Economic Issues, Vol. 15, Part 1, 2010

Stock Market Co-Movement in the Caribbean

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ABSTRACT

This paper investigates co-movement in five Caribbean stock markets (Barbados, Jamaica and Trinidad and Tobago, The Bahamas and Guyana) using common factor analysis. The common factors are obtained using principal component analysis and therefore account for the maximum portion of the variance present in the stock exchanges investigated. We break our analysis down and test for co-movement in different periods so as to ascertain any changes that have taken place from one period to the next. In particular we examine 10-year, 5-year and 3-year periods. We also specify a vector autoregression model and test for co-movement between the five markets during the sample period through impulse response functions. Both of our tests fail to find any evidence of co-movement between the exchanges over the entire sample period. However, we find evidence of periodic co-movement, particularly between exchanges in Barbados, Jamaica and Trinidad and Tobago.

1. INTRODUCTION

STOCK MARKET CO-MOVEMENT has recently attracted considerable attention in the literature for several reasons. For investors, the benefits of a diversified portfolio are well known, but diversification along international lines is only beneficial if returns from international stock markets are not significantly cointegrated with domestic market returns. Policy makers are also interested in stock market co-movement because stock market correlations along international lines might, through the wealth channel, impact on the effectiveness of monetary policy actions. For example, stock wealth plays a role in most mainstream econometric models of the U.S. economy and according to the Federal Reserve Board's model, a 20 per cent decline in stock prices lowers GDP by about 1.25 per cent after one year. (See Duca 2001, for example.) Dynan and Maki (2001), find that the consumer spending of shareholders is positively associated with stock price swings, while the consump-

tion of non-shareholders is not affected. Apergis and Miller (2004) found that positive stock market wealth shocks affect consumption more than negative shocks. It is likely that the strength of these shocks will vary between countries exhibiting stock market co-movement and this has implications for the effectiveness of monetary policy actions in different countries even when, through stock market co-movement, such countries are affected by the same shock.

Most investigations into stock market co-movement have focused on possible linkages between developed stock markets (see for example, Georgoutsos and Kouretas, 2001; Engsted and Tanggaard, 2002; Aggarwal, Lucey, and Muckley, 2003; Bessler and Yang, 2003; Fraser and Oyefeso, 2005). There have been fewer investigations into emerging markets and, to the best of our knowledge, only one investigation has focused on the emerging markets of the Caribbean (Lorde et al, 2009) which tests for co-movement between the stock markets of Barbados, Jamaica and Trinidad and Tobago for the period January 1991 - December 2006.

There are good reasons for believing that returns on Caribbean stock markets might be cointegrated. In recent decades, the Caribbean islands have evolved into an ever closer economic grouping, culminating in 2001 in the creation of a single market for many of the Caribbean countries and an agreement to encourage 'convergence of macro-economic performance and policies through the coordination or harmonisation of monetary and fiscal policies, including, in particular, policies relating to interest rates, exchange rates, tax structures and national budgetary deficits' (CARICOM Secretariat, 2002). In the case of the EU, closer economic union has encouraged stock market convergence. For instance, Phengpis *et al* (2004) investigated the impact of economic convergence on stock market returns in four stock markets in European Economic and Monetary Union (EMU) countries (France, Germany, Italy and the Netherlands) and one stock market outside EMU within the EU (the UK). They find that economic convergence is an important factor contributing to returns in the countries investigated, with the exception of Germany. Similarly Kim *et al* (2005) find that the increase in stock market integration in Europe over the period 1999-2003 has been significantly driven, in part, by macroeconomic convergence associated with EMU. In the case of the North American Free Trade Area (NAFTA) Gilmore and McManus (2004), Darrat and Zhong (2005) and Aggrawal and Kyaw (2005) conclude that convergence has taken place between the North American equity markets as a result of NAFTA.

The study by Lorde *et al* (2009) investigates the possibility of co-movement among three CARICOM stock markets: Barbados, Jamaica and Trinidad and Tobago using the techniques of cointegration and common feature testing. Using cointegration techniques also enables the authors to test whether these exchanges are weak form efficient. On the basis of these tests the authors confirm market efficiency, but fail to identify any significant co-move-

ment among the stock markets investigated. They therefore conclude that these markets are segmented. Since no evidence of co-movement is found between the stock markets of Barbados, Jamaica and Trinidad and Tobago, it is impossible these markets are collectively cointegrated with any other market. Lorde *et al* (2009) therefore suggest that at least some of the markets investigated, possibly all, offer benefits to investors seeking to diversify their portfolios along international lines.

In this paper we test for co-movement between a greater number of Caribbean stock exchanges than Lorde *et al* (2009). As well as the stock exchanges of Barbados, Jamaica and Trinidad and Tobago, we include data from The Bahamas and Guyana stock exchanges in our investigation. The Bahamas and Guyana are the most recently created of the Caribbean stock exchanges and we include them to test whether, as such, they follow any or all of the more established exchanges in Barbados, Jamaica or Trinidad and Tobago.

Our period of investigation is the same as Lorde et al (2009), which captures the effects of the development of the single market that might have encouraged co-movement between the exchanges. However, our methodology differs fundamentally from Lorde *et al* (2009). While cointegration and common feature techniques provide viable tests of co-movement, our aim is to test how robust the results of Lorde *et al* (2009) are by using an alternative methodology and to extend their analysis by the inclusion of data from these two newly created stock markets in the region. We also extend their work by evaluating whether the target stock markets are becoming more convergent over time.

The remainder of this paper is structured as follows. Section 2 analyses the observations on stock market returns for our target group of exchanges and Section 3 outlines the methodology we use to test for co-movement and the extent to which any co-movement identified might have changed during the period of investigation. In Section 4 we detail our empirical results and Section 5 provides a summary and conclusions.

2. Data and summary statistics

The study uses monthly data on five Caribbean Stock Exchanges: The Bahamas, Barbados, Guyana, Jamaica and Trinidad and Tobago. The data were obtained from the International Monetary Fund's *International Financial Statistics* (online edition) as well as the websites of the various exchanges. Table 1 provides summary statistics for the monthly returns between 1990 and 2008. Monthly returns are calculated as $r^i_{t,d} = \ln(p^i_{t,d} / p^i_{t,d-1})*100$, where $p^i_{t,d}$ is the stock market index of the *i*-th country, in year *t* at the end of month *d*. The highest mean returns were in Guyana (1.938 percent) and Jamaica (1.733 percent).

Table 1: Summary Statistics of Monthly Returns of Caribbean Stock Exchanges (1990-2008)

	mean	*median*	*max*	*min*	*st. dev.*	*skew*	*kurt*	*J-B*	*p-value*
The Bahamas (RBAH)	1.048	1.105	10.583	-4.510	2.230	0.667	6.915	52.025	0.000
Barbados (RBAR)	1.344	0.231	55.249	-30.418	7.374	2.952	24.067	4028.699	0.000
Guyana (RGUY)	1.938	1.014	27.049	-31.727	6.901	-0.770	12.866	265.913	0.000
Jamaica (RJAM)	1.733	0.880	36.935	-17.616	8.093	1.195	6.146	148.345	0.000
T'dad & Tobago (RTT)	1.205	0.845	20.235	-18.106	4.305	0.199	7.537	154.727	0.000

Note: J-B = Jarque-Bera

Despite the larger daily returns available on the Guyana and Jamaican stock exchanges, volatility was also significantly higher on these equity markets relative to those in other Caribbean islands. While the average volatility (measured by the standard deviation of monthly returns) of the stock exchange in Jamaica was 8.093 and 6.901 in Guyana, the average for the exchanges in the other three countries was 4.636. Of the Caribbean countries investigated, the stock exchange in the Bahamas was the least volatile. Corroborating evidence regarding the volatility of our target group of exchanges can also be obtained by examining Figure 1, which provides a plot of the monthly returns on these exchanges.

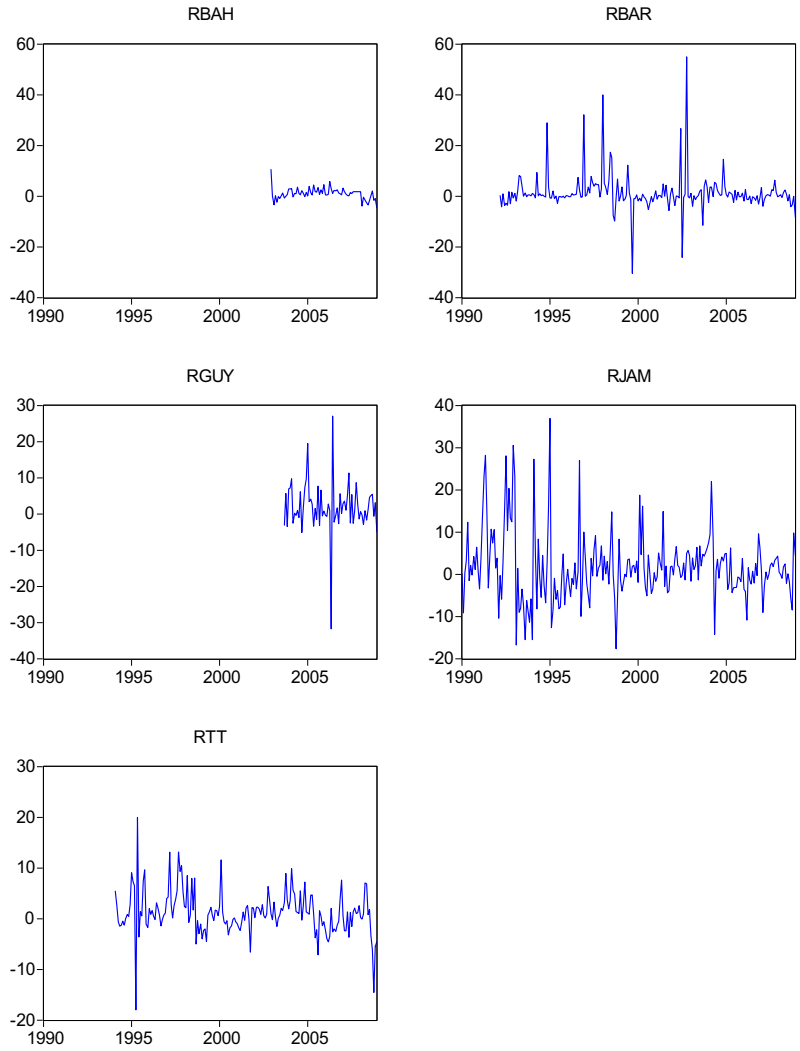
In addition to the relatively higher level of volatility in the Caribbean stock markets investigated, the distribution of returns also seems to be non-normal. With the exception of equity markets in Guyana, most of the returns are positively skewed, that is, the proportion of months with positive returns tends to be higher than those with negative returns. The measure of excess kurtosis for all the exchanges deviate significantly from expected returns drawn from a normal distribution, particularly in Barbados and Guyana. The non-normality is confirmed by the significance of the Jarque-Bera statistic.

3. EMPIRICAL APPROACH

This paper first investigates co-movement on the five stock markets investigated using common factor analysis. Let y_{it} denote a vector of stock market indicators for country i = 1,...,5 for period t = 1...T. The common factor (f_t) approach assumes that there is an unobservable variable (the factor) that accounts for the correlations among the stock exchanges:

$$y_{it} = \sum_{j=1}^{r} \lambda_{ij} f_{jt} + \varepsilon_{it} \qquad (1)$$

Figure 1: Monthly Returns on Caribbean Stock Exchanges (% change)



where λ_{ij} are the factor loading coefficients associated with each of the z common factors and ε_{it} is a well-behaved error term. The common factors are obtained using principal component analysis and therefore account for the maximum portion of the variance present in our target group of stock exchanges. (See Johnson and Wichern, 2002, for more details on principal component analysis).

Becker and Hall (2009) show that a set of variables are convergent if the general factor representation given in Equation (1) can be restricted to a

single factor. Using the calculated monthly returns, principal component analysis is employed to test for convergence over the sample period considered. The measure of convergence employed is the percentage R-squared of the first factor, which provides a measure of the total variation in returns explained by the first factor. The closer this value is to 1, the greater the degree of convergence between the returns. In addition, if the percentage R-squared over period 1 is less than that in some consequent period 2, then convergence has accelerated over the selected interval.

The linkages between the five markets during the sample period can also be evaluated by applying vector autoregression analysis (VAR). The VAR model is given as follows:

$$X_t = A_o + \sum_{k=1}^{p} A_k X_{t-k} + \varepsilon_t \tag{2}$$

where X_{t-k} is a n x 1 column vector of stock exchange returns at time t-k, A_0 is an n x 1 column vector of intercept terms, A_k is an n x n column matrix of coefficients, p is the number of lags and ε_t is an n x 1 column vector of disturbances that may be correlated.

The ordering of the VAR model employed is this study is as follows: Barbados, Jamaica, Trinidad and Tobago, Guyana and the Bahamas. This ordering was chosen based on findings of previous studies that suggest the Barbadian stock market is likely to be the most dominant market in the group. Jamaica and Trinidad and Tobago are ordered as the second and third countries given the size of their economies and their linkages with the Barbadian stock exchange. Guyana and the Bahamas are the fourth and fifth country respectively given that there are no cross listings with the other exchanges.

The lag length of the VAR model is of particular importance: too few lags and the model is underspecified, whilst with too many lags degrees of freedom are lost. To select the appropriate lag length, the sequentially modified likelihood ratio (LR) test is employed. Starting from the maximum lag of 12 months, the chi-squared test statistic is:

$$LR = (T - m)\{log|\Omega_{t-1}| - log|\Omega_t|\} \sim \chi^2(k^2) \tag{3}$$

where m is the number of parameters per equation under the alternative. The adequacy of the model specification is also evaluated using the autocorrelation LM test.

Once the VAR model has been specified, impulse response analysis is employed to evaluate the co-movement between the five stock exchanges. Impulse response analysis traces the effect of a shock in one of the VAR equations on current and future values of the endogenous variables included in the VAR. Following Pesaran and Shin (1998), generalised impulses are employed

since these are not significantly influenced by the VAR ordering.

4. EMPIRICAL RESULTS

4.1 Factor Analysis

In this section we report our results from applying the common factor approach to the database of Caribbean stock market returns over the period 1990 to 2008. For the entire sample period, the first principal component is able to explain approximately 47 percent of the variance in the data. This suggests that most of the variance in stock market returns in the Caribbean cannot be attributed to one factor over the full sample period. The clear implication is that there is incomplete convergence over this period. As a result, the study attempts to assess whether convergence has been period-specific or increasing over time.

To identify whether stock market co-movement is episodic, Table 2 provides the percentage R-squared for the first principal component over 10-year, 5-year and 3-year periods for the Caribbean stock exchanges over the sample period. In the case of the 10-year windows, the results were very similar to those for the entire sample period, that is, there is no significant difference in the convergence pattern in the 1990s and 2000s. In the case of the 5-year windows, however, there is some evidence of convergence in the latter years with the first principal component explaining more than 50 percent of the variance in Caribbean exchanges in the periods 2000-2004, and 2005-2008. Similar results are also obtained when 3-year windows are employed. In these cases, the percentage R-squared of the first principal component is above 50 percent when 3-year intervals are employed, reaching as high as 74 percent in the 2002-2004 period. These results are encouraging and are suggestive of convergence between the Caribbean stock exchanges in our sample for these sub-periods.

Table 2: %R^2 of the First Principal Component of the Five Caribbean Stock Exchanges

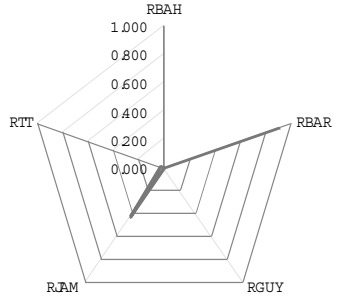
	1990-1999	2000-2008				
10-year windows	0.485	0.431				
	1990-1994	1995-1999	2000-2004	2005-2008		
5-year windows	—	0.491	0.633	0.570		
	1990-1992	1993-1995	1996-1998	1999-2001	2002-2004	2005-2007
3-year windows	—	—	0.589	0.520	0.738	0.571

The factor analysis model described earlier indicates the extent to which fluctuations in the returns in our sample have common features. It is also of interest, however, to identify how independently of the other country's returns a particular exchange's returns fluctuate about the common factor. With complete convergence, these factor loadings would be equivalent to 1 for all exchanges in our sample.

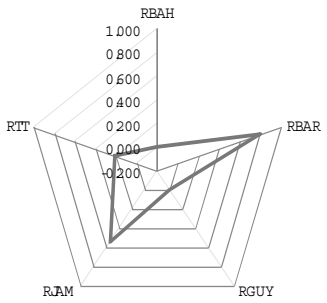
To identify the degree of independence, Figure 2 plots the factor loadings or weights on the first principal component for each country over the four 3-year intervals considered. The results suggest that with the exception of the 2005-2007 period, only the weights on the Barbados stock exchange are close to 1. The implication is that there are significant fluctuations in monthly returns that are not explained by the first principal component in the Bahamas, Jamaica, Guyana and Trinidad and Tobago exchanges.

Figure 2: Factor Loadings or Weights of the First Principal Component (3-year windows)

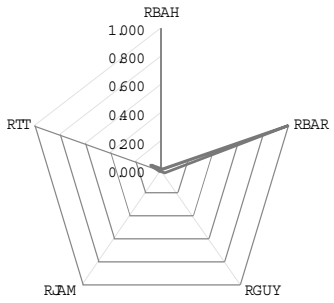
1996-98



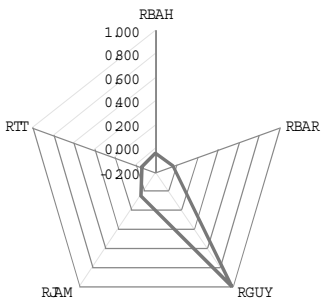
1999-2001



2002-04



2005-07



Since 1991, an arrangement has been in place to accommodate cross listing and cross trading on the Barbados, Jamaican and Trinidad and Tobago

exchanges. To account for this structural feature, the principal component analysis described earlier was applied to the monthly returns on a restricted sub-sample of these three countries, to test whether the degree of return co-movement for these three markets is greater than for the total sample. The results are provided in Table 3. The percentage R-squared values reported in this table for the 10-year windows are significantly larger than those for the full sample of stock market returns. For these three exchanges, the first principal component was able to account for, on average, 60 percent of the variance in the two 10-year intervals studied. Similar to the results for the full sample of countries, co-movement in smaller sample periods tends to be higher. For the 5-year intervals, the percentage R-squared for the first principal component rose from 0.491 in the 1995-1999 period to 0.678 between 2000-2004 and 0.668 for 2005-2008. Similarly, when 3-year horizons are utilised, the percentage R-squared rises from just under 60 percent in the 1996-1998 period, to 80 percent between 2002 and 2004 and 74 percent between 2005 and 2007. These findings seem to suggest the existence of cross listing and cross trading between the exchanges in Barbados, Jamaica and Trinidad and Tobago has indeed fostered convergence between the exchanges.

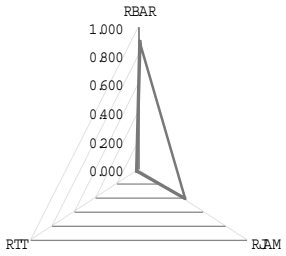
Table 3: %R^2 of the First Principal Component of Stock Exchanges in Barbados, Jamaica and Trinidad and Tobago

	1990-1999	2000-2008				
10-year windows	0.616	0.580				
	1990-1994	1995-1999	2000-2004	2005-2008		
5-year windows	—	0.491	0.678	0.668		
	1990-1992	1993-1995	1996-1998	1999-2001	2002-2004	2005-2007
3-year windows	—-	—	0.589	0.520	0.804	0.735

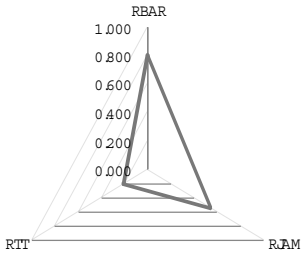
Even though the percentage R-squared for the first principal component for exchanges in Barbados, Jamaica and Trinidad and Tobago were relatively high, there still exists a significant degree of independent variation for individual exchanges. Figure 3 plots the factor loadings for the three exchanges for various 3-year intervals. The results suggest that in most periods, only Barbados tends to have a weight close to 1. This result could suggest that returns in Barbados tend to be more closely linked with the common regional variation when compared to other exchanges. Figure 4, which plots the average factor loadings over various 3-year horizons, supports this assertion and suggests that while this independent co-movement is rising among the full sample of exchanges, with the exception of the 2002-2004 period, independent variation has declined somewhat during the sample period under investigation.

Figure 3: Factor Loadings or Weights of the First Principal Component for Barbados, Jamaica and Trinidad and Tobago (3-year windows)

1996-98



1999-2001



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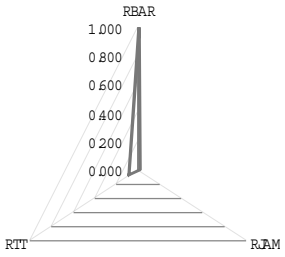

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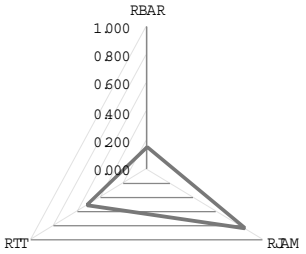
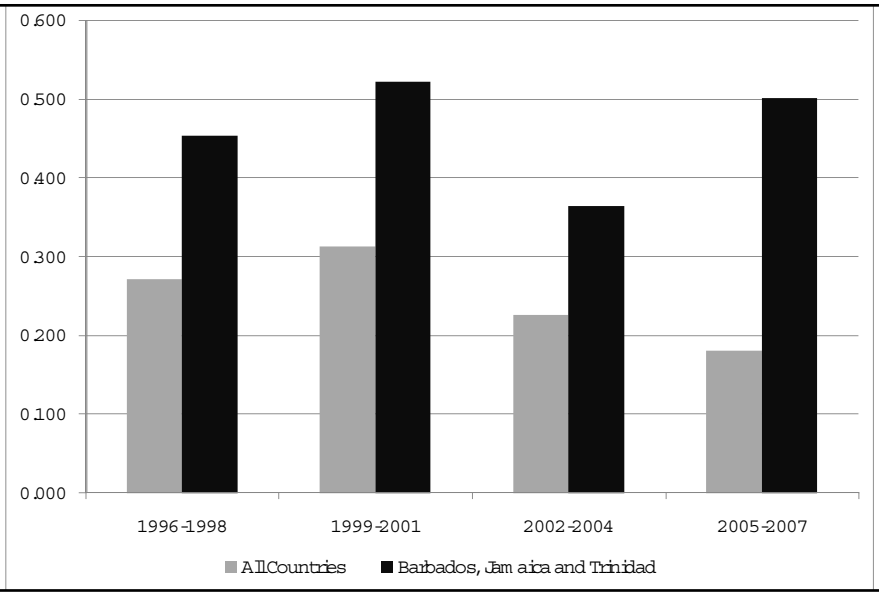


Figure 4: Average Factor Loadings or Weights of the First Principal Component



4.2 Impulse response analysis

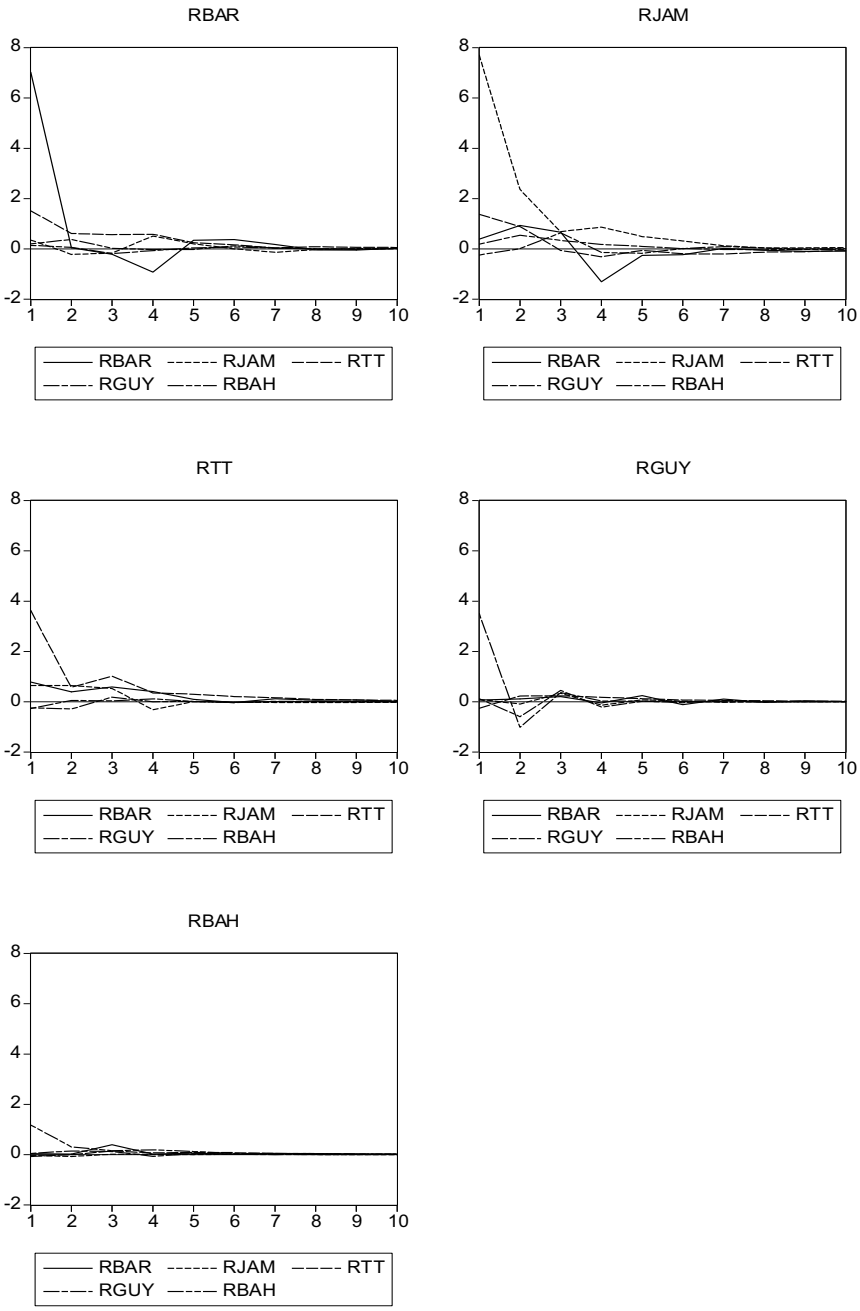
We further check for stock market co-movement using impulse response analysis. This provides a means of evaluating the extent to which shocks on one exchange are transmitted to other exchanges, and the length of time these shocks last. Before the impulse response analysis is conducted, however, a robust VAR representation of returns in the five exchanges investigated must first be obtained. The sequential LR statistic suggested that the optimal lag length was three for the sample period under investigation. When this lag length was employed, the autocorrelation LM test suggests that the null hypothesis of no autocorrelation between the residuals from the model could not be rejected at normal levels of testing.

Figure 5 provides the impulse responses of the five stock exchanges. The horizontal axis gives the number of lags, while the vertical axis provides a measure of the responses of each market in standard deviations. Similar to the findings from the principal component analysis, the responses of returns on the exchanges in the Bahamas and Guyana relative to innovations in the other markets were relatively small. In the case of the Bahamas, the mean absolute response in the first period was just 0.05 and 0.06 in the second period. Similarly in the case of Guyana, the mean response was about 0.13 and 0.25 in the first and second periods respectively. The marginal responses to shocks on the other exchanges also dissipate relatively rapidly. In both countries the impact almost disappears on all markets after the fifth lag.

In the cases of Barbados, Jamaica and Trinidad and Tobago, the responses to innovations on the other exchanges were somewhat larger. In the case of Barbados, the responses of returns on the Barbados stock exchange were relatively large (above 0.5) in the case of innovations from the exchange in Trinidad and Tobago. There were relatively small responses in relation to the other exchanges. The marginal responses to shocks from all the exchanges tended to dissipate after about eight to nine months.

Correspondingly for Trinidad and Tobago, the responses of returns were above the threshold in the case of shocks from Barbados and Trinidad and Tobago. The innovation response was above the 0.5 threshold for both the first and second lag for shocks to Jamaica, but only above the threshold for the first and third periods. There was only a marginal response from innovations on the exchanges in Guyana and the Bahamas. In the case of Jamaica, the response from shocks from the exchange in Trinidad and Tobago was greater than one in the first period, just under one in the second period and dissipating thereafter. In the case of shocks from the Barbados exchange, the response of returns in Jamaica was above the threshold in both the second and third periods, and dissipating thereafter.

Figure 5: Impulse Reponses of the Five Stock Markets



5. Conclusions

This study examines the issue of stock market co-movement between stock exchanges in the Caribbean. Two approaches were employed to examine the issue: principal component and impulse response analysis. The principal components approach provides an assessment of the extent to which the variance of the stock markets can be represented by a single factor, while the impulse response technique examines the degree to which shocks on one market are propagated throughout the region.

The results from the principal component analysis suggest that while there is no evidence of convergence over the entire sample period in relation to monthly returns, there is some indication of periodic convergence over shorter sample periods, that is, 3-year intervals. In addition, the degree of convergence is particularly strong between Barbados, Jamaica and Trinidad and Tobago. One reason put forward for this finding is that since April 1991, these exchanges have had in place an agreement to enable cross listing and cross trading of stocks. This facility seems to have led to a relatively high degree of convergence over the sample period.

The results from the impulse response approach were quite similar. Within the sub-group of Barbados, Jamaica and Trinidad and Tobago, innovations were propagated rapidly across the three exchanges. However, the exchanges in Guyana and the Bahamas had little impact on the other exchanges in the Caribbean and in turn were not significantly influenced by shocks in those other exchanges. In Barbados and Jamaica, shocks to the exchange in Trinidad and Tobago had the largest impact on returns in these two countries, while in Trinidad and Tobago the response to innovations from Barbados and Jamaica were equally important.

Similar to Lorde *et al* (2009), the results presented in this study suggest that there is no evidence of convergence over the entire sample period. The present study, however, does suggest that co-movement among stock markets in the Caribbean tends to be episodic. Tests for convergence over a given sample period are therefore likely to reject the hypothesis of convergence over relatively long sample periods. The finding of episodic convergence is not new and has been reported by Harrison and Moore (2009) for the case of Central and Eastern European countries.

Accepted for publication: 7 May 2009

Endnotes

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