Tranquil Period			**Crisis Period**		
	ADF Statistic	Critical Value at 10%*	Stationary?**	ADF Statistic	Critical Value at 10%*	Stationary?**
Egypt	-5.44	-3.14	Y	-4.77	-3.22	Y
Kenya	-5.03	-3.14	Y	-5.87	-3.22	Y
Mauritius	-3.36	-3.14	Y	-3.22	-3.22	Y
Morocco	-4.16	-3.14	Y	-3.48	-3.22	Y
Namibia	-5.05	-3.14	Y	-3.91	-3.22	Y
Nigeria	-4.63	-3.14	Y	-5.45	-3.22	Y
South Africa	-5.62	-3.14	Y	-3.46	-3.22	Y
Zimbabwe (Industrials)	-4.79	-3.14	Y	-3.65	-3.22	Y
FT World Index	-4.91	-3.43	Y	-4.00	-3.22	Y
Hong Kong Hang Seng Index	-5.70	-3.43	Y	-4.17	-3.22	Y

*MacKinnon critical values for rejection of hypothesis of unit root.
**Where Y=Yes, N=No

The unadjusted and adjusted correlation coefficients are estimated between eight African markets and the Hong Kong index. The unadjusted correlation coefficients are measured by the standard definition of the correlation coefficient:

$$\rho = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \tag{3}$$

The correlation coefficient is adjusted in the following way, as per Forbes and Rigobon (2002):

$$\rho^* = \frac{\rho}{\sqrt{1+\delta[1-(\rho)^2]}} \tag{4}$$

where

$$\delta = \frac{\sigma_{xx}^h}{\sigma_{xx}^l} - 1$$

which measures the change in high period volatility against the low period volatility. To calculate the adjusted correlation coefficients, the crisis period is used as the high volatility period and the tranquil period as the low volatility period.

Using a t test based on the differences between correlation coefficients, contagion is tested. Contagion is measured by the significance of increases in correlations during the turmoil period compared with the tranquil period to test for contagion, as defined by:

$$t = (\rho_1 - \rho_2)\sqrt{\frac{n_1 + n_2 - 4}{1-(\rho_1 - \rho_2)^2}} \tag{5}$$

where

$$t_{(0.01,\, n_1 + n_2 - 4)}$$

The following hypothesis is then tested:

$$H_o : \rho_1 - \rho_2 = 0 \text{ versus } H_1 : \rho_1 - \rho_2 > 0$$

where H_o is the null hypothesis of no contagion and H_1 is the alternative hypothesis that contagion does indeed exist.

(b) Analysis of Relationships between African markets

An analysis of the relationships between African countries uses longer periods of weekly data for ten African markets. A simple correlation matrix is calculated, using an unadjusted correlation coefficient as per equation (3) for the entire time period. The correlation coefficients are not adjusted as the variances of these markets all have their own patterns: for some, the variances have increased steadily through time, for others there are pockets of higher variance. These changes in variances account for some of the changing correlations that are observed through time.

Granger causality tests (Granger, 1969; Sims, 1972) will further deepen our understanding of not only contemporaneous relationships but also causal ones. The approach is based not on the common concept of causation but on the idea that if X causes Y then changes in X should precede changes in Y. To claim that X causes Y, two conditions must be met. First, X should help predict Y and second, Y should not help to predict X. Two equations help establish whether these conditions hold. To test the null hypothesis that X does not cause Y, values of Y are regressed against lagged values of Y and lagged values of X:

$$Y = \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + \varepsilon_t \tag{6}$$

and then Y is regressed only against lagged values of Y:

$$Y = \sum_{i=1}^{m} \alpha_i Y_{t-i} + \varepsilon_t \tag{7}$$

A simple F test determines whether the lagged values of X contributed significantly to the explanatory power of the first equation. If they do, the null hypothesis is rejected and the conclusion is that X does cause Y. The Granger causality test runs simultaneous tests on both variables to determine if *(a)* the

causality is unidirectional; *(b)* both variables have feedback causality; or *(c)* both variables are independent. A test such as this, which runs two tests simultaneously with the two variables on opposite sides of the equation, is used which gives results for the null hypothesis of no causality for both variables (Pindyck and Rubinfeld, 1998).

All Granger causality tests were run on weekly data, with six lags. This was a result of running a series of tests based on different lags and determining that there was little difference in the results.

3. RESULTS

The results in Table 3 from the Forbes and Rigobon (2002) methodology using unadjusted correlation coefficients suggest that some markets, including small markets like Mauritius and Namibia, showed evidence of contagion from Hong Kong in 1997. However, the adjustment to the correlation coefficient appears to give better intuitive results. The adjusted correlation coefficients suggest that there is no evidence of contagion for any African market, with the exception of South Africa and Egypt. Intuitively, South Africa is a significant player in the emerging market arena, in terms of market capitalisation, value traded and its weight in the International Finance Corporation Investibles (IFCI) index, and therefore would be more heavily influenced by international investors. Within an African context, Egypt is the next largest market included in the IFCI index. It stands to reason that these countries would be more likely to experience contagion, perhaps via herd behaviour or a portfolio re-balancing by international investors, than the smaller markets in Africa.

When placed in the context of the findings in Forbes and Rigobon (2002), the results are contradictory. Forbes and Rigobon (2002) showed that during the 1997 Asian crisis, no emerging market suffered contagion, including South Africa. However, one reason for the difference between their findings and those in this study is due to the different method used in hypothesis testing.

Another reason is that Forbes and Rigobon (2002) used a tranquil period starting at the beginning of 1996 while this study uses a tranquil period that starts at the beginning of 1997.

Table 3. Hong Kong crisis - correlation coefficients, unadjusted and adjusted (Correlation coefficient adjustments using method described in section 2a)

Unadjusted Correlation Coefficients[a]				
	Tranquil Period[c]	**Crisis Period[d]**	**t-statistic[e]**	**Contagion[f]?**
Egypt	-0.09	0.46	10.074	Y
Morocco	-0.19	-0.53	-5.464	N
Nigeria	0.00	-0.04	-0.551	N
Zimbabwe	0.08	-0.04	-1.775	N
Kenya	0.14	0.18	0.568	N
Mauritius	-0.16	0.05	3.265	Y
South Africa	0.31	0.61	4.839	Y
Namibia	0.12	0.37	3.936	Y
Adjusted Correlation Coefficients[b]				
	Tranquil Period	**Crisis Period**	**t-statistic**	**Contagion?**
Egypt	-0.03	0.17	3.022	Y
Morocco	-0.06	-0.20	-2.056	N
Nigeria	0.00	-0.01	-0.177	N
Zimbabwe	0.02	-0.01	-0.569	N
Kenya	0.05	0.06	0.189	N
Mauritius	-0.05	0.02	1.038	N
South Africa	0.10	0.24	2.100	Y
Namibia	0.04	0.13	1.353	N

[a] Unadjusted correlation coefficients are conditional correlation coefficients, using equation (1)

[b] Adjusted correlation coefficients are adjusted for changes in variance, using equation (2)

[c] The tranquil period is from January 2, 1997 to October 17, 1997

[d] The crisis period is from October 20, 1997 to November 28, 1997

[e] The t-statistic is calculated using equation (3)

[f] All t-statistics are tested at the 5 % confidence level.

When looking at the relationships between African countries, the results in Table 4 show that there are fourteen significant correlation coefficients between African countries. Some of the strongest relationships are within the Southern Africa region: between South Africa and Botswana, Namibia and South Africa and Botswana and Namibia. Egypt and South Africa are the only markets to show a strong inter-regional relationship.

Table 4. Unadjusted correlation coefficients between African market equity Returns using weekly data from 9/28/1995 to 6/07/2001

	Botswana	Egypt	Ghana	Kenya	Mauritius	Morocco	Namibia	Nigeria	South Africa	Zimbabwe
Botswana	1.000									
Egypt	0.021	1.000								
Ghana	0.093	0.032	1.000							
Kenya	-0.086	0.041	-0.056	1.000						
Mauritius	-0.007	0.104	0.090	0.102	1.000					
Morocco	***0.181***	0.123	0.126	-0.021	0.074	1.000				
Namibia	***0.202***	0.096	0.001	0.005	-0.054	0.092	1.000			
Nigeria	0.002	0.005	-0.111	-0.019	0.003	0.052	-0.082	1.000		
South Africa	***0.339***	***0.218***	0.026	-0.027	-0.026	0.072	***0.306***	0.118	1.000	
Zimbabwe	-0.017	***0.151***	-0.004	0.001	0.016	***-0.170***	-0.011	-0.079	0.087	1.000

Correlation coefficients in bold and italics are significant at the 1% level.

Granger causality tests in Table 5 show that there are few examples of significant causal relationships. At the 1 per cent significance level, there are only two cases where the null hypothesis can be rejected, or where there is a good possibility that one country 'Granger causes' the other. Stock market returns in Egypt Granger cause returns in Morocco and South African stock market returns Granger cause those in Zimbabwe.

Table 5. Granger causality tests between African market equity returns probability of accepting the null hypothesis Null hypothesis: Country A does NOT granger cause Country B

	Country A									
Country B	**Botswana**	**Egypt**	**Ghana**	**Kenya**	**Mauritius**	**Morocco**	**Namibia**	**Nigeria**	**S.Africa**	**Zimbabwe**
Botswana	-	0.378	0.804	0.321	0.065	0.957	0.024	0.024	0.799	0.357
Egypt	0.436	-	0.186	0.726	0.791	0.749	0.932	0.165	0.523	0.955
Ghana	0.803	0.849	-	0.559	0.829	0.388	0.550	0.302	0.638	0.128
Kenya	0.102	0.182	0.974	-	0.334	0.023	0.613	0.414	0.102	0.292
Mauritius	0.043	0.901	0.056	0.918	-	0.332	0.019	0.490	0.848	0.052
Morocco	0.803	0.006	0.056	0.543	0.415	-	0.336	0.782	0.303	0.504
Namibia	0.690	0.087	0.659	0.672	0.071	0.858	-	0.918	0.860	0.822
Nigeria	0.624	0.855	0.110	0.823	0.689	0.577	0.692	-	0.669	0.151
South Africa	0.502	0.183	0.625	0.464	0.318	0.330	0.792	0.451	-	0.175
Zimbabwe	0.806	0.198	0.011	0.568	0.865	0.849	0.305	0.041	0.008	-

How to read this Table. Causality is tested from Country A to Country B. Therefore, there is a .378 probability that Egypt does NOT Granger Cause returns in Botswana, which suggests there is no causality from Egypt to Botswana. However, there is a .006 probability that returns in Egypt do NOT Granger Cause returns in Morocco, which suggests there is causality from Egypt to Morocco Probabilities in bold and italics indicate that Country A Granger Causes Country B at the 1% level.

4. CONCLUDING REMARKS

These results show that there is evidence of contagion in African markets from global emerging market crises only in the largest and most traded markets, *i.e.* Egypt and South Africa. One interpretation of this result may be that African equity markets offer a true source of diversification to global emerging market managers. Given the small size of most of these markets, however, that is hardly significant for asset managers with more than $200 million under management.

The analysis of the relationships between African stock markets suggests that inter-relationships between African markets fall mostly on regional lines. This could be explained by fundamental trade and economic links, such as the strong relationships within Southern Africa, rather than investor behaviour links. The only relationships that appear not to be linked by fundamental influences are those that show evidence of contagion in respect of global financial events, i.e. Egypt and South Africa. The explanation may lie in the role international investors have come to play in both markets.

The lack of causal relationships between African markets emphasises their isolation. An interesting exception, however, is the significant causal relationship between South Africa and Zimbabwe. The common suspicion in the South African local markets is that the causal effect has been running from Zimbabwe to South Africa rather than in the other direction. Due to the nature of domestic asset opportunities, however, Zimbabwe's stock market has not reflected its poor economic conditions. Therefore, it would be important to test whether Zimbabwe's fundamentals, rather than its asset prices, are the transmission mechanism for some form of negative neighbourhood effect on South Africa.

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