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STOCK RETURN VOLATILITY SPILLOVERS UNDER FOREIGN EXCHANGE MARKET LIBERALIZATION: CASE OF JAMAICA, TRINIDAD AND TOBAGO AND THE UNITED STATES

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STOCK PRICE MOVEMENTS AND VOLATILITY SPILLOVERS UNDER FOREIGN EXCHANGE LIBERALIZATION:

The Case of Jamaica, Trinidad and Tobago, and The United States

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ABSTRACT

Many researchers have found increased stock return volatility spillovers from the "developed" stock markets to the small "emerging" stock markets following the liberalization of the emerging market to direct purchases of domestic securities by foreign investors. This is seen to be caused by the easier access by the foreign investors who are seeking to hedge or diversify his portfolio with stocks whose returns and return volatility is not correlated with the developed markets. This paper examines the question of whether such increase in volatility spillovers is observed from a liberalization in the foreign exchange market of a small, emerging stock market. As controls on capital movements, including repatriation of the investment proceeds is relaxed, it makes it easier for foreign and domestic investors to move assets into and out of these small, emerging stock markets, increasing such volatility spillovers. Using Generalized Autoregressive Conditional Heteroscedasticity (GARCH) methodology to estimate an asymmetric, short-run model of stock return volatility spillovers from the U.S. stock market to the Jamaica and Trinidad and Tobago stock markets, it is found that the volatility spillovers has indeed increased following the liberalization of foreign exchange market in Jamaica but not for Trinidad. It is argued that this difference in the result of the foreign exchange market liberalization is caused by the difference in the effectiveness of the barriers to entry, as described by Bekaert and Harvey (1995), prior to the market liberalization. The barriers to entry to the stock market in Jamaica was more "binding" than Trinidad before the liberalization.

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1. Introduction

The growing interest in the international integration of stock markets has been evidenced in many recent empirical studies. Specifically, these studies have examined the transmission of stock price movements and return volatility across national stock markets. Especially in light of the spillover effects of the October 1987 stock market crash on the world stock markets, research has shown that there was significant stock return volatility spillovers in international stock markets. From this, researchers have concluded that the global stock markets are becoming increasingly integrated.

Until recently, much of this research has concentrated on the developed markets of the U.S., Japan, and the U.K., among others. But with the increasing importance of the "emerging" small national stock markets in rest of the world, the market integration of these markets are becoming an important research issue. As Bekaert and Harvey (1995a, 1995b) point out, these markets' stock price movements have very little correlation with those of the developed markets and hence represents a possible hedging opportunity for the investors in the developed markets. However, as Bekaert (1995) documents, much of these emerging markets have investment restrictions on foreign investors and hence much of these hedging opportunities are exploited through the closed end country funds or American Depository Receipts (ADR) that are traded on the major exchanges such as the New York Stock Exchange (NYSE).

Recent research by Kim and Rogers (1995) have shown that increased market integration and volatility spillovers occur when a stock market is liberalized to allow direct investment by foreign investors. They further postulate that it is through this hedging opportunity that information regarding the developed markets that were previously unimportant are now becoming "pertinent" to the domestic market and hence represents increased market efficiency in processing information.

While the implications of market liberalization to allow direct investment by foreign investors is now clear, it remains to be seen whether a general market liberalization policies of a small economy will have a similar effect on the stock market integration and the volatility spillovers. To this end, Jamaica and Trinidad and Tobago (T&T), with their national stock exchanges that are small yet vibrant and, until

recently, relatively closed to direct foreign investment, represent two interesting cases where the overall economy is in the process of liberalization and is geographically, politically, and economically close to the U.S., a developed stock market. This paper will take one specific step in the market liberalization process, namely the foreign exchange market liberalization, and examine whether this has lead to increased stock return volatility spillovers.

Rest of the paper is organized as follows. Section 2 gives a brief institutional background on the market liberalization policies and a description of the stock markets of Jamaica and T&T. Section 3 provides a brief review of the relevant literature. Our model and the methodology is described in section 4 followed by the description of the data set in section 5. Empirical results are presented in section 6 and section 7 presents some concluding comments.

2. Institutional Background

Both Jamaica and T&T are former British colonies in the Caribbean that now have closer economic and political ties to the U.S. due to their geographic proximity, among other things. They have very different economic bases, with Jamaica relying on its Bauxite exports and the tourism industry and T&T on its exports of light manufacturing and petroleum products. The economic policies and development, however, were very similar for both countries, especially in their market liberalization policies.

Together with the stock exchange in Barbados, Jamaica and T&T stock markets represent the only stock markets in the Caribbean. Some of the larger firms are cross listed and investors from these three countries (and other English speaking Caribbean countries, in some cases) enjoy resident investor status. Currently, there are plans to link all three markets and other English speaking island nations of the Caribbean through an electronic network of an over-the-counter market. Very briefly, we will discuss the policy on foreign investment in the stock markets, capital movemtns, and foreign exchange markets of Jamaica and T&T.

2.1 Jamaica

After a failure of an "allocation" system of exchange rate determination which was instituted in November 1989, the Jamaican government made a renewed attempt to establish an equilibrium in the foreign exchange market by commencing a process of economic deregulation. On September 17, 1990, the Jamaican government instituted a flexible exchange rate inter-bank system. This system allowed all authorized dealers, which now included commercial banks, to set their own buying and selling rates. In the same year, residents and non-residents were allowed to operate foreign currency accounts, along with tax exemption on interest earnings under the Income Tax (Amendment) Act, 1990.

This was followed by the Exchange Control (Removal of Restrictions) Order on September 25, 1991, which eliminated exchange controls in existence since 1939. The date of removal of exchange controls, previously set for 1992, had been advanced to September 1991 in order to curtail speculation which had exacerbated problems such as increased private capital outflows and below forecast flows into the official foreign exchange system.

Other controls on the movements of capital were also abolished. These include: prohibition of outward portfolio investment; all repatriation and surrender requirements for residents earning foreign exchange; all controls on the repatriation of interest, profits, dividends, and capital by non-resident investors; prohibitions on the holding of foreign currency accounts abroad by Jamaican residents; all exchange control requirements on current and capital account transactions (excluding portfolio outflows by deposit taking institutions); and all controls on the currency used by residents and non-residents to settle international transactions

Beginning in January 1990, Jamaica Stock Exchange (JSE) trades four times a week, Monday through Thursday. Up to that time, JSE traded twice a week (Tuesday and Thursday, up to January 1990) and then three times a week (Tuesday through Thursday, up to October 1991). Trading begins at 10:00 am and continues in a sequential auction market, with equities traded in an alphabetical order, until all equities had come up for trading. Recently, the most active stocks, at the completion of the trading

cycle, are auctioned one more time before the daily trading session is completed. As Jamaica operates on Eastern Standard Time (EST) without daily light savings adjustment, JSE's trading hours overlap with that of NYSE, with NYSE trading for another two to one hour beyond JSE. With the development of telecommunication systems, Jamaican investors receive real time financial news on the trading activities in New York. Thus, in absence of market inefficiency, liquidity and market depth problems, we would expect *a priori* that any volatility spillovers from the U.S. will occur within the same day, or at the very least by the next trading day, as was found by Karoly (1995) for NYSE and Toronto Stock Exchange.

2.2 Trinidad and Tobago

The process of the foreign exchange market liberalization in T&T has been very similar to that of Jamaica except for the institution dates. With increasing marginalization of the T&T dollar (TT$), the government instituted sweeping changes in the operation of the foreign exchange market and capital controls, beginning in April 13, 1993. TT$ was allowed to float and other non-traditional traders such as cambios (or currency dealers) were allowed to purchase and sell foreign currency. Residents as well as non-residents were allowed to hold foreign currency denominated bank accounts with removal of virtually all restrictions on repatriation of funds. The only remaining restriction on non-resident residents was that in order to acquire 30% or more of the total issued shares of a public company, a non-resident or group of non-residents had to obtain a license from the Ministry of Finance.

T&T Stock Exchange (TTSE) operates three times a week: up until February 1989, the market traded Mondays, Wednesdays, and Fridays. Since then, the trading occurs Tuesdays, Wednesdays, and Fridays. T&T local time is one hour ahead of EST with no daylight savings adjustment. So the trading hours overlap perfectly with NYSE. As of December 1995, the total market capitalization was at TT$5.68 billion, or at the prevailing rate of exchange, US$947 million. In addition, there is a small, yet vibrant cross border trading between Jamaica and T&T. In 1993, for example, Jamaican investors invested over TT$2 million in T&T stocks while the T&T investors invested over J$146,000 in Jamaican stocks.

3. Previous Research

An early study on the major stock markets by Eun and Shim (1989) found that the stock price movements in the U.S. stock market greatly influence short-term price movements in other major stock markets, leading to their conclusion of market integration of international stock markets. Furthermore, they found that, by and large, the effects of unexpected developments from the U.S. stock market to other international stock markets were significantly larger than shocks originating in other markets that affect the U.S. market. This result was also found by Hamao, Masulis, and Ng (1990) for the U.S., Tokyo, and London stock markets. They argued that price volatility across markets could represent a "causal phenomenon."

The link between volatility in returns and economic variables was further explored in a study by King, Sentana, and Wadhwani (1994), where a dynamic asset pricing model is used to examine financial integration among international stock markets. They reject the assumptions that idiosyncratic risk is not priced and that the "price of risk" associated with each of the underlying factors is common across countries. Additionally, the "unobservable" factors were found to be much more significant in explaining volatility in stock returns across markets than "observable" factors.

Bekaert and Harvey (1995a) found that the covariance of a segmented market and a common world factor is unlikely to explain the markets' expected returns. Furthermore, whereas the rewards to risk are common in integrated stock markets, different sources of risk in segmented markets may result in dissimilar rewards. A regime-switching, one factor asset pricing model was used to provide empirical evidence which shows that regulatory policies determine the degree of integration (or segmentation) of international financial markets. Bekaert and Harvey (1995a, 1996b) also found that the regulatory policies, such as direct barriers to investment, may not be an indicator of integration. The effects of the various barriers on integration depends mostly on the type of restrictions and whether they are binding. They base this conclusion on the fact that they found the emerging markets to have varying degrees of market integration whether they had explicitly carried out policies of liberalization of their stock

markets. Much of the degree of the integration depended on the access (direct investment or through closed-end country funds) to the market and, to some extent, the integration of the rest of the economy. It is important to note that, notwithstanding the recent liberalization of restrictions by developing countries on foreign equity ownership, Bekaert and Harvey (1995a) found no significant evidence of increased integration.

Bekaert (1995) and Bekaert and Harvey (1995a, 1995b) also studied the stock returns and return volatility of the emerging stock markets. They show that the emerging market returns are higher, more predictable (due to market inefficiency and/or liquidity or thin market problems) with higher volatility than developed markets, and correlations with developed markets are low, thus representing attractive hedging opportunities to the investors in the developed markets.

Kim and Rogers (1995) examined whether the volatility spillovers from the developed markets increased following the stock market liberalization to allow direct foreign investments in the Korean stock market, which is one of the largest emerging markets with good liquidity and is considered to be efficient. Examining the spillovers from the U.S. and Japan, they showed that the spillovers did increase following the market liberalization and concluded informational market efficiency.

One of the more important empirical characteristics in studying global market integration and volatility spillovers is that the trading in various markets occur at different times around the globe. For example, Hamao et al. (1990) had to adjust for the fact that the during the trading hours in New York, Tokyo had already completed its trading day while London has not yet opened for trading. However, Karolyi's (1995) study of price spillovers between the US and Canada differs from Hamao et al. (1990) and Kim and Rogers (1995) in that the trading hours in the two markets studied are perfectly synchronous. Therefore, Karolyi's (1995) study captures the typical one-day spillover effect described in the theoretical literature. Additionally, to strengthen the previous point, more definitive inferences may be made in Karolyi's (1995) study due to the similarity in market microstructure and regulations regarding equity trading and ownership in addition to the barrier-free flow of capital and information

between the U.S. and Canadian stock markets. He found that the most of the spillovers would occur within one trading day and concluded that these markets were informationally efficient.

4. Model and the Empirical Methodology

Thus the question remains whether the liberalization of the foreign exchange market and relaxation of capital controls in an emerging market that allows easier repatriation of funds and conversion of domestic currency to the US dollars will have increased the volatility spillovers from the developed market to the emerging market. As it becomes easier for foreigners and domestic residents alike to move assets abroad, the investors, both foreign and domestic, in the emerging stock market will become more sensitive to the stock price movements elsewhere in the world, especially the developed markets. This will cause the emerging market to become more integrated with the world capital markets and will increase the volatility spillovers and increase information efficiency of the market. However, if the liberalization of foreign exchange markets does not increase direct foreign investment nor the sensitivity of domestic investors to the stock price movements elsewhere in the world, then the degree of volatility spillovers would be expected to remain the same.

Another issue in studying the volatility spillovers lies in the modeling of the second moment of the stock returns. As argued by Hamao et al. (1990), Kim and Rogers (1995), and Karolyi (1995), volatility spillovers will affect both the returns and volatility and requires that the second moment of the stock returns be modeled explicitly. Difficulty lies in the fact that the volatility spillovers is an unobservable variable and hence the regressors must be generated or some suitable instrument variable be used. To this end, we use the methodology that is similar to that used by Hamao et al. (1990), Kim and Rogers (1995), and Karolyi (1995). These studies used Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models developed by Engle (1982) and Bollerslev (1986) to examine the transmission mechanism of the conditional first and second moments in stock prices across international stock markets.[1] As postulated by French and Roll (1985) and Tauchen and Pitts (1983), incorporation of news will first affect the stock volatility. GARCH allows a parsimonious parameterization of the

conditional second moment that will allow a modeling of the volatility spillovers from one market to another.[2]

We are also interested in the asymmetric variance effects that can be caused by leverage effects first postulated by Black (1976). As the stock price falls and returns become negative, firms engaged in debt financing find that the leverage of the firm increases, resulting in higher return volatility when the stock prices are falling than when it is rising. While various empirical methods exist to model this asymmetry in volatility, we choose the method proposed by Engle and Ng (1993). They found that inclusion of a simple indicator dummy variable in the conditional variance equation allows for an easier parameterization, and hence estimation, and performed better in Monte Carlo experiments. Thus, our asymmetric GARCH(p,q) model of volatility spillovers can be set up as follows:

$$R_{i,t}|\psi_t = a_0 + a_1 R_{i,t-1} + a_2 h_t^{1/2} + \sum_{k=1}^{K} \gamma_k X_{k,t} + \varepsilon_{i,t}, \tag{1}$$

$$\varepsilon_{i,t}|\psi_t \sim t_v(0, h_{i,t}), \tag{2}$$

$$h_{it} = \omega_0 + \sum_{j=1}^{q} \alpha_j h_{i,t-j} + \sum_{j=1}^{p} \beta_j \varepsilon_{i,t-j}^2 + \sum_{k=1}^{K} \delta_k X_{k,t}^2 + \varphi V_{i,t} \varepsilon_{i,t-1}^2. \tag{3}$$

We model the returns and variances conditional on Ψ_t, the information set available at time t. Ψ_t will contain the information from the U.S. market, including the price movements of time t, but it will not contain the price movements at home. The conditional mean equation contains an autoregressive term designed to capture some of the serial correlation present in the data. It also contains the GARCH in mean term to capture the effect of risk, proxied by the square root of conditional variance, on the returns. Finally the mean equation includes spillover variables, $X_{k,t}$, which are the squared residuals from the estimation of a univariate GARCH(1,1) model to the U.S. data.[3] The conditional variance equation defined in (3) is a GARCH(p,q) model which includes squares of the spillover variables and the asymmetric volatility effect dummy variable, $V_{i,t}$, which is 0 when $\varepsilon_{i,t}$ is non-negative and 1 when it is negative. We make the student *t* distribution assumption and estimate (1) to (3) using maximum

likelihood estimation with ν, the degrees of freedom parameter in the student t distribution, as one of the estimated parameters.[4]

5. Preliminary Data Analysis

The data used in this study consists of daily stock market index returns in percent terms at closing time for the U.S., Jamaica, and T&T stock markets. To avoid any undue effects from the October 1987 U.S. stock market crash, our sample period begins on November 10, 1987 and ends on December 31, 1995. This data is also divided into exchange control and non-exchange control subperiods. This allows an estimation of changes in volatility spillovers from the U.S. to Jamaica and T&T stock markets following the lifting of foreign exchange controls in the respective countries. Thus, for Jamaica the exchange control subperiod (pre-lib) ranges from November 10, 1987 to September 19, 1991 while the non-exchange control subperiod (post-lib) ranges from October 1, 1991 to December 28, 1995. For T&T, pre-lib subperiod ranges from November 11, 1987 to April 7, 1993 and post-lib subperiod ranges from April 27, 1993 to December 29, 1995. The full data for the U.S. ranges from November 10, 1987 to December 29, 1995.

The most comprehensive and diversified value weighted stock index is used for each market. For the U.S. stock market, the Standard & Poors 500 (S&P) index is used. For the Jamaican and T&T stock markets, the Composite Index for the respective market is used, which consists of all common stocks listed on each exchange. The primary data source is the listings of the stock exchanges of the respective countries. This study uses daily returns to capture the possible spillover effects because, as most studies in this context have determined, these effects are usually short-term.

In table 1 we present the descriptive statistics for the daily stock returns. If the underlying unconditional distributions of our three return series were normal, then the skewness and kurtosis measures would all be zero. The kurtosis measure for all returns series indicate that they have a distribution that has thicker tails than the normal distribution. However, whereas the S&P returns indicate significant negative skewness in all periods, this statistic is significantly positive for the JSE and

T&T returns. Overall, the descriptive statistics for the returns of JSE and S&P series during the subperiods do not deviate much from those in the full sample. However, for T&T returns, there is a dramatic reduction of kurtosis and an increase of skewness in the post-lib subperiod. It seems that the full sample results are mainly driven by these subperiod phenomena.

Engle's (1982) Autoregressive Conditional Heteroscedasticity (ARCH) Test checks for the presence of conditional heteroscedasticity and is also useful in checking for the appropriateness of applying the GARCH methodology. The test results rejects the null hypothesis of homoscedasticity, for all three series in the full sample, for 4 and 8 lags at the 1% level of significance, indicating the presence of heteroscedasticity. However, ARCH effect is not present in the post-lib S&P returns. In the November 10, 1991 to March 31, 1992 subperiod (and throughout 1992), the U.S. stock prices traded within a narrow range without any major fluctuations as a reaction to sharply lowered interest rates in 1991. In fact, during 1992 U.S. stock prices were relatively flat, with the narrowest margins between highs and lows in history. This phenomenon may explain the low ARCH test statistic for the post-lib subperiod.

Several studies (*e.g.*, Scholes and Williams, 1977) have shown that institutional factors such as non-synchronous trading and bid-ask spreads may induce serial correlation in stock returns. The Breusch-Godfrey LM test verifies, at the 1% significance level, that there exists first-order autocorrelation in all subperiods of JSE and T&T returns, while finding only marginal presence of first-order autocorrelation (or none, in the pre-lib subperiod) for the S&P returns. Moreover, the Ljung-Box (LB) Q statistics for 10 lags reject the null hypothesis of no autocorrelation for JSE and T&T returns for all subperiods, confirming the presence of serial correlation.[5] The serial correlation is either absent or much weaker in the case of the U.S. stock market. This significant difference in the results may be seen as overwhelming evidence that the characteristic non-synchronous and infrequent trading of securities in the JSE and T&T induces significant serial correlation in the series for all subperiods.

The contemporaneous and lagged cross-correlations of close-to-close returns and squared returns for the three return series are presented in Table 2. The cross-correlations between the returns and squared returns are all fairly low, unlike those between developed stock markets reported by Hamao et al. (1990) and others. This observation is in line with that found by Kim and Rogers (1995) and Bekaert and Harvey (1995a) of emerging, less developed market returns' low correlation with the returns of developed markets. Even between the two regional stock markets of Jamaica and T&T, the cross-correlations are very low, ranging between 0.005 and 0.108 in absolute value.

However, there is a striking increase in the contemporaneous cross-correlation between S&P and JSE following the foreign exchange market liberalization. This increase is observed both for return levels and the squared returns. Between S&P and T&T, however, the increase in cross-correlations between the two subperiods are not as large in the levels and negligible in the squares. Also, the cross-correlation on JSE mean returns lasts until day two and then tapers off, while at the same time, the cross-market influence on squared returns is interchangeably weaker and stronger as the lag length increases.

According to Eun and Shim (1989), we may infer from the correlation coefficients the degree of financial integration between two countries. However, Berkaert and Harvey (1995a) suggest that this correlation may not reflect financial integration but rather a different country-specific industry mix. Notwithstanding this, the contemporaneous and lagged correlations provides some very interesting results. The findings of other researchers in the literature are that spillover effects are short-term (usually one day) and then taper off rapidly. However, the data in this study suggest that this phenomenon occurs only in the latter subperiod when all foreign exchange restrictions that existed previously had been lifted.

6. Estimation Results

Our empirical strategy is to estimate a GARCH(1,1) model described in (1) to (3), without the $X_{k,t}$ variables, for S&P returns. Using the squared residuals from this estimated model, we generate the spillover variables $X_{k,t}$. We "match" up the spillover variables so that the most recent spillover variable

is used. This is important because the JSE and TTSE trade only four and three times a week, respectively, while the NYSE trades five times a week. Also, the non-synchronous exchange holidays make this critical in aligning the spillover effects properly.

We report the estimation results of the basic GARCH model for JSE and T&T in Table 3, along with some diagnostic statistics.[6] As can be seen, we found GARCH(2,2) to provide the best fit for JSE returns while GARCH(1,1) provided the best fit for T&T and S&P returns. All variations of GARCH specifications, up to GARCH(3,3), were estimated for JSE and T&T returns. We then chose the most parsimonious GARCH specification given that it provided a similar fit as the more complex one.

For both JSE and T&T returns, our estimation seems to fit the data well, judging by the similarity in the kurtosis of the standardized residuals and the implied kurtosis calculated from our estimated degrees of freedom term for the student *t* distribution. Also, the absence of higher order serial correlations in the squared residuals implies that the GARCH model was able to model the heteroscedasticity, but the high Q statistics for the levels of the residuals indicate that our mean equation is unable to account for the persistence of the returns. The GARCH in mean term, a_2, is positive as expected given the risk-return tradeoff. However, they are statistically insignificant for both JSE and T&T, indicating that the risks are not priced in these markets.

Interestingly, our asymmetric variance term, φ, is significant and negative. It was hypothesized by the leverage argument that the higher leveraged firms will find their leverage ratio increase in times of falling stock prices and therefore the volatility will respond more to falling prices than rising prices. One possible explanation for this unexpected outcome is that these markets, in order to survive, has had to have some rein on excess volatility, putting some limits to the volatility movements. If this is true for JSE and T&T markets, then this result is not so unusual.

Spillovers from the U.S. Market

We now use the squared residuals from the GARCH estimation of S&P returns to form spillover variables, X_t. Using these variables, we will be able to determine if there are any spillover effects from

the U.S. to these two markets and if these effects have increased with the foreign exchange market liberalization. If the fixed exchange rate regime and the capital controls were binding form of barriers to entry, then we would expect to see an increase in the volatility spillovers in the post-lib subperiod. Thus, our GARCH model for the JSE and T&T stock returns with volatility spillovers can be set up as follows:

$$R_{i,t}|\psi_t = a_0 + a_1 R_{i,t-1} + a_2 h_t^{1/2} + \gamma_1 X_{i,t} + \gamma_2 D_{i,t} X_{i,t} + \varepsilon_{i,t}, \tag{4}$$

$$\varepsilon_{i,t}|\psi_t \sim t_v(0, h_{i,t}), \tag{5}$$

$$h_{it} = \omega_0 + \sum_{j=1}^{q} \alpha_j h_{i,t-j} + \sum_{j=1}^{p} \beta_j \varepsilon_{i,t-j}^2 + \delta_1 X_{i,t}^2 + \delta_2 D_{i,t} X_{i,t}^2 + \varphi V_{i,t} \varepsilon_{i,t-1}^2. \tag{6}$$

Here, $D_{i,t}$ are the dummy variables that equals 1 in the post-lib subperiod for the JSE and T&T and 0 elsewhere. Thus, γ_2 and δ_2 terms describe the increase (or decrease, if negative) in the volatility spillovers from the U.S. to these markets in the mean returns and volatility, respectively. Other parameters are as described for equations (1), (2), and (3).

Maximum likelihood estimation results of (4) through (6) are given in Table 4. The most striking difference of this model with volatility spillovers is that the asymmetric volatility term, φ, are zero for both JSE and T&T. It would seem that the asymmetric effects are well approximated by the spillovers from the U.S. As before, the model fits the data well, but is better at fitting the heteroscedasticity than the mean returns, as shown by the Q tests.

Of greater interest to us is the significance of the volatility spillovers and whether it has increased following the foreign exchange market liberalization. For JSE conditional variance equation, the spillovers have the hypothesized positive signs in that increased spillovers will cause JSE return volatility to increase as well. The magnitude increases drastically following the foreign exchange market liberalization, going from 0.001 for the full sample to 0.212 for the postlib subperiod. For the mean equation, we see that for the full sample, increased spillovers will cause the JSE returns to rise. But following the liberalization, the spillover coefficient is negative, implying that the volatility spillovers have less impact on the returns. But why the change in the sign? It may be that before liberalization, the

low correlation with U.S. returns meant that none of the foreign nor domestic investors could diversify away the risk in the U.S. market (during high volatility periods) by moving funds invested in the U.S. into the JSE. But with the liberalization, such capital movements could occur and hence the negative post-lib relationship between U.S. volatility and the JSE returns. This implies an increase in the informational efficiency in the market. Using the LR test to test the null hypothesis of zero increase in spillovers in the post-lib period, the LR(2) test statistic (21.68) indicates that the null will be rejected at all reasonable significance levels.[7] LR(4) test statistic for the null of no volatility spillovers at all is also strongly rejected.

Another interesting note is that the ARCH and GARCH parameters for the second lags, α_2 and β_2, are no longer significant. In fact, LR(2) statistic testing the null of zero second lag coefficients could not be rejected, implying that the volatility persistence has been reduced with the introduction of the volatility spillover variables. Lamoreaux and Lastrapes (1990) have argued that the GARCH effect is caused by the processing of the newly arrived information by the market, this reduction in persistence of GARCH effects can be seen as our volatility spillover variable being able to proxy some of this information effects.

On the other hand, T&T returns and volatility shows that the spillovers from the U.S. is practically non-existent. γ coefficient estimates are very small and not significant, and δ coefficients are also very small and only the full sample coefficient is significant. However, the LR(4) statistic for the significance of the volatility spillovers is rejected strongly, implying that the volatility spillovers do affect the returns and return volatility of T&T. The variance equation spillovers variables both have the expected positive signs. The mean equation signs are just opposite of what was found for the JSE: the full sample coefficient is negative and post-lib coefficient is positive. LR(2) test to test the increase in the spillovers following the foreign exchange market liberalization cannot be rejected even at 10% significance level. While this may be a result of the short post-lib subperiod for T&T data, such small coefficients seem to indicate that the volatility spillovers did not increase. This can be a result of the fact

that the barriers to entry for T&T was not binding even before the foreign exchange market liberalization, which allowed significant spillovers to occur, and hence liberalization should not be expected to cause an increase in the spillovers.[8] This could be an indication that while the foreign exchange market liberalization in Jamaica amounted to a removal of some binding barriers to entry while it did not in T&T.

7. Concluding Remarks

In this study, we were interested in finding out if the foreign exchange market liberalization with the market determined exchange rates and removal of controls on the movement of capital across the borders of Jamaica and T&T represented a removal of binding barrier(s) to entry. This barrier(s) could keep the foreign investors out, but more importantly, it would keep the domestic investors in, and the combined effect, without any alternative means (such as the closed end country fund, American Depository Receipts, etc.) would keep the domestic market relatively free from volatility spillovers from the U.S. market. Our empirical results show that while the liberalization policy in Jamaica has lead to increased spillovers, it did not in T&T.

As the volatility spillovers are found to be important in explaining the volatility in both markets, it was argued that the pre-liberalization conditions were more binding in Jamaica than in T&T. Thus, with the relaxation of these barriers, spillovers would increase for Jamaica but not for T&T.

There is an alternative explanation, one that is more problematic to prove. The fact that TTSE is a smaller market than JSE may imply that market efficiency problems found in small markets such as liquidity problems, thin markets, and infrequent trading, could be worse than JSE and cause the spillovers not to occur, or more likely, prevent the full spillovers from occurring. But if we accept the explanation that there still remains other binding barriers to entry, then more work needs to be done to identify these barriers. With respect to informational efficiency of the market, this is critical as these barriers are causing investors to not use all available information and hence cause inefficiency in the market.

Endnotes

1 GARCH models and their applications in finance are surveyed by Bollerslev, Chou, and Kroner (1993).

2 However, as King et al. (1994) points out, the sources of changes in volatility cannot be distinguished according to the source in the GARCH models.

3 This is the methodology used by Hamao et al. (1990) and Kim and Rogers (1995).

4 We use Bernt, Hall, Hall, and Hausman (BHHH) algorithm using numerical derivatives in our maximum likelihood estimation.

5 In fact, we found serial correlation at all lags, from 1 to 10, using Breusch-Godfrey test and for up to 20 lags using Ljung-Box Q test. For space considerations, we refrain from reporting those results here. Results are available from the authors.

6 We refrain from reporting the estimation results for S&P returns as this has been widely reported by other researchers. The results are available from the authors as well as other sources such as Kim and Rogers (1995) and Karolyi (1995).

7 Our spillover variables may suffer from the "generated regressor bias" described by Pagan and Ullah (1988), which could impart a bias in our LR statistics. The complexity of the model makes correction for this problem difficult. But since our rejected LR statistics are very large and not rejected are very small, our results are still suggestive even with this problem.

8 We thank Peter-John Gordon for providing this interpretation.

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Table 1 : Summary Statistics for S&P, JSE, and T&T Stock Returns

	Full Period:[1]		
	JSE	S&P	T&T
Observations	1340	2055	1216
Mean	0.1642*	0.0450**	0.1057
Variance	2.9994	0.6684	0.4605
Skewness	0.8060*	-0.6410*	1.0952*
Kurtosis	6.4660*	6.6060*	19.1241*
ARCH(4)	198.3328*	54.5169*	339.2600*
ARCH(8)	220.3775*	92.6349*	339.7081*
LM(1)	415.1466*	6.5277**	315.5877*
Q(10)	527.6461*	20.3214**	1013.4574*

	Jamaica[2]			
	Pre-lib Subperiod:		Post-lib Subperiod:	
	JSE	S&P	JSE	S&P
Observations	480	976	857	1072
Mean	0.2737*	0.0477	0.0950	0.0429**
Variance	1.8527	1.0152	3.6126	0.3569
Skewness	0.7344*	-0.6720*	0.8600*	-0.2425*
Kurtosis	6.5051*	5.0501*	5.7892*	2.5273*
ARCH(4)	70.0656*	15.9971*	130.0470*	8.5102***
ARCH(8)	73.8432*	30.4732*	146.3414*	11.2352
LM(1)	64.3028*	2.3676	258.4384*	5.6549**
Q(10)	301.4653*	14.2231	308.3080*	13.4743**

	Trinidad and Tobago (T&T)[3]			
	Pre-lib Subperiod:		Post-lib Subperiod:	
	T&T	S&P	T&T	S&P
Observations	802	1368	408	675
Mean	0.0443	0.0438	0.1787*	0.0516**
Variance	0.4303	0.8531	0.3441	0.2995
Skewness	0.2206*	-0.6476*	1.5750*	-0.2043**
Kurtosis	24.9595*	5.5965*	5.6694*	1.3789*
ARCH(4)	221.6948*	26.5728*	54.3510*	11.3142**
ARCH(8)	221.7812*	48.6232*	62.3123*	13.1675
LM(1)	122.8287*	3.3138**	153.2054*	6.0506**
Q(10)	777.9928*	16.1228***	217.5062*	11.5077

[1]The full period for all three markets range from November 10, 1987 to December 29, 1995

[2]For Jamaica, the pre-lib subperiod ranges from November 10, 1987 to September 19, 1991 and the post-lib subperiod ranges from October 1, 1991 to December 28, 1995.

[3]For T&T, the pre-lib subperiod ranges from November 10, 1987 to April 7, 1993 and the post-lib subperiod ranges from April 27, 1993 to December 29, 1995.

*Significantly different from zero at 1% significance levels.

**Significantly different from zero at 5% significance levels.

*** Significantly different from zero at 10% significance levels.

Table 2 : Cross-correlations Between JSE, T&T, and S&P Returns

Panel A:
Return Levels

		JSE		T&T	
	Lags	Pre-lib	Post-lib	Pre-lib	Post-lib
S&P	0	0.0001	0.0636	0.0342	0.0722
	1	-0.0158	-0.0131	0.0154	0.0471
	2	0.0265	-0.0532	0.0229	-0.0055
JSE	0			0.0557	0.1089
	1			0.0630	0.0713
	2			-0.0056	0.0313

Panel B:
Squared Returns

		JSE		T&T	
	Lags	Pre-lib	Post-lib	Pre-lib	Post-lib
S&P	0	-0.0039	-0.0278	-0.0299	0.0285
	1	-0.0643	-0.0647	-0.0338	-0.0140
	2	0.0677	0.0101	-0.0256	0.1138
JSE	0			-0.0477	0.0854
	1			-0.0498	0.0146
	2			-0.0156	0.0593

Table 3 : GARCH Estimation of JSE and T&T Returns Without Spillover Terms

Model:

$$R_{i,t}|\psi_t = a_0 + a_1 R_{i,t-1} + a_2 h_t^{1/2} + \varepsilon_{i,t},$$

$$h_{it} = \omega_0 + \sum_{j=1}^{q} \alpha_j h_{i,t-j} + \sum_{j=1}^{p} \beta_j \varepsilon_{i,t-j}^2 + \varphi V_{i,t} \varepsilon_{i,t-1}^2 .$$

	JSE (-2186.45)[1]		T&T (-693.66)[1]	
Coefficient	Estimate	Asymtotic T- Stat.	Estimate	Asymtotic T- Stat.
a_0	-0.0730	-2.7295	-0.0131	-1.1809
a_1	0.4268	22.0293	0.4497	19.5017
a_2	0.0690	1.6190	0.0388	0.7656
ω_0	0.0094	2.0316	0.0075	6.3238
α_1	0.3166	7.4234	0.6327	9.2301
α_2	0.2176	3.9725	-	-
β_1	0.2331	1.4289	0.3673	13.1374
β_2	0.2328	2.1363	-	-
φ	-0.1782	-3.9995	-0.1936	-2.5425
$1/\nu$	0.1899	13.3844	0.2418	17.5146
Sample Kurtosis		7.3753	46.8073	
Implied Kurtosis[2]		7.7495	47.3256	
Q(20)[3]		82.5403*	66.3810*	
Q^2(20)[4]		29.0045	2.6003	

[1]Numbers in the parenthesis are Log-likelihood.
[2]Implied kurtosis calculated from the estimated value of ν.
[3]Ljung-Box Q test for the presence of higher order serial correlation in the standardized residuals at 20 lags.
[4]Ljung-Box Q test for the squared standardized residuals at 20 lags.
*Significantly different from zero at 1% significance levels.

Table 4: GARCH Estimation of JSE and T&T Returns With Spillover Terms

Model:

$$R_{i,t}|\psi_t = a_0 + a_1 R_{i,t-1} + a_2 h_t^{1/2} + \gamma_1 X_{i,t} + \gamma_2 D_{i,t} X_{i,t} + \varepsilon_{i,t},$$

$$h_{it} = \omega_0 + \sum_{j=1}^{q} \alpha_j h_{i,t-j} + \sum_{j=1}^{p} \beta_j \varepsilon_{i,t-j}^2 + \delta_1 X_{i,t}^2 + \delta_2 D_{i,t} X_{i,t}^2 + \varphi V_{i,t} \varepsilon_{i,t-1}^2 .$$

		JSE (-2064.50)[1]		T&T (-693.66)[1]	
Coefficient		Estimate	Asymtotic T- Stat.	Estimate	Asymtotic T- Stat.
a_0		-0.0727	-1.5994	-0.0038	-0.2716
a_1		0.4732	17.6482	0.4674	18.0082
a_2		0.0786	1.5596	0.1667	0.3026
γ_1		0.0191	0.7351	-0.0007	-0.0911
γ_2		-0.0576	-1.0861	0.0063	0.4013
ω_0		0.0463	2.0787	0.0086	4.0651
α_1		0.4135	5.8626	0.6355	8.2581
α_2		0.0215	0.1226	-	-
β_1		0.5385	1.3542	0.3645	11.5385
β_2		0.0265	0.1122	-	-
δ_1		0.0012	0.1269	0.0047	2.2962
δ_2		0.2124	2.14256	0.0004	0.0908
φ		0.0000	0.0000	0.0000	0.0000
$1/\nu$		0.1952	9.0087	0.2408	15.3211
Sample Kurtosis			7.4464	41.8224	
Implied Kurtosis[2]			8.3401	42.3743	
Q(20)[3]			65.2813*	73.6935*	
$Q^2(20)$[4]			22.9796	2.6003	
LR(2)	H_0: $\gamma_2 = \delta_2 = 0$		21.6780*	2.0501	
LR(4)	H_0: $\gamma_1=\gamma_2=\delta_1=\delta_2=0$		229.8800*	85.8640*	
LR(2)	H_0: $\alpha_2 = \beta_2 = 0$		14.0205*	-	

[1]Numbers in the parenthesis are Log-likelihood.
[2]Implied kurtosis calculated from the estimated value of ν.
[3]Ljung-Box Q test for the presence of higher order serial correlation in the standardized residuals at 20 lags.
[4]Ljung-Box Q test for the squared standardized residuals at 20 lags.
*Significantly different from zero at 1% significance levels.