

Cointegration Relationships between Markets under Different Currency Systems: Post 2007 Financial Crisis

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Abstract

In this study, we examine the cointegration relationships between the US stock market and those of 76 international markets (with 22 developed, 24 emerging, and 29 frontier markets) in the post 2007 Financial Crisis period. Overall, we find that international stock markets are not cointegrated with the US stock market. Over the long run, international portfolio diversification is an effective way to manage country risk. Stock markets in countries with free-floating exchange rate system seem to be more integrated with the US stock market. In other words, US investors may enjoy greater benefits from portfolio diversification by investing in countries whose currencies are not free-floating. However, during a crisis, stock markets becomes more cointegrated as observed by the spike in the recursive cointegration graphs. A financial crisis in one country can have an impact on the stock market of another country. The observed contagion effect makes international portfolio diversification strategy less effective during a crisis.

I. Introduction

It has been widely recognized that international portfolio diversification offers potential benefits that goes beyond wholly domestic investments albeit conditional in some cases (Chiou, 2008; De Roon, Nijman and Werker, 2001; Harvey, 1995; Lessard, 1976; Levy and Sarnat, 1970; Li, Sarkar and Wang, 2003; and Solnik 1974). Despite the perceived association of higher return and higher risks (Bartman and Dufey, 2001), as emerging markets gradually become more accessible, they appear to be promising investment targets to both the US and global investors (Butler and Joaquin, 2002; Zonouzi, Mansourfar and Azar, 2014). This may explain the remarkable increase in portfolio investment inflow to emerging equity markets from merely US\$6.2 billion in 1990 to US\$217 billion in 2014 (Arouri, Jawadi and Nguyen, 2009; Koepke, Brandt and Mohammed, 2015). In addition, the literature also suggests emerging equity markets display very low correlation of returns with assets in developed markets, which further motivates investors in the developed markets such as the U.S. to pursue internationally (Naranjo and Porter, 2007).

The primary success factor of international diversification strategy stems from the correlations between constituent stock markets in the portfolio. As globalization-driven interdependence among countries ushered the growing interconnectedness and integration of the international financial markets in the past several decades, it is arguably that the emerging and developed financial markets remain gently correlated. In fact a rising level of co-movement and cointegration across developed and emerging markets has been documented, and catching the attention among scholars (Ratanapakorn and Sharma, 2002, Su and Yip, 2014; Zonouzi, Mansourfar and Azar, 2014). Nonetheless, DeSantis and Gerard (1997) shows that international portfolio diversification is still beneficial to investors.

Another issue in international portfolio diversification is stability of correlations. Longin and Solnik (1995) argues that international correlation increases when global factors dominate

domestic factors, and they tend to affect all markets. As a result, these may be considered as global systematic risks because they cannot be easily diversified away by forming an international portfolio. According to their findings, a negative shock, such as the 1974 oil crisis, and 1987 stock market crash, or a positive shock like the end of the 1991 Gulf War, will lead not only to an increase in volatility but also subsequently an increase in correlation in international financial markets. However, given that they did not find any asymmetry in reaction since a positive shock would also lead to an increase in correlation, their findings suggest that this contagious effect may arise from positive events as well. On the other hand, the correlations between emerging and developed equity markets moved in a rising trend in a volatile economic environment, as found in two sub-periods, 1988-1993 and 1994-1995, studied by Saunders and Walter (2002). It suggests that major economic crisis promotes financial market volatility and contagiousness. Because low correlations between markets is critical in reducing the contagion effect of financial crisis, the higher the correlation during bear and/or volatile time will potentially further reduce or even offset the benefits of international portfolio diversification.

Further investigation results in cointegration relationships between the US and emerging stock markets seem inconsistent and contradictory (Su and Yip, 2014). On one hand, Ghosh, Saidi, and Johnson (1999), Sheng and Tu (2000), and Darrat and Zhong (2002) provide evidences that the US stock market and emerging stock markets are indeed cointegrated in the long run and point to the overemphasizing of the long-term benefits of internationally diversified portfolio. On the other hand, studies by Chan, Gup and Pan (1992); DeFusco, Geppert, and Tsetsekos (1996); Choudhry (1997) and Soydemir (2000), and Su and Yip (2014) found the exact opposite patterns. None of the studies was able to detect or verify any long-term cointegration relation between the US and emerging stock markets, which implies that there is simply no long-term correlation between them. In other words, cointegration does not exist, and long investment horizon is still considered as a key factor to US investors' success in international portfolio diversification strategy.

Perhaps the contradicting results can be better explained in Yang, Kolari and Sutanto (2004). This study explores the long-term stability patterns between the US and emerging stock markets from 1981 to 2001. The findings propose that the degree of cointegration depends on the overall economic environment. Specifically, major economic crisis, such as the Asian Economic Crisis of 1997-1998, is to be responsible for the heightened degree of cointegration during that time. Su and Yip (2014) reported consistent results when examining the impacts of the financial crisis in 2007 on cointegration. The strong contagion effect observed by Saunders and Walter (2002) during a bear market seems to put into question that the perceived advantages and rationale behind international portfolio diversification.

From the theoretical perspective, Goldstein and Pauzner (2004) proposes a model depicting how contagion of financial crises happened due to diversified investment portfolio across countries where two of them share the same group of investors. Despite their independent economic fundamentals, it is highly probable that the effects of a financial crisis in one country can be felt in other countries due to the sharing of common investors. Against the backdrop of intense globalization and rapidly growing acceptance of exchange traded country funds, globally well-diversified investment portfolios are still favored by experienced and ambitious investors. As long as this phenomenon prevails, one may find it logical to assume that a financial crisis will be mutually spread between emerging and developed economies regardless of the differences in their economic structures.

II. Contributions of the Study

The purpose of this paper is to examine how the currency system affects the cointegration relationship between US and the emerging stock markets. Our contributions can be considered in threefold. Firstly, to study the impact of currency systems on cointegration relationship, we will apply the recursive cointegration procedure by Yang, Kolari and Sutanto (2004) to the monthly stock returns measured both in US dollars and in local currencies. Since the cointegration relationship derived from returns measured in local currencies are free of the impact of currency market, it represents the real nature of the cointegration relationship between underlying economics. A comparison between the cointegration relationships derived from before- and after-currency adjusted returns will provide evidence on whether the currency system plays a role in global portfolio diversification.

Secondly, including both developed, emerging and frontier markets in this study allows us to investigate how different currency systems affect international investing. Generally speaking, developed countries tend to adopt floating-rate currency system while emerging countries are more inclined to use fixed-rate or managed currency system.

Thirdly, we examine the influence of major economic event post 2007 financial crisis on the cointegration relationships between markets under different currency systems.

III. Data and Methodology

A. Data

The daily stock index prices of 69 countries are obtained from Morgan Stanley Capital International, Inc. (MSCI) for the sampling period from October 27, 2010 through October 27, 2015. The 69 market indices include the US, 22 developed market indices (Australia, Austria, Belgium, Canada, Denmark, Hong Kong, Finland, France, Germany, Ireland, Israel, Italy, Japan, New Zealand, Netherlands, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, and United Kingdom), 18 emerging market indices (Chile, China, Colombia, Czech Republic, Egypt, Greece, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Taiwan, Thailand, Turkey, Qatar, and United Arab) and 29 frontier market indices (Argentina, Bahrain, Bangladesh, Bosnia, Botswana, Bulgaria, Croatia, Estonia, Ghana, Jamaica, Jordan, Kazakhstan, Kenya, Kuwait, Lebanon, Lithuania, Mauritius, Morocco, Nigeria, Oman, Romania, Pakistan, Saudi Arabia, Slovenia, Serbia, Sri Lanka, Trinidad, Ukraine, and Vietnam).

The MSCI “Total Return Indices with Net dividends” series are used in this study. This index measures the price performance of markets with dividends reinvested after the deduction of withholding taxes. For each market index, two prices indices are collected. First, market indices measured in local currencies (LC), which present the market movements in each domestic stock market without the currency effect. Second, market indices measured in US dollars presenting the market movements adjusted by the currency effect. This price series is more relevant for US investors who are interested in diversifying their stock portfolios.

B. Methodology

Unit Root Tests

We have to ascertain if these series are nonstationary with unit roots using the augmented Dickey-Fuller (ADF) test procedure before we are able to test whether two index series are cointegrated. If the market index series, $x_{i,t}$, follows an AR(p) process, the ADF regression model (Corbae and Ouliaris, 1988) is applied, and the model as given in equation (1).

$$\Delta x_{i,t} = a_{i,0} + a_{i,1}t + a_{i,2}x_{i,t-1} + \sum_{i=1}^{p-1} b_{i,1}\Delta x_{i,t-i} + v_{i,t} \quad (1)$$

Under the null hypothesis which state that $a_{i,2} = 0$, i.e., the variable has a unit root. As such, an insignificant ADF t-statistics suggests that one cannot reject the hypothesis of the existence of a unit root.

Cointegration Analysis

We next use Johansen's (1988) maximum-likelihood estimator (MLE) approach to test the hypothesis that there exists a long-run relationship between the US and a foreign stock market indexes. Assuming that two market indices follow a Vector Autoregressive process (VAR(k)) with a constant term as shown in equation (2), the cointegration model and the hypothesis of c cointegration vectors take the form of equation (3).

$$H_1 : \Delta X_t = \Pi X_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta X_{t-j} + \mu + v_t \quad (2)$$

where $X_t = (X_{US,t} \quad X_{FOR,t})$

$$Z_{0t} = \Pi Z_{1t} + \Gamma Z_{2t} + \varepsilon_t \quad (3)$$

where $Z_{0t} = \Delta X_t$

$$Z_{1t} = X_{t-1}$$

$$Z_{2t} = (\Delta X'_{t-1}, \dots, \Delta X'_{t-k+1}, 1)'$$

$$\Gamma = (\Gamma_1, \dots, \Gamma_{k-1}, \mu)$$

$$\Pi = \alpha\beta'$$

$$H_2 : \Pi = \alpha\beta'$$

To obtain the MLE results, regressions of Z_{0t} and Z_{1t} on Z_{2t} are adopted and the following "R-representation" residuals by Hansen and Johansen (1993, 1999) are produced:

$$R_{0t} = Z_{0t} - A_{0t}Z_{2t} \quad (4)$$

$$R_{1t} = Z_{1t} - A_{1t}Z_{2t} \quad (5)$$

A trace test (Johansen 1991) statistic, testing the hypothesis that there are at most c cointegration vectors, is given as:

$$-2 \ln(Q; H_2 | H_1) = -T \sum_{l=c+1}^2 \ln(1 - \lambda_l) = \lambda_{trace}$$

where $\lambda_{c+1}, \dots, \lambda_3$ are the $2 - c$ smallest square canonical correlations on the residuals from equations (4) and (5).

The Johansen (1991) trace statistic is applied to each pair of market indices to test the hypothesis that there are at most c cointegration vectors. The TC_{trace} is then calculated as the Trace test normalized by the 5% critical values. That is, $TC_{trace} = \lambda_{trace} / C_{(5\%)}$ where $C_{(5\%)}$ is the 5% trace test critical value. The null hypothesis of $r \leq 1$ (or $r = 0$, i.e., no cointegration exists) will be rejected if $TC_{trace} > 1$.

Recursive Cointegration Analysis

A recursive cointegration analysis is employed to examine the stability of the cointegration relationships over time. Following the procedure outlined by Yang, Kolari, and Sutanto (2004) and Dimpfl (2014), we investigate the constancy of the cointegration rank through time using a rolling-window framework. The procedure is described as the following:

Step 1: Estimate the model using equation (3) over the full sample period.

Step 2: Re-estimate the model with equations (4) and (5) using the data from the initial 500 days as our initial estimation period. That is, our first sample includes observations from the 1st to the 500th observation. The trace statistics is obtained and scaled by the corresponding critical value.

That is,

$TC_{trace} = \lambda_{trace} / C_{(5\%)}$ where $C_{(5\%)}$ is the 5% trace test critical value. The null hypothesis of $r \leq 1$ (or $r = 0$, no cointegration exists) will be rejected if $TC_{trace} > 1$.

Step 3: Create a rolling window of 500 observations by adding the succeeding 5 observations and removing the first 5 observations (that is, a sample including observation $t+5$ to $t+505$). The scaled trace statistic is then re-estimated using this new sample. This procedure is repeated until the last sample observation is included in the regression. This procedure will give us a sequence of scaled trace test statistics.

Step 4: Apply Step 1 to Step 3 to both market price indices, measured in local currency as well as in US dollars. The trace statistics calculated based on market price indices measured in local currency is denoted as TC^{LC}_{trace} while the one measured in US dollars is denoted as $TC^{\$}_{trace}$. To compare whether the currency effect facilitates the cointegration of global stock markets, a ratio between these two trace statistics is calculated as $TC^{\$}_{trace} / TC^{LC}_{trace}$. If the $TC^{\$}_{trace}$ is greater than the TC^{LC}_{trace} (or $TC^{\$}_{trace} / TC^{LC}_{trace} > 1$), it suggests that the currency effect enhances the cointegration relationship between foreign and US stock markets.

IV. Empirical Results

All sampling firms are grouped into four sub-samples according to their classifications of exchange rate arrangements provided by IMF in 2015. These four subsamples are: 1) Free Floating System, 2) Floating System, 3) Other Managed Arrangement and Crawl-Like Arrangement System and 4) Other Exchange Rate Arrangement Systems. Appendix A reports the reclassification of exchange rate arrangement by IMF for each country during the sampling period. Table I reports the descriptive statistics for the full sample.

Table I. Summary Statistics for Daily Stock Returns

Panel A. Free Floating System										
US						LC				
Market	N	Mean	SD	Min	Max	Mean	SD	Min	Max	
Panel A.1 Developed Markets										
Australia	1304	0.01%	1.28%	-6.60%	6.45%	0.03%	0.91%	-4.22%	3.76%	Free floating
Austria	1304	-0.01%	1.71%	-8.56%	9.42%	0.00%	1.46%	-6.98%	6.93%	Free floating
Belgium	1304	0.05%	1.32%	-6.33%	6.15%	0.06%	1.14%	-5.08%	5.84%	Free floating
Canada	1304	0.00%	1.07%	-6.00%	5.52%	0.02%	0.83%	-3.96%	4.27%	Free floating
Finland	1304	0.02%	1.61%	-7.18%	8.02%	0.04%	1.40%	-6.24%	6.16%	Free floating
France	1304	0.02%	1.52%	-7.06%	8.44%	0.04%	1.28%	-5.40%	5.96%	Free floating
Germany	1304	0.03%	1.51%	-6.74%	7.68%	0.04%	1.28%	-5.83%	5.34%	Free floating
Ireland	1304	0.07%	1.58%	-6.87%	6.97%	0.08%	1.43%	-5.32%	5.97%	Free floating
Italy	1304	0.01%	1.84%	-8.24%	8.61%	0.03%	1.61%	-6.42%	6.38%	Free floating
Japan	1304	0.03%	1.20%	-8.20%	7.39%	0.06%	1.26%	-9.12%	6.60%	Free floating
Netherlands	1304	0.04%	1.33%	-6.00%	6.48%	0.05%	1.11%	-4.64%	4.36%	Free floating
Norway	1304	0.01%	1.57%	-7.68%	6.07%	0.03%	1.16%	-5.66%	4.76%	Free floating
Portugal	1304	-0.04%	1.56%	-6.81%	5.06%	-0.03%	1.35%	-6.41%	4.23%	Free floating
Spain	1304	0.01%	1.77%	-6.81%	8.12%	0.02%	1.51%	-6.09%	6.43%	Free floating
Sweden	1304	0.03%	1.59%	-8.37%	8.51%	0.04%	1.21%	-6.73%	6.11%	Free floating
UK	1304	0.03%	1.14%	-6.25%	5.02%	0.03%	0.96%	-4.67%	4.00%	Free floating
Panel A.2 Emerging Markets										
Chile	1304	-0.04%	1.23%	-8.70%	6.95%	-0.02%	0.94%	-6.67%	6.08%	Free floating
Greece	1304	-0.09%	3.11%	-21.60%	18.73%	-0.08%	2.99%	-21.05%	17.58%	Free floating
Mexico	1304	0.01%	1.28%	-7.76%	5.61%	0.03%	0.90%	-5.57%	4.16%	Free floating
Poland	1304	-0.01%	1.66%	-10.61%	7.44%	0.01%	1.13%	-7.22%	5.05%	Free floating
Panel A.3 Frontier Markets										
Estonia	1304	0.00%	1.36%	-6.54%	9.61%	0.02%	1.18%	-6.51%	9.21%	Free floating
Slovenia	1304	-0.01%	1.20%	-6.28%	5.22%	0.01%	1.03%	-6.49%	4.66%	Free floating

Panel B. Floating System										
		US				LC				
Market	N	Mean	SD	Min	Max	Mean	SD	Min	Max	
Panel B.1 Developed Markets										
Israel	1304	0.01%	1.19%	-7.38%	6.67%	0.01%	1.09%	-8.26%	5.42%	Floating
New Zealand	1304	0.04%	1.12%	-5.40%	4.86%	0.05%	0.81%	-3.90%	3.06%	Floating
Panel B.2 Emerging Markets										
Colombia	1304	-0.04%	1.28%	-7.15%	5.45%	-0.01%	0.97%	-4.58%	4.76%	Floating
India	1304	0.00%	1.34%	-7.21%	6.00%	0.03%	1.03%	-6.07%	3.81%	Floating
Indonesia	1304	0.00%	1.56%	-9.33%	7.58%	0.03%	1.39%	-10.43%	6.28%	Floating
Peru	1304	-0.03%	1.51%	-15.21%	7.56%	-0.03%	1.51%	-15.21%	7.56%	Floating
Philippines	1304	0.05%	1.24%	-7.62%	6.62%	0.05%	1.12%	-6.90%	6.54%	Floating
Taiwan	1304	0.02%	1.14%	-5.50%	5.28%	0.02%	1.02%	-5.48%	4.95%	Floating
Thailand	1304	0.02%	1.37%	-6.46%	7.32%	0.03%	1.22%	-6.18%	6.93%	Floating
Turkey	1304	-0.02%	1.92%	-10.86%	9.14%	0.03%	1.51%	-10.20%	6.99%	Floating
Panel B.3 Frontier Markets										
Ghana	1304	0.00%	1.30%	-10.67%	9.36%	0.08%	1.01%	-9.97%	9.40%	Floating
Kenya	1304	0.04%	1.01%	-6.59%	4.90%	0.06%	0.89%	-4.94%	4.95%	Floating
Mauritius	1304	0.01%	0.68%	-3.64%	4.00%	0.02%	0.53%	-3.64%	3.62%	Floating
Romania	1304	0.04%	1.41%	-9.44%	8.40%	0.05%	1.14%	-9.25%	6.87%	Floating
Serbia	1304	-0.02%	1.47%	-9.38%	12.82%	0.00%	1.25%	-8.71%	11.38%	Floating
Ukraine	1304	-0.09%	2.73%	-29.39%	23.73%	-0.03%	2.18%	-14.42%	23.70%	Floating

Panel C. Other managed and Crawl-like arrangement System										
		US				LC				
Market	N	Mean	SD	Min	Max	Mean	SD	Min	Max	
Panel C.1 Developed Markets										
Switzerland	1304	0.04%	1.04%	-4.69%	4.67%	0.04%	0.98%	-8.74%	4.88%	Crawl-like
Panel C.2 Emerging Markets										
China 50	1304	0.02%	1.35%	-6.30%	6.78%	0.02%	1.34%	-6.34%	6.72%	Crawl-like
Czech Republic	1304	-0.02%	1.37%	-6.64%	6.68%	0.00%	1.06%	-6.37%	4.76%	Other managed arrangement
Malaysia	1304	0.00%	0.90%	-4.35%	5.95%	0.02%	0.61%	-2.88%	3.96%	Other managed arrangement
Panel C.3 Frontier Markets										
Argentina	1304	0.01%	2.20%	-12.71%	11.89%	0.01%	2.20%	-12.71%	11.89%	Crawl-like
Croatia	1304	-0.01%	0.91%	-3.63%	7.61%	0.01%	0.66%	-3.91%	7.35%	Crawl-like
Jamaica	1304	0.03%	1.76%	-7.72%	9.67%	0.06%	1.75%	-7.37%	9.67%	Crawl-like
Nigeria	1304	0.02%	1.28%	-7.64%	8.89%	0.04%	1.16%	-5.42%	8.89%	Other managed arrangement
Pakistan	1304	0.05%	1.04%	-6.24%	4.65%	0.07%	1.00%	-4.45%	4.71%	Other managed arrangement

Panel D. Other Systems										
		US				LC				
Market	N	Mean	SD	Min	Max	Mean	SD	Min	Max	
Panel D.1 Developed Markets										
Denmark	1304	0.05%	1.28%	-7.64%	6.30%	0.07%	1.12%	-7.61%	5.34%	Conventional peg
Hong Kong	1304	0.03%	1.06%	-5.13%	5.98%	0.03%	1.06%	-5.11%	5.97%	Currency board
Singapore	1304	0.01%	1.00%	-4.85%	5.26%	0.01%	0.81%	-4.22%	3.06%	Stabilized arrangement
Panel D.2 Emerging Markets										
Egypt	1304	0.01%	1.55%	-10.28%	11.03%	0.03%	1.53%	-9.93%	11.14%	Stabilized arrangement
Qatar	1304	0.05%	0.95%	-6.71%	10.34%	0.05%	0.95%	-6.71%	10.34%	Conventional peg
United Arab	1304	0.06%	1.49%	-8.91%	11.12%	0.06%	1.49%	-8.91%	11.12%	Conventional peg
Panel D.3 Frontier Markets										
Bahrain	1304	-0.05%	1.11%	-8.32%	8.15%	-0.05%	1.11%	-8.32%	8.15%	Conventional peg
Bangladesh	1304	-0.01%	1.76%	-15.44%	16.70%	-0.01%	1.75%	-15.24%	16.63%	Stabilized arrangement
Bosnia	1304	0.00%	1.30%	-5.31%	6.29%	0.01%	1.14%	-5.84%	6.87%	Currency board
Botswana	1304	0.01%	0.96%	-8.57%	6.56%	0.05%	0.78%	-8.51%	5.77%	Crawling peg
Bulgaria	1304	-0.03%	1.52%	-6.52%	5.47%	-0.02%	1.39%	-6.62%	6.36%	Currency board
Jordan	1304	-0.02%	1.06%	-7.30%	9.67%	-0.02%	1.06%	-7.28%	9.76%	Conventional peg
Kazakhstan	1304	-0.02%	1.79%	-9.94%	8.39%	-0.02%	1.79%	-9.94%	8.39%	Stabilized arrangement
Kuwait	1304	-0.02%	0.87%	-5.25%	8.90%	-0.01%	0.86%	-5.11%	8.90%	Conventional peg
Lebanon	1304	-0.02%	0.81%	-5.47%	4.83%	-0.02%	0.81%	-5.47%	4.83%	Stabilized arrangement
Lithuania	1304	0.01%	0.95%	-5.27%	5.52%	0.03%	0.74%	-5.24%	5.88%	Currency board
Morocco	1304	-0.03%	0.95%	-3.34%	4.59%	-0.02%	0.84%	-3.39%	4.62%	Conventional peg
Oman	1304	0.01%	0.89%	-9.63%	11.48%	0.01%	0.89%	-9.61%	11.48%	Conventional peg
Saudi Arabia	1304	0.03%	1.14%	-11.54%	10.90%	0.03%	1.14%	-11.53%	10.92%	Conventional peg
Sri Lanka	1304	-0.01%	0.97%	-7.01%	3.79%	0.01%	0.93%	-6.90%	3.70%	Stabilized arrangement
Trinidad	1304	0.05%	0.46%	-3.77%	3.34%	0.05%	0.42%	-3.69%	3.34%	Stabilized arrangement
Vietnam	1304	0.00%	1.34%	-6.50%	4.64%	0.01%	1.32%	-5.95%	4.67%	Stabilized arrangement

A. Empirical Results for Full Sample

Countries with Free Floating System (Panel A of Table II)

With few exceptions, most of the stock markets, as measured in their local currencies, are not cointegrated with US stock market during the period-examined (10/27/2010 to 10/27/2015). Only three stock markets, Germany, Spain, and Greece, report significant TC_{trace}^{LC} ratio. When measured in US dollars, the stock markets, which are cointegrated with the US stock market, are Belgium, Finland, and Greece.

It is interesting to note that after taking into consideration the currency effect, the US dollar denominated stock price indices of Germany and Spain become non-cointegrated with the US market, suggesting that the currency effect actually drive the German and Spain stock market from integration with the US stock market.

Countries with Floating System (Panel B of Table II)

Similar to results in Panel A, majority of the stock markets in this sample are not cointegrated with US stock market during the sample period. Only three stock markets measured

in local currency, New Zealand, India, and Romania, report significant TC^{LC}_{trace} ratio. However, only India stock market is cointegrated with US stock market when reported in US dollar term.

Countries with Other Managed and Crawl-Like Arrangement (Panel C of Table II)

With the exception of Switzerland, all of the stock markets in this sample, as measured in local currency, are not cointegrated with US stock market. However, when measured in US dollar, none of the stock markets is cointegrated with US stock market.

Countries with Other Currency System (Panel D of Table II)

Most of the countries in this sample are considered to be frontier markets. Therefore, it is not surprising to see that most of the stock markets in this sample are not cointegrated with US stock market. Only 3 out of 16 frontier stock markets, namely, Bangladesh, Botswana, and Trinidad, as measured in local currency, reports significant TC^{LC}_{trace} ratio. Only Trinidad stock market remains cointegrated with the US stock market when exchange rate is taken into consideration.

Effect of Exchange Rate Arrangement

Overall, most of the stock markets, regardless of whether they are classified as developed, emerging or frontier markets, do not cointegrate with the US stock market. When exchange rate is taken into account, as measured in US dollar term, even fewer markets are cointegrated with the US market.

Although there are fewer stock markets reporting significant cointegration with the US stock market, there is evidence that a free-floating currency system does enhance the global integration of national stock markets. This is shown by the fact that TC^S_{trace} is higher TC^{LC}_{trace} (that is, $TC^S_{trace} / TC^{LC}_{trace} > 1$) for 14 out of the 22 (64%) stock markets reported in Panel A. Specifically, there are 10 out of 16 developed markets, 3 out of 4 emerging markets and 1 out of 2 frontier markets fall into this category.

A floating system (“managed” floating system) does improve the degree of integration of these markets with US market, but the effect is not as strong as a free-floating system. For example, only 8 out of 16 (50%) report a higher TC^S_{trace} ratio as compared to the TC^{LC}_{trace} . Specifically, there are 1 out of 2 developed markets, 4 out of 8 emerging markets and 3 out of 6 frontier markets.

A managed or/and crawl-like arrangement system seems to help bringing China, Czech Republic, Malaysia, Russia, Croatia, and Pakistan stock markets more integrated with US market. However, it has adverse effect on the Swiss stock market.

A number of countries listed under other exchange rate system have their currencies pegged to the US dollar. Therefore, we expect minimal difference between their stock market return measured in local currency and those measured in US dollar. This is evident that most of the $TC^S_{trace} / TC^{LC}_{trace}$ are very close to 1.

Our results seem to suggest that when exchange rate is taken into consideration, stock markets in countries with free-floating system are more cointegrated with the US stock market. In

other words, the freer movement of money under the free-floating system seem to increase the cointegration of these markets with the US market.

Table II. Bivariate Cointegration Test between US and Each of the Equity Markets

The US and foreign stock markets are assumed to follow a Vector Autoregressive Process (VAR(k)). The AIC is used to select the optimal lag k . Augmented Dickey-Fuller (ADF) tests for stock market indices are reported for the whole sample period applicable to each market. The ADF without trend regression is given as:

$$\Delta x_{i,t} = a_{i,0} + a_{i,2}x_{i,t-1} + \sum_{i=1}^{p-1} b_{i,1}\Delta x_{i,t-i} + v_{i,t}$$

The ADF test is reported for AR(k). The null hypothesis states that the stock index follows a unit root, i.e., $a_{i,2} = 0$. An insignificant ADF t-statistic indicates that one cannot reject the hypothesis of the existence of a unit root. The Johansen (1991) trace statistic, testing the hypothesis that there are at most c cointegration vectors, $H: c = 0$, is applied to each of the bivariate markets for the available sample period. Given no linear trend is found, a constant is restricted in the cointegration vector. Finally, a TC_{trace} ratio is calculated as the Trace test normalized by the 5% critical values.

Panel A. Free Floating System									
Market	US\$				LC			Free floating	$TC_{trace}^S / TC_{trace}^{LC}$
	VAR ^S (k)	ADF ^S (k)	TC_{trace}^S	VAR ^{LC} (k)	ADF ^{LC} (k)	TC_{trace}^{LC}			
Panel A.1 Developed Markets									
Australia	1	3	2.42	0.64	3	-0.86	0.76	Free floating	0.84
Austria	2	3	-1.92	0.88	3	-2.26	0.88	Free floating	1.00 +
Belgium	3	5	-0.53	1.24 *	3	0.03	0.41	Free floating	2.15 +
Canada	4	3	-2.59	0.95	5	-1.30	0.56	Free floating	1.70 +
Finland	13	5	-1.10	1.11 *	3	-0.55	0.76	Free floating	1.46 +
France	14	3	-1.61	0.69	3	-0.73	0.81	Free floating	0.85
Germany	15	3	-1.56	0.57	1	-0.90	1.07 *	Free floating	0.53
Ireland	17	3	-1.01	0.80	3	-0.33	0.44	Free floating	1.82 +
Italy	19	3	-2.06	0.81	3	-1.25	0.89	Free floating	0.91
Japan	20	3	-1.25	0.51	5	-0.27	0.51	Free floating	1.00 +
Netherlands	22	3	-1.04	0.74	3	-0.23	0.57	Free floating	1.21 +
Norway	26	3	-2.16	0.69	3	-1.58	0.53	Free floating	1.30 +
Portugal	29	3	-1.63	0.92	1	-1.86	0.74	Free floating	1.24 +
Spain	31	3	-1.93	0.80	3	-1.26	1.02 *	Free floating	0.67
Sweden	32	5	-1.75	0.74	3	-0.73	0.76	Free floating	0.97
UK	34	3	-1.77	0.58	3	-1.54	0.55	Free floating	1.05 +
Panel A.2 Emerging Markets									
Chile	4	3	-1.21	0.96	3	-2.28	0.77	Free floating	1.25 +
Greece	18	3	-2.26	1.08 *	3	-2.34	1.11 *	Free floating	0.97
Mexico	24	1	-2.52	0.50	3	-1.64	0.39	Free floating	1.28 +
Poland	27	3	-2.15	0.61	3	-2.31	0.51	Free floating	1.20 +
Panel A.3 Frontier Markets									
Estonia	9	3	-1.52	0.50	3	1.59	0.39	Free floating	1.28 +
Slovenia	34	1	-1.89	0.60	3	-1.40	0.88	Free floating	0.68

^a * indicate the statistic is significant at 5% level, respectively.

Panel B. Floating System										
	US\$				LC					$TC^S_{trace}/$
Market	$VAR^S(k)$	$ADF^S(k)$	TC^S_{trace}		$VAR^{LC}(k)$	$ADF^{LC}(k)$	TC^{LC}_{trace}			TC^{LC}_{trace}
Panel B.1 Developed Markets										
Israel	18	5	-1.15	0.86	3	-0.86	0.82		Floating	1.05 +
New Zealand	23	3	-1.69	0.47	3	-0.79	1.23 *		Floating	0.38
Panel B.2 Emerging Markets										
Colombia	8	5	-0.27	0.94	5	-1.74	0.63		Floating	1.49 +
India	20	5	-2.18	1.08 *	2	-0.52	1.18 *		Floating	0.92
Indonesia	21	6	-2.29	0.59	3	-1.90	0.57		Floating	1.04 +
Peru	25	5	-2.21	0.87	5	-2.20	0.87		Floating	1.00 +
Philippines	26	5	-0.97	0.72	5	-0.57	0.86		Floating	0.84
Taiwan	33	8	-1.79	0.60	8	-1.11	0.67			0.90
Thailand	34	3	-2.26	0.40	3	-2.00	0.42		Floating	0.95
Turkey	35	5	-2.68	0.94	5	-1.56	0.92		Floating	1.02 +
Panel B.3 Frontier Markets										
Ghana	16	7	-1.34	0.46	5	-1.27	0.45		Floating	1.02 +
Kenya	20	5	-0.79	0.44	3	-0.61	0.60		Floating	0.73
Mauritius	25	6	-1.53	0.43	5	-1.22	0.46		Floating	0.93
Romania	31	3	-1.26	0.60	3	-0.30	1.15 *		Floating	0.52
Serbia	33	5	-1.02	0.45	3	-1.69	0.36		Floating	1.25 +
Ukraine	38	5	-0.83	0.61	5	-1.05	0.53		Floating	1.15 +

^a * indicate the statistic is significant at 5% level, respectively.

^b Israel was reclassified from “Free Floating” to “Floating”, effective May 13, 2013. New Zealand was reclassified from “Free Floating” to “Floating”, effective November 1, 2012. Indonesia was reclassified from “Stabilized Arrangement” to “Floating”, effective February 14, 2011; from “Floating” to “Crawl-Like Arrangement”, effective June 1, 2012; from “Crawl-Like Arrangement” to “Floating”, effective August 19, 2013. Peru was reclassified from “Crawl-Like Arrangement” to “Floating”, effective April 1, 2011. Turkey was reclassified from “Free floating” to “Floating”, effective August 2009. Mauritius was reclassified from “Free floating” to “Floating” in 2010 (double check). Ukraine was reclassified from “Other Management Arrangement” to “Stabilized Arrangement”, effective 2010 (double check); from “Stabilized Arrangement” to “Floating”, effective February 7, 2014.

Panel C. Other managed and Crawl-like arrangement System										
		US\$			LC					
Market		$VAR^S(k)$	$ADF^S(k)$	TC^S_{trace}	$VAR^{LC}(k)$	$ADF^{LC}(k)$	TC^{LC}_{trac}		$TC^S_{trace}/TC^{LC}_{trace}$	
Panel C.1 Developed Markets										
Switzerland	33	3	-1.15	0.47	5	-0.74	1.26 *	Crawl-like	0.37	
Panel C.2 Emerging Markets										
China	50	5	3	-1.92	0.73	3	-1.92	0.72	Crawl-like	1.01 +
Czech Republic	9	3	-1.70	0.47	3	-2.32	0.37	Other managed arrangement	1.27 +	
Malaysia	23	6	-1.35	0.92	9	-1.49	0.57	Other managed arrangement	1.61 +	
Russia	31	3	-1.42	0.75	3	-1.42	0.75	Other managed arrangement	1.00 +	
Panel C.3 Frontier Markets										
Argentina	1	3	-1.65	0.73	3	-1.56	0.74	Crawl-like	0.99	
Croatia	8	5	-1.10	0.47	5	-2.38	0.35	Crawl-like	1.34 +	
Jamaica	17	3	-1.16	0.36	3	-0.21	0.55	Crawl-like	0.65	
Nigeria	27	3	-1.27	0.39	3	-1.46	0.49	Other managed arrangement	0.80	
Pakistan	30	3	-1.34	1.35	3	-1.16	0.88	Other managed arrangement	1.53 +	
Tunisia										

^a * indicate the statistic is significant at 5% level, respectively.

^b Switzerland was reclassified from “Free Floating” to “Other Managed”, effective September 6, 2011; “Other Managed Arrangement” to “Stabilized Arrangement”, effective January 1, 2012; from “Stabilized” to “Other Managed”, effective January 14, 2013; “Other Managed” to “Crawl-Like Arrangement”, effective May 29, 2013. China was reclassified from “Stabilized Arrangement” to “Crawl-Like Arrangement” in 2010 (double check). Czech Republic was reclassified from “Free Floating” to “Other managed Arrangement”, effective 11/7/2013. Argentina was reclassified from “Floating” to “Crawl-Like Arrangement” in 2010 (double check). Croatia was reclassified from “Stabilized Arrangement” to “Crawl-Like Arrangement” in 2010 (double check). Jamaica was reclassified from “Stabilized Arrangement” to “Crawl-Like Arrangement”, effective June 1, 2011. Pakistan was reclassified from “Stabilized Arrangement” to “Floating”, effective April 11, 2011; from “Floating” to “Other Managed Arrangement”, effective December 5, 2013. Tunisia was reclassified from “Stabilized Arrangement” to “Crawl-Like Arrangement”, effective September 1, 2011.

Panel D. Other Systems									
		US\$			LC				
Market		$VAR^S(k)$	$ADF^S(k)$	TC^S_{trace}	$VAR^{LC}(k)$	$ADF^{LC}(k)$	TC^{LC}_{trace}		$TC^S_{trace}/TC^{LC}_{trace}$
Panel D.1 Developed Markets									
Denmark	5	3	-0.42	0.79	1	0.31	0.68	Conventional peg	1.16 +
Hong Kong	16	5	-1.09	0.75	5	-1.10	0.74	Currency board	1.01 +
Singapore	30	5	-2.15	0.63	5	-1.67	0.65	Stabilized arrangement	0.97
Panel D.2 Emerging Markets									
Egypt	10	1	-1.45	0.89	1	-0.83	0.99	Stabilized arrangement	0.90
Qatar	28,29	3	-1.25	0.67	3	-1.25	0.67	Conventional peg	1.00
United Arab	36	7	-0.92	0.51	7	-0.92	0.51	Conventional peg	1.00 +
Panel D.3 Frontier Markets									
Bahrain	3	5	-0.93	0.72	5	-0.93	0.72	Conventional peg	1.00 +
Bangladesh	4	3	-2.60	0.27	3	-2.42	1.16 *	Stabilized arrangement	0.23
Bosnia	5	5	-1.39	0.40	5	-1.66	0.43	Currency board	0.93
Botswana	6	3	-1.30	0.95	6	-0.10	1.22 *	Crawling peg	0.78
Bulgaria	7	5	-0.86	0.54	3	-0.93	0.42	Currency board	1.29 +
Jordan	18	5	-2.47	0.54	5	-2.47	0.51	Conventional peg	1.06 +
Kazakhstan	19	3	-1.25	0.54	3	-1.25	0.50	Stabilized arrangement	1.08 +
Kuwait	21	3	-1.65	0.49	3	-2.03	0.47	Conventional peg	1.04 +
Lebanon	23	3	-2.25	0.53	3	-2.25	0.53	Stabilized arrangement	1.00 +
Lithuania	24	3	-1.27	0.43	3	-0.54	0.79	Currency board	0.54
Morocco	26	5	-1.20	0.64	5	-1.45	0.53	Conventional peg	1.21 +
Oman	29	3	-1.99	0.49	3	-1.75	0.49	Conventional peg	1.00
Saudi Arabia	32	5	-1.39	0.41	5	-1.41	0.41	Conventional peg	1.00 +
Sri Lanka	35	9	-2.06	0.73	5	-1.58	0.73	Stabilized arrangement	1.00 +
Trinidad	36	5	-1.91	1.46 *	5	-2.03	1.41 *	Stabilized arrangement	1.04 +
Vietnam	39	3	-2.79	0.51	3	-2.73	0.50	Stabilized arrangement	1.02 +

^a * indicate the statistic is significant at 5% level, respectively.

^b Singapore was reclassified from “Other Managed Arrangement” to “Crawl-Like Arrangement”, effective April 14, 2010; from “Crawl-Like Arrangement” to “Other Managed Arrangement”, effective September 12, 2011; from “Other Managed Arrangement” to “Crawl-Like Arrangement”, effective January 1, 2012; “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective January 1, 2013. Egypt was reclassified from “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective April 1, 2011; from “Stabilized Arrangement” to “Crawl-Like Arrangement”, effective January 1, 2012; from “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective July 3, 2013. Bangladesh was reclassified from “Crawl-Like Arrangement” to “Other Managed Arrangement”, effective December 19, 2011; from “Other Managed” to “Stabilized Arrangement”, effective February 7, 2013. Kazakhstan was reclassified from “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective February 11, 2014. Sri Lanka was reclassified from “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective May 1, 2011; from “Stabilized Arrangement” to “Floating”, effective February 9, 2012; from “Floating” to “Stabilized Arrangement”, effective October 1, 2013.

B. Empirical Results for Recursive Cointegration Analysis

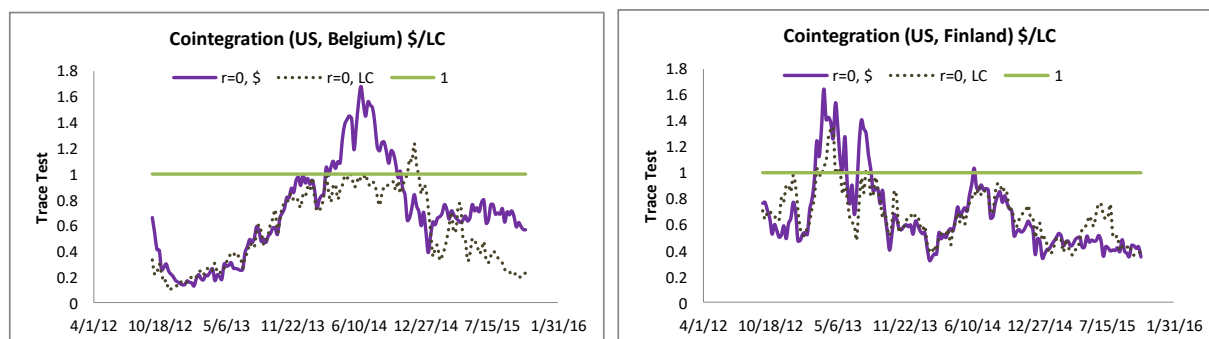
Figures I through IV plots the results of the recursive cointegration tests for the four different exchange rate regimes, namely, free-floating, floating, managed and crawl-like arrangement and others. When the trace statistic, TC_{trace} , is plotted above 1, it indicates that cointegration exists. A common feature of all these graphs is that most of the time, the stock markets are not cointegrated with the US stock market. However, there are occasional spikes that are triggered by major economic events.

Prior to 2010, Greece government was able to borrow at very low interest rate of about 5% p.a. which was only slightly higher than that of Germany. Since 2010, the beginning of the Greece Debt Crisis interest rate rose quickly to reflect the much high financial risk, the 10-year Greece government bond interest rate reached a rate of more than 25% p.a. in 2013. The crisis is clearly reflected in the cointegration graph for the Greece stock market, and this shows up as a substantial spike in 2013. The spike in 2013 shows up in the graphs for most of the European stock markets (such as Finland, Germany, Spain, Greece, Romania and Switzerland) but it is not significant for the stock markets in Asia.

By December 2014, oil prices has fallen by more than 40% since June 2014 when it was at \$115/barrel. The sharp decline in oil prices can be observed from the cointegration graph for United Arab Emirates. This spike in cointegration shows up in the stock markets in developed economies such as those in Europe, Hong Kong, Singapore, and New Zealand.

During an economic crisis whether it is due to a sudden drastic drop in oil prices or severe debt crisis in member countries of European Union, the global stock markets become more cointegrated. In other words, there is a contagion effect. The effect of crisis in one country can spread to the stock market of another country.

Figure I. Countries with Free Floating System



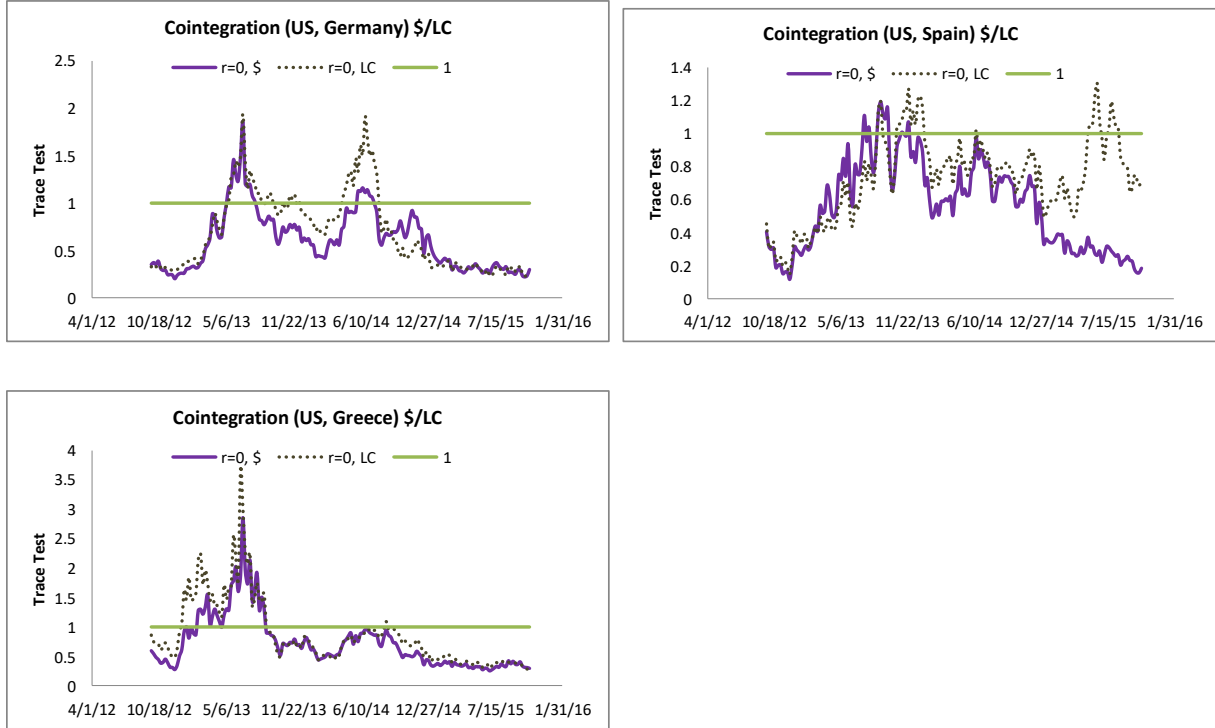


Figure II. Countries with Floating Rate System

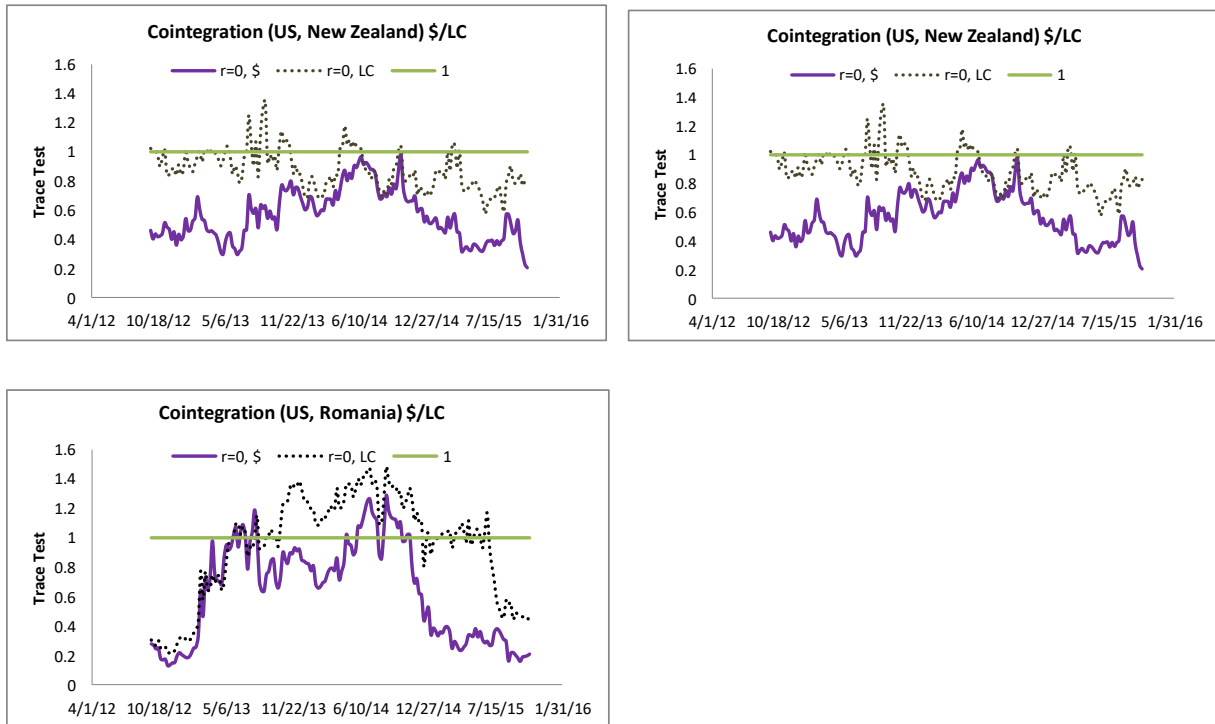


Figure III. Countries with Other Managed and Crawl-Like Arrangement System

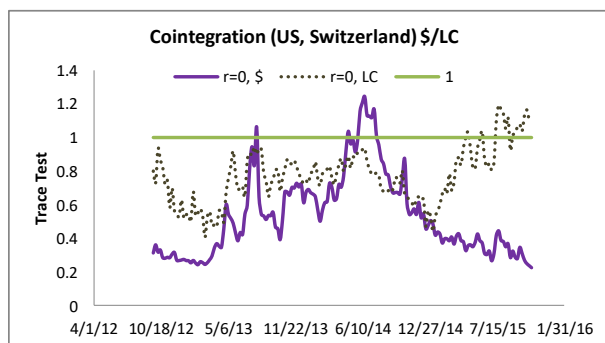
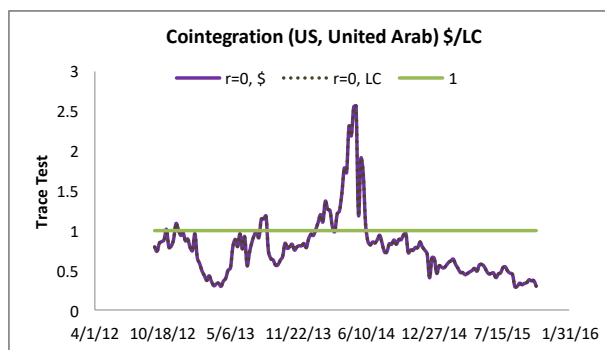
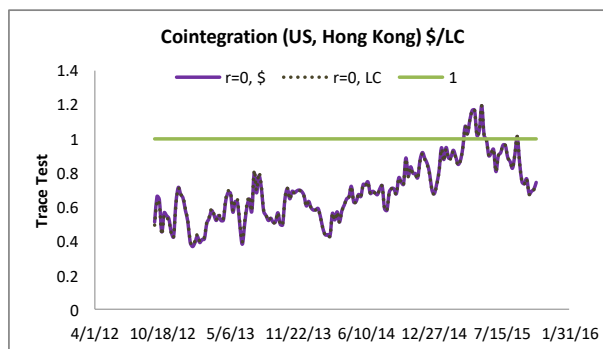
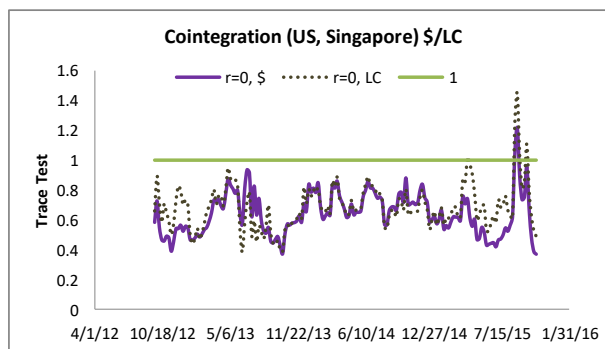


Figure IV. Countries with Other Currency System



V. Conclusions

Consistent with the results reported by Yang et al. (2004), and Su and Yip (2014), our results show that stock markets are not cointegrated with the US stock market over the period from 2010 to 2015. Stock markets in countries with free-floating exchange rate system seem to be more integrated with the US stock market. In other words, US investors may enjoy greater benefits from portfolio diversification by investing in countries whose currencies are not free-floating.

Similar to the observations made by Yang et al. (2004), Guidi and Ugur (2014), and Su and Yip (2014), our empirical results indicate that stock markets becomes more cointegrated during a crisis, as observed by the spike in the recursive cointegration graphs. A crisis in one country can

have an impact on the stock market of another country. This observation suggests the portfolio diversification effect diminishes when it is needed the most. Nevertheless, although the observed contagion effect makes international portfolio diversification strategy less effective during a crisis, we believe diversification benefits still do exist. First, it is argued that even if the diversification benefit is reduced due to the increased cointegration relationship during most of the crisis periods, it still outperforms a purely domestic portfolio. For example, DeSantis and Gerard (1997) in their empirical finding state that “Although severe market declines are contagious, the expected gain from international diversification for an US investor average 2.11% per year, and have not significantly declined over the last two decades”. Similarly, Guidi and Ugur (2014) report that diversification benefits still exist from September 2007 to June 2013 despite evidence of increased cointegration during most of the crisis period from September 2008 to May 2010.

Second, although over the last two decades the benefits of international portfolio diversification has declined, Driessen and Laeven (2007) argue that investors can still benefit from international diversification particularly for investors in high risk countries. As pointed by Longin and Solnik (1995) that global events may lead to an increase in market volatility, and hence an increase in correlation among international stock markets. The contagion effect caused by global events are not diversifiable. We would argue that a major benefit of international portfolio diversification is to alleviate country specific risks. Greater benefits from international diversification may be gained by investors in countries with non-free floating currency systems.

Third, as suggested in Su and Yip (2014), the contagion effect tends to be short-lived and dissipates over the long run. This suggests that even in today’s integrated financial environment with evidence of dynamic cointegration, a global portfolio investment is still valuable over a long-term investment horizon. That is, over the long run, global portfolio diversification is still an effective way to manage risk.

Appendix A Reclassification of Exchange Rate Arrangement by IMF (10/24/2010 – 10/24/2015)

	Panel A. Free Floating System
Mexico	From “Floating” to “Free Floating”, effective 11/1/2011
Poland	From “Free Floating” “Floating”, effective 9/23/2011
	From “Floating” to “Free Floating”, effective 12/31/2011
Estonia	From “”Currency Board” to “Free floating”, effective 1/1/2011
	Panel B. Floating System
Israel	From “Floating” to “Free Floating”, Effective 8/1/2011
	From “Free Floating” to “Floating”, effective 5/13/2013
New Zealand	From “Free Floating” to “Floating”, effective 11/1/2012
Indonesia	From “Stabilized Arrangement” to “Floating”, effective 2/14/2011
	From “Floating” to “Crawl-Like Arrangement”, effective 6/1/2012
	From “Crawl-Like Arrangement” to “Floating”, effective 8/19/2013
Peru	From “Crawl-Like Arrangement” to “Floating”, effective 4/1/2011
Turkey	From “Free floating” to “Floating”, effective August 2009
Mauritius	From “Free floating” to “Floating” in 2010
Ukraine	From “Other Management Arrangement” to “Stabilized Arrangement”, effective 2010
	From “Stabilized Arrangement” to “Floating”, effective 2/7/2014.
	Panel C. Other Managed and Crawl-Like Arrangement System
Switzerland	From “Free Floating” to “Other Managed Arrangement“, effective 9/6/2011
	From “Other Managed Arrangement” to “Stabilized Arrangement”, effective 1/1/2012
	From “Stabilized Arrangement” to “Other Managed Arrangement”, effective 1/14/2013
	From ”Other Managed Arrangement” to “Crawl-Like Arrangement”, effective 5/29/2013
China	From “Stabilized Arrangement” to “Crawl-Like Arrangement” in 2010
Czech Republic	From “Free Floating” to “Other managed Arrangement”, effective 11/7/2013
Argentina	From “Floating” to “Crawl-Like Arrangement” in 2010
Croatia	From “Stabilized Arrangement” to “Crawl-Like Arrangement” in 2010
Jamaica	From “Stabilized Arrangement” to “Crawl-Like Arrangement”, effective 6/1/2011
Nigeria	
Pakistan	From “Stabilized Arrangement” to “Floating”, effective 4/11/2011
	From “Floating” to “Other Managed Arrangement”, effective 12/5/2013
Tunisia	From “Stabilized Arrangement” to “Crawl-Like Arrangement”, effective 9/1/2011
	Panel D. Other Currency System
Singapore	From “Other Managed Arrangement” to “Crawl-Like Arrangement”, effective 4/14/2010
	From “Crawl-Like Arrangement” to “Other Managed Arrangement”, effective 9/12/2011
	From “Other Managed Arrangement” to “Crawl-Like Arrangement”, effective 11/9/2011
	From “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective 1/1/2013
Egypt	From “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective 4/1/2011
	From “Stabilized Arrangement” to “Crawl-Like Arrangement”, effective 11/10/2011
	From “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective 7/3/2013
Bangladesh	From “Crawl-Like Arrangement” to “Other Managed Arrangement”, effective 12/19/2011
Kazakhstan	From “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective 2/11/2014
Sri Lanka	From “Crawl-Like Arrangement” to “Stabilized Arrangement”, effective 5/1/2011
	From “Stabilized Arrangement” to “Floating”, effective 2/9/2012
	From “Floating” to “Stabilized Arrangement”, effective 10/1/2013.

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