THE STOCK EXCHANGE OF MAURITIUS: A STUDY OF SEGMENTATION VERSUS INTEGRATION AT THE REGIONAL AND GLOBAL LEVEL

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ABSTRACT

The present research investigates the Stock Exchange of Mauritius and whether there is enough evidence to conclude that the market is segmented or integrated both at the regional level and at the global level. The methodology employed is the Jorion and Schwartz (1986) Capital Asset Pricing Model for testing the polar case of segmentation versus integration. Further, due to the low level of market activity observed on the Stock Exchange of Mauritius, the Dimson (1979) beta coefficients were also included to adjust for thin trading. Implementing the testing procedure leads to inconclusive results. More than half of the test outcomes were conflicting, with three of the twelve pair-wise tests rejecting the null hypotheses while four of the tests fail to reject the null hypotheses.

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I. INTRODUCTION

This paper examines whether the stocks listed on the Stock Exchange of Mauritius (SEM) are integrated with the world markets via an analysis of whether their pricing is affected by domestic factors or by regional and/or global factors. The empirical framework employed will follow the work of the Jorion and Schwartz (1986) Capital Asset Pricing Model (CAPM) and test for the polar case of segmentation versus integration. While the integration of the SEM has not been tested formally in an asset pricing framework, previous studies have explored the inter-relationships of the Mauritian economy with other economies (Bundoo (2000), Agathee (2008) and Bundoo (2008)) or various aspects of the SEM (Magnusson and Wydick (2002), Bundoo (2007), Bundoo (2008), Nowbutsing and Naregadu (2009)). We extend this literature to a formal asset pricing model.

The results of the present empirical work reveal conflicting results making it hard to determine with certainty whether the SEM is regionally and/or globally segmented or integrated. In the case of the 'Sector' portfolios all four pair-wise tests failed to reject the null hypothesis; while both of the regional pair-wise test on the 'Market capitalization' portfolios reject the null hypothesis.

Section II proceeds with a review of the previous studies relevant in the understanding of the methodology; while Section III details the empirical data, construction of the portfolios and the testing methodology employed, which is the CAPM model following Jorion and Schwartz (1986). Section IV presents the empirical results of the tests carried out; and finally Section V concludes and summarizes the key findings.

II. LITERATURE REVIEW

The origin of the CAPM model for testing financial market integration versus segmentation stems from Jordon and Schwartz (1986). Motivated by the inability of Stehle (1977) to reject neither the integration nor segmentation hypothesis, Jorion and Schwartz investigated the same hypotheses employing a different estimation approach. In their paper, Jorion and Schwartz (1986) directed their paper towards analyzing the polar case of integration versus segmentation for the Canadian equity market vis-à-vis a global North American market focusing on the barriers placed on asset pricing. The empirical result of the paper was that the Canadian stock market is segmented from the North American market for both the domestic and interlisted firms. The evolution and application of the CAPM model are very important in the literature and is now remarkably very broad. Asset pricing based tests of integration have been applied to a range of countries including the US-Canada pair (Jorion and

Schwartz (1986) and Mittoo (1992)), Australia-US pair (Ragunathan, Faff and Brooks (1998) and Ragunathan, Faff and Brooks (2000)) and the China-US pair (Wang and Di Iorio, 2005).

III. DATA AND METHODOLOGY

The required data for the stock prices and indices were collected from the DataStream database and included weekly stock prices for forty one companies and the Standard & Poor's national index for the Stock Exchange of Mauritius, Johannesburg Stock Exchange and the S&P 500 for the United States. For consistency with previous research, only the companies that had observations for the whole period considered were sampled which left thirty-six companies in total with weekly observations running from April 4th, 2000 to March 20th, 2009. Similarly, the indices run for the same sample period with the S&P Index for Mauritius, the S&P Index for Johannesburg and the S&P 500 proxying as the domestic, regional and global benchmarks respectively. The data was constrained to weekly observations due to the risk free rate that could only be downloaded from the Bank of Mauritius website[3] in the weekly format for the sample period under review.

In analyzing the plausibility of the integration or segmentation of the SEM, the stocks were considered individually and by grouping them into portfolios. The first set of portfolios was formed by grouping the stocks according to their market capitalization sorted in descending order which resulted in ten portfolios. For the second set of portfolios, the stocks were grouped according to their respective sectors which resulted in seven portfolios.

The methodology employed in this research is the CAPM framework following the work of Jorion and Schwartz (1986) and is outlined below in detail to aid in the understanding of the testing procedure.

The purely international CAPM model implies

$$E(\tilde{r}_i) = \gamma_0 + \gamma_1 \beta_i^G \qquad (1)$$

whereby, all the returns are expressed as excess returns over a designated risk-free rate. Therefore, $\tilde{r}_i = \tilde{r}_i^* - r_f$ meaning the excess return on asset *i*, which is the difference between the nominal return on asset *i* $(\tilde{r}_i^*)$and the risk-free rate(r_f). It is important to note here that (1) confines

[3] *Bank of Mauritius, 2009*

$\gamma_1 = E(\tilde{r}_G) - \gamma_0$ and that a 'zero γ_0 implies a version of the Sharpe-Lintner model; while a non-zero γ_0 implies a version of the Black model' (Jorion and Schwartz, 1986). Therefore the return on portfolio *i* is governed by the following equation with respect to the testing of integration:

$$\tilde{r}_{it} = E(\tilde{r}_i) + \beta_i^D(\tilde{r}_{Dt} - E(\tilde{r}_{Dt})) + \beta_i^G V_{Gt} + \tilde{\varepsilon}_{it} \quad (2)$$

Due to the possible existence of correlation and collinearity between the two markets, as pointed by Stehle (1977), it is not safe to carry out neither a univariate regression of return on only the systematic risk β_i^G nor even a multiple regression of the two factors. What was suggested is that the component of the domestic index which is independent from the global index to be isolated through the following projection:

$$\tilde{r}_D = c_0 + c_1\tilde{r}_G + \tilde{V}_{D,G} \quad (3)$$

This then produces the residual estimate $\tilde{V}_{D,G}$ implying that part of the international return which is orthogonal to the return of domestic benchmark. This leads to the two-factor model for testing for integration:

$$E(\tilde{r}_i) = \gamma_0 + \gamma_D\beta_i^D + \gamma_G\beta_i^G \quad (4)$$

Substituting (4) into (2) gives the model for testing the joint hypothesis of integration and efficiency of the global market:

$$\tilde{r}_{it} = \gamma_0(1 - \beta_i^D) + \gamma_G\beta_i^G + \beta_i^D\tilde{r}_{Dt} + \beta_i^G\tilde{V}_{Gt} + \tilde{\varepsilon}_{it} \quad (5)$$

From equation (5), the hypotheses to test jointly for integration and efficiency of the global market may be formulated to represent the null hypothesis of $\gamma_G = 0$ against the alternative hypothesis of $\gamma_G \neq 0$. Under the null hypothesis the model entails that the portfolio stocks are not priced according to the purely international risk factor thus implying that the portfolio is segmented. Conversely, rejecting the null hypothesis would mean that the international risk factor is useful in pricing domestic stocks.

Further, (5) is the basis of the CAPM model in testing the polar case of integration. To test for the polar case of segmentation, the same steps as above are undertaken but however switching between the domestic and the global benchmarks. This thus results in the following set of equations:

$$\tilde{r}_{it} = E(\tilde{r}_i) + \beta_i^G(\tilde{r}_{Gt} - E(\tilde{r}_{Gt})) + \beta_i^D V_{Dt} + \tilde{\varepsilon}_{it} \quad (2a)$$

$$\tilde{r}_G = c_0 + c_1\tilde{r}_D + \tilde{V}_{G,D} \quad (3a)$$

$$E(\tilde{r}_i) = \gamma_0 + \gamma_D\beta_i^D + \gamma_G\beta_i^G \quad (4a)$$

$$\tilde{r}_{it} = \gamma_0(1-\beta_i^G) + \gamma_D\beta_i^D + \beta_i^G\tilde{r}_{Gt} + \beta_i^D\tilde{V}_{Dt} + \tilde{\varepsilon}_{it} \quad (5a)$$

In this particular case, the test of segmentation would suggest that the null hypothesis is $\gamma_D = 0$ against the alternative hypothesis that it is not. Under the null hypotheses, the domestic stocks are believed to be priced according to solely international factors, thus implying that the domestic portfolios are integrated. On the other hand, if the null hypothesis is rejected, it may be concluded that the domestic risk factor is useful in pricing domestic stocks.

Equations (5) and (5a) gives the two testing models for the polar case of integration against segmentation at the global level. These same equations may be altered to cater for the polar test of integration versus segmentation at the regional level. This is done by substituting the international benchmark with a regional benchmark. The altered equations are thus:

$$\tilde{r}_{it} = \gamma_0(1-\beta_i^D) + \gamma_R\beta_i^R + \beta_i^D\tilde{r}_{Dt} + \beta_i^R\tilde{V}_{Rt} + \tilde{\varepsilon}_{it} \quad (5b)$$

$$\tilde{r}_{it} = \gamma_0(1-\beta_i^R) + \gamma_D\beta_i^D + \beta_i^R\tilde{r}_{Rt} + \beta_i^D\tilde{V}_{Dt} + \tilde{\varepsilon}_{it} \quad (5c)$$

In order to correct for thin trading of the Mauritian stock market, the Dimson (1979) beta is used to modify the Jorion and Schwartz (1986) model. This revision of the model was done by including Dimson (1979) betas in each of the regression (5), (5a), and (5b) and (5c) a multiple regression of the market index. In the present case, this multiple regression will include one lag and one lead Dimson (1979) beta coefficients. The altered equations which now consider the thin trading adjustments are given in (6), (6a), (6b) and (6c) respectively

(6)

$$\tilde{R}_{it} = \gamma_0\left(1-\sum_{k=-1}^{+1}\beta_{ik}^{D}\right)+\gamma_G\sum_{k=-1}^{+1}\beta_{ik}^{G}+\sum_{k=-1}^{+1}\beta_{ik}^{D}\tilde{R}_{D,t+k}+\sum_{k=-1}^{+1}\beta_{ik}^{G}\tilde{V}_{G,t+k}+\tilde{\varepsilon}_{it}$$

$$\tilde{R}_{it} = \gamma_0\left(1-\sum_{k=-1}^{+1}\beta_{ik}^{G}\right)+\gamma_D\sum_{k=-1}^{+1}\beta_{ik}^{D}+\sum_{k=-1}^{+1}\beta_{ik}^{G}\tilde{R}_{G,t+k}+\sum_{k=-1}^{+1}\beta_{ik}^{D}\tilde{V}_{D,t+k}+\tilde{\varepsilon}_{it} \quad (6a)$$

$$\tilde{R}_{it} = \gamma_0\left(1-\sum_{k=-1}^{+1}\beta_{ik}^{D}\right)+\gamma_R\sum_{k=-1}^{+1}\beta_{ik}^{R}+\sum_{k=-1}^{+1}\beta_{ik}^{D}\tilde{R}_{D,t+k}+\sum_{k=-1}^{+1}\beta_{ik}^{R}\tilde{V}_{R,t+k}+\tilde{\varepsilon}_{it} \quad (6b)$$

$$\tilde{R}_{it} = \gamma_0\left(1-\sum_{k=-1}^{+1}\beta_{ik}^{R}\right)+\gamma_D\sum_{k=-1}^{+1}\beta_{ik}^{D}+\sum_{k=-1}^{+1}\beta_{ik}^{R}\tilde{R}_{R,t+k}+\sum_{k=-1}^{+1}\beta_{ik}^{D}\tilde{V}_{D,t+k}+\tilde{\varepsilon}_{it} \quad (6c)$$

IV. EMPIRICAL RESULTS

The results of our analysis are reported in table 1 and overall the test outcomes revealed mixed conclusions. From the pair-wise testing methodology used, there were four possible outcomes when conducting the tests, and these possible outcomes are: (1) both tests consistently conclude in favour of integration; (2) both tests consistently conclude in favour of segmentation; (3) both tests reject the null hypothesis leading to contradictory results; and, (4) both tests fail to reject the null hypothesis also leading to contradictory results (Ragunathan, Faff and Brooks, 1998).

The summary results for testing at the global level reveals consistent test conclusions. In four of six pair-wise tests, both the segmentation and integration tests ended with the same conclusion. As for whether the consideration of thin trading adjustments did impact the conclusion, here again, only four of six tests had observed a change in their test results. Coincidentally, the only two pair-wise tests that ended with contradictory results were also the ones that were not impacted by the thin trading adjustments and these relate to the 'Sector' portfolios.

In contrast to the global results, regional results show that only one of the pair-wise tests consistently concluded in favour of integration, which is for the 'Individual' stocks. All the other pair-wise tests are contradictory, with one test concluding towards segmentation while the other towards integration. Further, the results from the modified testing models taking into consideration the thin trading adjustments were not impacted as they remained same as the results obtained from the models used without the thin trading adjustments. The only case where the thin trading adjustments did impact the results were in the case of the segmentation test applied on the 'Individual' stocks.

Overall the tests performed on the 'Individual' and 'Market capitalisation' portfolios revealed fairly mixed results both at the regional and global level; however, the regional tests on the 'Market capitalisation' portfolio, both with and without the thin trading adjustments, rejected the null hypothesis. Moreover, in the case of the 'Sector' portfolios; all tests failed to reject the null hypothesis. In an effort to explain the mix of results, the

main reasons were attributed to the risk adjustment used and the power of the test.

V. CONCLUSION

The level of financial integration between countries or stock exchanges has become the interest of various studies (Errunza and Losq (1985); Yang, Kolari and Min (2003); Wang, Yang and Bessler (2003); Tahai, Rutledge and Karim (2004)), mainly triggered by more and more countries relaxing controls on capital flows. This is usually carried out due to the attractiveness of risk diversification, potential for higher returns, positive spillover effect and an increased efficiency of the financial market. Paradoxically though, as the financial market becomes more and more integrated, at the global level for example, this implies that the price of the domestic stocks and portfolios are affected more and more by the global factors than the domestic factors. This then results in "similar assets should display the same risk-adjusted returns" (Ragunathan, Faff and Brooks, 1998) which consequently leads to reduced opportunity for higher returns but still maintains the attractiveness for risk diversification and market efficiency.

The present research has examined whether the SEM is segmented or integrated to the South African national index and the United States index. The SEM being an emerging financial market, and one of the most stable and prosperous countries in the Sub-Saharan African region, it is important to determine whether regional factors and/or global factors would affect the domestic stocks or portfolios in its attempt to becoming one of the key financial hub of the Indian Ocean.

The present research has employed the Jorion and Schwartz (1986) CAPM methodology and tested for the polar case of either segmentation or integration at the regional or global level. The empirical results discussed above revealed mixed results, with only five of the pair-wise tests consistently concluding in favour of either segmentation or integration, while the rest of the pair-wise tests had conflicting results with one test concluding in favour of segmentation while the other in favour of integration. It was therefore not clear as to whether the SEM was in fact segmented or integrated with respect to South Africa and/or America. This conforms to literature such as Wang and Di Iorio (2005) who were not able to reject the null of neither global segmentation nor global integration in their study of China.

Table 1: Gamma coefficients and Tests of integration and segmentation		**GLOBAL**				**REGIONAL**		
INDIVIDUAL		**Coefficient**	**Test Statistic**	**Conclusion**		**Coefficient**	**Test Statistic**	**Conclusion**
Without thin trading adjustments			Equations (5) and (5a)				Equations (5b) and (5c)	
- Regional integration test	γ_G	-0.0039	-2.6331	Integrated	γ_R	0.0579	2.1431	Integrated
- Regional segmentation test	γ_D	-0.0009	-0.4473	Integrated	γ_D	-0.0012	-0.6676	Integrated
With thin trading adjustments			Equations (6) and (6a)				Equations (6b) and (6c)	
- Regional integration test	γ_G	0.0012	1.3293	Segmented	γ_R	0.0123	3.6169	Integrated
- Regional segmentation test	γ_D	-0.0046	-2.8691	Segmented	γ_D	-0.0043	-3.7889	Segmented
MARKET CAPITALISATION		**Coefficient**	**Test Statistic**	**Conclusion**		**Coefficient**	**Test Statistic**	**Conclusion**
Without thin trading adjustments			Equations (5) and (5a)				Equations (5b) and (5c)	
- Regional integration test	γ_G	0.0096	1.795	Integrated	γ_R	0.0437	1.7168	Integrated
- Regional segmentation test	γ_D	-0.0295	-0.5657	Integrated	γ_D	-0.0242	-1.8873	Segmented
With thin trading adjustments			Equations (6) and (6a)				Equations (6b) and (6c)	
- Regional integration test	γ_G	0.0144	1.2108	Segmented	γ_R	0.0157	2.5049	Integrated
- Regional segmentation test	γ_D	-0.0159	-1.8049	Segmented	γ_D	-0.0076	-2.7417	Segmented
SECTOR		**Coefficient**	**Test Statistic**	**Conclusion**		**Coefficient**	**Test Statistic**	**Conclusion**
Without thin trading adjustments			Equations (5) and (5a)				Equations (5b) and (5c)	
- Regional integration test	γ_G	-0.0066	-1.5433	Segmented	γ_R	0.0404	1.2497	Segmented
- Regional segmentation test	γ_D	-0.145	-0.2497	Integrated	γ_D	-0.089	-0.4442	Integrated
With thin trading adjustments			Equations (6) and (6a)				Equations (6b) and (6c)	
- Regional integration test	γ_G	-0.0112	-0.9725	Segmented	γ_R	0.0319	1.2035	Segmented
- Regional segmentation test	γ_D	-0.0222	-0.8861	Integrated	γ_D	-0.0097	-1.4717	Integrated

This table reports parameter estimates, t-statistics on the significance of the estimated gamma parameters, and the conclusion drawn by the significance test with regards to the polar case of integration and segmentation.

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