Research Journal of Applied Sciences, Engineering and Technology 7(17): 3663-3670, 2014
DOI:10.19026/rjaset.7.720
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: November 26, 2013 Accepted: December 05, 2013 Published: May 05, 2014

Research Article

Correlation Pattern among "Asian Paper Tigers" Currencies: A Dynamic Conditional Correlation Approach

Rozaimah Zainudin and Jacinta Chan Phooi M'ng
Department of Finance and Banking, Faculty of Business and Accountancy, University of Malaya, 50603 Kuala Lumpur, Malaysia

Abstract: This study attempts to investigate the Dynamic Conditional Correlation (DCC) for eight currencies in the East Asia region, known as Asian Paper Tigers from the period of July 2002 to July 2012. The estimation results generated from DCC model verify that each tested exchange rate's volatility is determined by its own previous volatility shock, however failed to find any evidence with its own residual shock. While for correlation estimation results, we support the evidence that the conditional correlations for all tested pairs currencies are highly affected by their previous correlation. Most of the Asian Paper Tigers currencies recorded a low conditional correlation over the tested sampling period except for CNYJPY, MYRCNY, MYRIDR, MYRTHB, JPYTHB and PHPKRW. The findings further verify that mixing the currencies within different monetary regime plays a significant role in enhancing the currency portfolio diversification results. Although in unstable period, both JPYTHB and MYRJPY are the most promising combinations to be included in the optimal currency investment basket where both pairs have small and stable correlations either during the global recession period or European liquidity crisis period.

Keywords: Asian paper tigers, correlation, crisis, currencies, DCC, diversification

INTRODUCTION

In recent years, interest in correlation has been growing rapidly since the parameter is crucial in explaining the co-movement behaviour within financial and economic application investigations (Li, 2011). He postulates that the results of currencies co-movements have implications in managing portfolio, for example, for purposes of predicting the changing directions of currencies co-movements in optimising the currency portfolios performances. In general, how the currencies move together is also matters towards the real economy activities. As for central banks, they are interested to know whether they could achieve the desired domestic appreciation or depreciation against other foreign currencies (Benediktsdóttir and Scotti, 2009). In practical perspective, currencies co-movements are vital in portfolio construction, where fund managers can use the correlation coefficients to determine the right international currencies combination or other financial assets combination in their investment portfolio basket.

There are two approaches used to find the currencies co-movements; correlation and tail dependence. Correlation looks at how pairs of currencies move together across distribution. This is relevant to investors and fund managers who are constructing portfolios with global minimum variance. Previously, many researchers estimate the unconditional correlation between assets over a certain period of study (Solnik, 1974; Solnik *et al*., 1996). However, new information flow has a tendency to influence the correlation pattern among asset classes (Makridakis and Wheelwright, 1974; Bennett and Kelleher, 1988). They are among the earliest to discover the co-movements of international stock markets are unstable over the time. As such, conditional or non-monotonic correlation estimation is much more relevant for portfolio managers. Thus, recently a large number of correlation investigation studies apply Dynamic Conditional Correlation (DCC henceforth) to estimate the conditional correlation pattern among tested currencies (Li, 2011; Zhang, 2011; Li *et al*., 2012; Tamakoshi and Hamori, 2013). When these countries' currencies are strong, they tend to display higher positive correlation among these currencies especially when they are tied with US dollar, Euro and Japanesse Yen. Bong-Han *et al*. (2011) compares the movement of Japanese yen with five other emerging Asian currencies. Their findings display downward correlations trend between tested currencies.

The other approach is tail dependence, which focuses on the level of dependence of two distribution tails (either lower-left quadrant or upper-right quadrant). Lately, many have explored the financial data distribution pattern within this paradigm (Hauksson *et al*., 2001; Fortin and Kuzmics, 2002;

Corresponding Author: Rozaimah Zainudin, Department of Finance and Banking, Faculty of Business and Accountancy, University of Malaya, 50603 Kuala Lumpur, Malaysia, Tel.: +603-79673904; Fax: +603-79673810

Beine *et al*., 2010) in equity market, Patton (2006) in currency market inter alia). Benediktsdóttir and Scotti (2009) however, combined the correlation and tail dependence techniques in their co-movements investigation. They portrayed the effect of recession in both correlation and tail dependence estimation. The finding confirms that currencies tend to move differently between high interest rate differential currencies. Using European stock indices, Fortin and Kuzmics (2002) find that these returns are highly dependent in its lower tail due to the downward movement of European exchange rate volatility but fail to find any asymmetric effect. Similar pattern is displayed in Asian stock markets, where the crisis affects the co-movements of currencies within Asian region (Caillault and Guégan, 2007). Additionally the introduction of the Euro currency have pushed up the co-movement between entire euro stock return distributions, hence minimize the portfolio diversification benefits within this European region (Beine *et al*., 2010).

Non monotonic correlation estimation is much more relevant since the market volatility vary over the time for any financial and economic series. Further, Li (2011) finds that correlation among five inflation-targeted currencies[1] tend to move in a time varying manner. Hence, in this research we intend to focus on correlations estimation between pairs of currencies in the East Asian region or also known as Asian Paper Tigers using a time varying Dynamic Conditional Correlation (DCC henceforth) on the currencies returns. Within the GARCH volatility framework, we estimate the conditional correlation using DCC model for these 28 pairs of currencies as time varying volatility is a pervasive phenomena that occurs to a greater or lesser degree with most time series of financial returns. We choose the Asian Paper Tigers currencies as these currencies are likely to move together with the other currencies within their geographically close countries (Mizuno *et al*., 2006).

Economic climate constantly changes over the time therefore; these changes may affect the movements of these pair's currencies. Economic turmoil's have affected Asian Tigers currencies in many ways including:

- Changes in their liquidity climate
- Upward movement of the level of risk aversion among Asian paper tigers
- Loosen of carry-trade among these countries (Kohler, 2010)

Apart from that, de-leveraging also plays a significant role in influencing the currencies co-movement in this region (Melvin and Taylor, 2009). Any liquidity instability in market condition may increase the correlation between Asian countries and US (Zhang, 2011). Tamakoshi and Hamori (2013) infer the effect of European liquidity bubble on the conditional correlation between European cross currencies swap. The liquidity turbulence have resulted an extreme incremental in the co-movement within cross currency swap market. Other example whose demonstrated the effect of economic climate on correlation movement between various currencies are King and Wadhwani (1990), Baig and Goldfajn (1999), Caillault and Guégan (2007) and Bong-Han *et al*. (2011). Based on the empirical evidence, we posit that global economic and financial climate may influence the correlation features between each Asian paper tigers currencies. In order to investigate the effects of these changes, we demarcate the sampling period into three sub periods to cater for stable period (pre Global financial crisis) and unstable period (Global financial crisis and European Liquidity Crisis).

The research contributes in threefold:

- Enrich the cross currencies correlation investigation literature for Asian Paper Tigers
- The findings may provide some ideas for investors on which Asian Paper Tigers' currencies are best in their investment basket and which currencies need to be avoided from their portfolio basket
- The findings can be used as a reference in enhancing the effectiveness of central bank's intervention on controlling their domestic currency exchange rate against other Asian Tiger foreign currencies.

Data: The data comprises the daily spot exchange rate for eight Asian Paper Tigers currencies: Malaysian Ringgit (MYR), Singapore Dollar (SGD), China Yuan Renminbi (CNY), Japanese Yen (JPY), Indonesian Rupiah (IDR), Thailand Baht (THB), Philippine Peso (PHP), Korean Won (KRW). The exchange rate currencies are obtained from DataStream database. The study covers the period between 24 July 2002 and 24 July 2012. In this study, the daily exchange rate for each currencies are transformed into natural log return, which is computed as Return = $100\times [\ln (P_{t+1}/P_t)]$, where P_{t+1} is exchange rate for period t+1, while P_t denotes the exchange rate for the period of t. To examine the possibility of potential crisis likely to influence the exchange rate co-movements, we segregate the tested series into three sub periods to cater for Pre-Global Financial Crisis (24/7/2002 to 31/12/2006), Global Financial Crisis (02/01/2007 to 31/12/2008) and European Liquidity Crisis (02/01/2009 to 24/07/2012).

METHODOLOGY

Within the GARCH volatility framework, using the computed returns, we employ Dynamic Conditional Correlation to estimate the conditional correlation between these eight Asian Paper Tigers currencies. We estimate the conditional correlations for the 28 pairs of currencies. Further, we also compute the descriptive statistics for each estimated conditional correlation series.

Dynamic conditional correlation model specification: Bollerslev (1990) develops a simple conditional correlation (Constant Conditional Correlation Model) that encompasses the univariate GARCH framework. The model's basic assumption is correlation moves in a monotonic fashion. Economic and financial climate tend to change over time and markets incorporate these changes into their price movements. Hence, it is less accurate for the researcher to posit monotonic conditional correlations for many economic and financial variables. Consequently, Tse and Tsui (2000) and Engle (2002) introduce the time varying conditional correlation GARCH models, namely, DCC. The model is able to capture time varying correlation between two random currency returns. For the purpose of this research, Engle (2002)'s DCC model (Appendix A) is used; where the model is outlined according to the following requirement:

$$Ht = D_t P D_t \quad (1)$$

where, D_t is the diag $(h_{1t}^{1/2},.....,h_{Nt}^{1/2})$ and P follows the dynamic process (contrary to Constant Correlation model where *p* is set to constant):

$$P_t = diag(q_{11,t}^{-1/2},....q_{NN,t}^{-1/2})Q_t diag(q_{11,t}^{-1/2},....q_{NN,t}^{-1/2}) \quad (2)$$

where the N×N is a symmetric positive definite matrix $Q_t = (q_{ij,t})$ and Q_t formulates as follows:

$$Q_t = (1-\alpha-\beta)\overline{Q} + \alpha u_{t-1}u_{t-1}^{'} + \beta Q_{t-1} \quad (3)$$

where u_t represents the standardized residual $(\varepsilon_{it}/\sqrt{h_{ij}})$, $\bar{Q}$ is the N×N unconditional correlation matrix of standardize u_t, α and β are the non-negative scalar parameters, which are restricted to be α + β<1.

The Q_t matrix is written similar to the GARCH process and transformed into a matrix. However, a constant conditional correlation can be tested by restricting α = β = 0 towards the DCC model. This model, however, tends to drive the conditional correlation to similar dynamics because α and β are scalars. On the other hand, when N is large, the model becomes easy and flexible to use because the model can be estimated through the two-step process consisting; dynamic volatility clustering structure and dynamic correlations parameters.

ESTIMATION RESULTS

In this section, we segregate the estimation results into two parts:

- DCC estimation results
- Conditional Correlations

Table 1: Estimation for DCC model

Panel 1

	MYRIDR	MYRJPY	MYRCNY	MYRSGD	MYRKRW	MYRTHB	CNYJPY
C_{11}	4.71E-05	5.10E-05	5.05E-05	5.38E-05	5.14E-05	4.90E-05	1.01E-03
C_{22}	0.0224	6.76E-03	1.07E-03	1.23E-03	3.76E-03	4.73E-03	8.80E-03
B^*_{11}	0.2162	0.2305	0.2313	0.2380	0.23230	0.2266	0.1773
B^*_{22}	0.3030	0.0422	0.1784	0.0490	0.09740	0.2892	0.0482
A^*_{11}	0.8349	0.8213	0.8215	0.8141	0.81890	0.8229	0.7436
A^*_{22}	0.6747	0.9415	0.7355	0.9420	0.89100	0.7176	0.9319
A	0.0462	0.0579	0.0203	0.0518	0.00097[a]	7.15E-03	0.0439
B	0.9529	0.9250	0.9797	0.6826	0.99340	0.9929	0.9563

Panel 2

	CNYSGD	CNYTHB	CNYPHP	IDRJPY	IDRTHB	JPYPHP	SGDTHB
C_{11}	9.44E-04	9.63E-04	9.52E-04	9.63E-04	0.0241	0.00730	0.0012
C_{22}	1.13E-03	4.77E-03	6.92E-04	4.77E-03	0.0046	0.00070	0.0048
B^*_{11}	0.1608000	0.1612	0.15880	0.1612	0.2974	0.04270	0.0456
B^*_{22}	0.0450000	0.2933	0.10730	0.2933	0.2830	0.10840	0.2962
A^*_{11}	0.7577000	0.7544	0.75870	0.7544	0.6583	0.93880	0.9451
A^*_{22}	0.9458000	0.7122	0.89350	0.7122	0.7166	0.89250	0.7097
A	0.0085401[b]	3.45E-03	0.00112[a]	3.45E-03	0.0246	0.00202[b]	0.0110
B	0.9769000	0.9966	0.99320	0.9966	0.9553	0.99790	0.9742

Panel 3

	JPYSGD	JPYTHB	KWNTHB	PHPKWN	PHPSGD	PHPTHB	SGDKWN
C_{11}	0.00720	0.0073	0.00370	0.0010	0.00070	0.0007	0.0011
C_{22}	0.00110	0.0048	0.00460	0.0038	0.00110	0.0045	0.0037
B^*_{11}	0.04230	0.0466	0.09640	0.1047	0.10700	0.1088	0.0445
B^*_{22}	0.04480	0.2930	0.29390	0.1053	0.04480	0.2916	0.0958
A^*_{11}	0.93920	0.9356	0.89230	0.8920	0.89390	0.8921	0.9468
A^*_{22}	0.94640	0.7112	0.71500	0.8856	0.94630	0.7169	0.8929
A	0.00747[a]	0.0863	0.00509[a]	0.0569	0.00269[b]	-0.0048	0.0014
B	0.95210	0.8628	0.73370[a]	0.9309	0.99680	0.0436[a]	0.8711

a: Represents insignificant at the 10% level; b: Represents 10% level of significance

For the first sub section, we describe the findings generated from DCC model estimation for selected pairs tested currencies. Then, we proceed to explain the correlation behaviours within the full and three sub-sampling periods for the related series.

DCC estimation results: Table 1 represents the estimation results for selected exchange rate generated from the DCC model. The results exhibit strong evidence that each exchange rate's volatility is determined by its own volatility shock (refer to A_{11} and A_{22} parameters) rather than its own shock (refer to B_{11} and B_{22} parameters). Overall, the correlation results support the evidence that the conditional correlations for all tested pairs currencies (except for PHPTHB) are highly affected by its previous period correlation (refer to B). However, lower magnitudes are displayed from their residual terms (refer to A). Contrary results are displayed for JPYSGD, MYRKRW, CNYPHP and PHPTHB correlations where each of the pair's correlation is strongly influenced by its own residual shocks and the results fail to find any significant influence from its previous period correlation. Unique by itself, there is no evidence to infer that KRWTHB current correlation is affected either by its own residual or its previous term correlation.

Conditional correlations results:

Full sample: Based on the mean equality test results[2], we find that the conditional mean between the 28 pairs of currencies are significantly different with one and another. Table 2 summarises the statistical descriptive for the selected pairs of currencies' correlations.

For instance the conditional correlation for CNYJPY, MYRCNY, MYRIDR, MYRJPY, MYRTHB, JPYTHB, PHPKRW in Panel 1 are volatile over the full sampling period. Among the unstable correlation pairs, MYRCNY display an extreme correlation movement ranging from -0.125 to 0.979 over the 10 years tested period. While, MYRIDR conditional correlations swing quite widely from 0.033 to 0.87. Further the average conditional correlation for JPYTHB, CNYJPY, MYRCNY, MYRIDR, MYRTHB and PHPKRW are positively correlated to each pairs. And PHPKRW exhibits the highest average conditional correlation which is at 0.47. In contrast, MYRJPY are inversely correlated where the pair's average conditional correlation is -0.03.

On the other scenario, the rest of the 21 pairs were found to move within a stable state where the standard

Table 2: Descriptive statistic for tested pairs conditional correlation (full sample period)

	Panel 1 (unstable scenario)			
	Mean	Max.	Min.	S.D.
JPYTHB (FF/DF)	0.20650	0.77417	-0.58130	0.18370
CNYJPY (DF/FF)	0.13260	0.73650	-0.68220	0.22950
MYRCNY (DF/DF)	0.28380	0.97930	-0.12580	0.21840
MYRIDR (DF/DF)	0.38040	0.86610	-0.03280	0.25110
MYRJPY (DF/FF)	-0.03384	0.52980	-0.65000	0.20230
MYRTHB (DF/DF)	0.31150	0.66220	0.00194	0.18870
PHPKWN (FF/FF)	0.47120	0.78760	-0.14820	0.15430
	Panel 2 (stable scenario)			
JPYKWN (FF/FF)	-0.01360	-0.02230	-0.00816	-0.00240
JPYPHP (FF/FF)	0.03140	0.09180	-0.05090	0.03950
JAPSING (FF/DF)	0.05390	0.16740	-0.12050	0.02950
CNYIDR (DF/DF)	0.05140	0.05210	0.05100	0.00020
CNYKWN (DF/FF)	0.00037	0.00330	0.00010	0.00040
CNYPHP (DF/FF)	0.04330	0.08550	0.00500	0.01430
CNYSGD (DF/DF)	0.16820	0.52000	0.00920	0.05770
CNYTHB (DF/DF)	0.17270	0.17510	0.17000	0.00050
IDRJPY (DF/FF)	0.16440	0.25170	0.04390	0.05830
IDRKWN (DF/FF)	0.04240	0.53320	-0.99990	0.03850
IDRPHP (DF/FF)	0.09777	0.99970	-0.62980	0.02330
IDRSGD (DF/DF)	0.00894	0.22230	0.00240	0.01350
IDRTHB (DF/DF)	0.27340	0.62000	-0.02878	0.08000
MYRKWN (DF/FF)	0.06430	0.11110	0.04580	0.00920
MYRPHP (DF/FF)	0.09000	0.15800	0.03380	0.00680
MYRSGD (DF/DF)	0.22350	0.61200	-0.29270	0.06670
PHPSGD (FF/DF)	0.00896	0.11320	-0.65000	0.03249
PHPTHB (FF/DF)	0.08250	0.76710	0.01790	0.01470
SGDKWN (DF/FF)	-0.00405	0.03750	-0.02532	0.00370
SGDTHB (DF/DF)	0.16630	0.32950	-0.03870	0.05850
KWNTHB (FF/DF)	0.03418	0.11800	-0.03940	0.00750

Panel 1 represents pairs currencies with high correlation volatility (high standard deviation or S.D.) and panel 2 shows pairs currencies with stable correlation volatility (low standard deviation or S.D.); DF: Dirty float exchange rate regime; FF: Free floating exchange rate regime; Min.: Minimum; Max.: Maximum; S.D.: Standard deviation

Table 3: Mean and standard deviation for selected pairs currencies conditional correlation according to three sub periods

	Panel 1 (high S.D.)					
	Mean			S.D.		
	Sub period 1	Sub period 2	Sub period 3	Sub period 1	Sub period 2	Sub period 3
CNYJPY (DF/FF)	0.07	0.25	0.130	0.29	0.15	0.12
MYRCNY (DF/DF)	0.35	0.24	0.220	0.28	0.15	0.10
MYRIDR (DF/DF)	0.21	0.52	0.520	0.21	0.17	0.19
MYRJPY (DF/FF)	0.02	-0.14	-0.046	0.13	0.26	0.21
MYRTHB (DF/DF)	0.19	0.23	0.500	0.16	0.12	0.08
JPYTHB (FF/DF)	0.30	0.10	0.150	0.14	0.22	0.14
PHPKWN (FF/FF)	0.39	0.44	0.590	0.14	0.13	0.10
	Panel 2 (low SD)					
MYRSGD (DF/DF)	0.21	0.23	0.230	0.0200	0.0700	0.0900
JPYKWN (FF/FF)	-0.01	0.01	0.020	0.0010	0.0020	0.0006
SGDTHB (DF/DF)	0.18	0.13	0.170	0.0400	0.0700	0.0500
IDRTHB (DF/DF)	0.29	0.21	0.290	0.0900	0.0800	0.0400
CNYIDR (DF/DF)	0.05	0.05	0.050	0.0001	0.0002	0.0001
PHPTHB (FF/DF)	0.08	0.08	0.080	0.0400	0.0300	0.0040
MYRKWN (DF/FF)	0.06	0.06	0.600	0.0010	0.0080	0.0100
IDRJPY (DF/FF)	0.11	0.20	0.210	0.0400	0.0200	0.0300
JPYPHP (FF/FF)	0.06	0.05	-0.020	0.0100	0.0100	0.0200

Sub period 1, sub period 2 and sub period 3 show the pre global recession, global recession and European liquidity crisis, respectively; DF: Dirty float exchange rate regime; FF: Free floating exchange rate regime; S.D.: Standard deviation

(refer to panel 2). The largest ranges of movement were displayed by IDRKRW (from -0.999 to 0.533) and IDRPHP (from -0.629 to 0.999). Although they have an extreme range of conditional correlation movements, it is not a threat for investors to invest in these two pairs currencies. This is because both pairs moved in a stable pattern throughout the sampling period. IDRTHB and MYRSGD have the highest average conditional correlations which were at 0.27 and 0.22, respectively. However, only JPYKRW and SGDKRW are inversely correlated to each pair's.

Intuitively, we can suggest that investor should consider investing for all 19 pairs currencies in Panel 2 without the Indonesian Rupiah and Thai Baht combination (IDRTHB) and Malaysian Ringgit and Singapore Dollar (MYRSGD). These 19 pairs currencies have a weak and stable conditional correlation which are best for investment diversification results. However, investor should avoid investing in CNYJPY, MYRCNY, MYRIDR, MYRTHB, JPYTHB and PHPKRW since these pairs displayed a volatile conditional correlation pattern. Such unstable movement may not give the best diversification results for investors. On the other hand, relating the findings with the Paper Tigers exchange rate regime context, we find that good diversification synergy can be achieved when the investors combine currencies between countries that apply dirty floating and free floating exchange rate regime (see Panel 2). Dirty float countries adjust their domestic currency value via central bank intervention to maintain a desired domestic currency value accordingly, such regime will complement the movement of the country with a free floating regime. This does not work when the conditional correlations are in volatile state (refer to Panel 1). Based on Panel 1, JPYTHB and CNYJPY are under dirty and free floating regime but they have considerable among high pairs correlation. Nevertheless, investors try to avoid combining two currencies that under the same regime (MYRSGD and IDRTHB for Dirty float regime and PHPKRW for free float regime). Within the same regime, both countries apply a very much similar exchange rate system for their currencies, hence no diversification effect could be generated. However, this does not apply when you tend to combine a stronger Big Paper Tigers with the smaller one (such as JPYKRW, JPYPHP and CNYIDR).

Three sub periods: Table 3 describes the descriptive statistic characteristics for selected pairs of currencies. The findings in Panel 1 (Table 3) describes the mean and standard deviation conditional correlation in unstable situation according to three sub periods. We found that CNYJPY is more volatile in Sub Period 1 compared to the other two sub periods. Japan and China was a big rival in dominating the Asian market in mid 2000s (Bong-Han *et al*., 2011), as such it is not surprise that these two currencies correlation have a volatile movement during that period. Although CNYJPY correlation is highly volatile in sub period 1, but the average correlation is merely small (0.07), hence we suggest that investor should consider to combine these two currencies into their investment basket when the global financial market is quite stable. Despite the fact that both countries adopt different exchange rate regime which may produce good diversification results, however, this could not be manifested when the global market was not in a good shape. Hence, investor should avoid combining Chinese Yuan and Japanese Yen when the global financial climate is turbulence state (sub period 2).

Contrary to CNYJPY, MYRCNY and JPYTHB are a bad investment combination in stable market (sub period 1). However, JPYTHB have a lower range of correlation during the recent European liquidity crisis (Sub Period 3), hence investor can combine these two

currencies in their investment basket during the unstable market. While, we can see an accelerating pattern in conditional correlation from sub period 1 to sub period 3 for MYRIDR, MYRTHB and PHPKRW. These three pairs were not well diversified currencies since they have a strong positive correlation in these three sub period. Such strong correlation displayed may be due to these three pairs are within the same exchange rate regime where MYRIDR and MYRTHB are imposing the dirty float regime while, PHPKRW is adopting the free float system. A similar regime between two countries imply that both countries have a very much similar exchange rate climate and such similarity may led to a less promising diversification results. Therefore either in stable or less stable market condition, investor should not consider these three pairs in their currency investment portfolio.

The results in Panel 1, further showed that MYRJPY have a moderate correlation movement ranging from -0.6 to 0.3 in the recent European Liquidity crisis period (Sub Periods 3). Prior to the Global Financial crisis, we found that Malaysian Ringgit and Japanese Yen conditional correlation mean was merely small (Sub Period 1), while the other two sub periods displayed an opposite direction. During the year end of 2008, the other European currencies were weakening, Yen displayed a strong position parallel with dollar and Swiss France. Such strong currency have resulted an influx of investors shifted into YEN rather than European currencies during that European liquidity crisis. Due to this, combination of Malaysian Ringgit with Japanese Yen gives a good choice of investment. Further, such weak and negative correlations are the best criteria in getting the best diversification result in portfolio management.

Next in Panel 2 presents the summarization of the mean and standard deviation selected pairs currencies in a stable correlation movement in the three sub periods. Most of the standard deviation for all 9 pairs were at the lowest (below than 0.09). We can conclude that these 9 selected pairs have the most stable correlation fluctuation within the tested three sub periods. Stable does not always a good indication, since MYRSGD, SGDTHB, IDRTHB and IDRJPY are among the ineffective combination to be included in your currency investment portfolio either in stable or unstable global market condition. Moreover some of the good examples of investment are JPYKRW, CNYIDR, MYRKRW and JPYPHP. These 4 pairs of currencies recorded an extremely small correlation between each other (conditional correlation <0.08). As such at any market condition, investors may acquire a good investment result in these four pairs currency. Although JPYKRW, CNYIDR and JPYPHP are within the same exchange rate regime, however these pairs displayed a good diversification result due to strong Asian tigers paired with the smaller ones.

Overall, when we segregated the full sampling period into three sub periods, the results infer that JPYTHB and MYRJPY are a good choices to put in your currency investment basket when market are in crisis period (in Global recession and European liquidity crisis period). A strong free float currency such as Yen is able to minimize the effects of unstable dirty float currency such as Malaysian Ringgit and Thailand Bath. Although, both Malaysia's and Thailand's central banks play a significant role in buying and selling their currencies in open market to protect the currency value during that crisis period, a strong Yen sufficient to shield the crisis effect toward their currencies. On the other side of coin, CNYJPY turned out to be the best investment option when the market is stable (sub period 1). Either in crisis or non-crisis scenario, a weak, stable correlation movement, strong/small paper tigers combination either within similar regime or different regime are some of the investment criterions to be considered in achieving the best diversification result (such as JPYKRW, CNYIDR, MYRKRW and JPYPHP).

CONCLUDING REMARKS

This study explores the co-movements between eight Asian Paper tigers consisting Malaysian Ringgit (MYR), Singapore Dollar (SGD), China Yuan Renminbi (CNY), Japanese Yen (JPY), Indonesian Rupiah (IDR), Thailand Baht (THB), Philippine Peso (PHP), Korean Won (KRW) currencies for the period between 24/7/2002 and 24/07/2012. We employ the DCC model to estimate the dynamic condition correlations between 28 pairs currencies. Empirical evidence infers that co-movements between assets classes tend to change accordingly to the economic climate. Hence to identify the implication of crisis towards Asian Paper Tigers currencies co-movements, we further divide the sampling period into three sub periods consisting Pre Global financial crisis, Global financial crisis and recent European Liquidity Crisis.
The main research findings are as follows:

- Eighteen pairs of Asian paper tigers currencies recorded a low conditional correlation over the full sampling period except CNYJPY, MYRCNY, MYRIDR, MYRTHB, JPYTHB and PHPKRW.
- Mixing differ exchange rate regimes between currencies play a significant role in enhancing the currency portfolio diversification results.
- Similar exchange rate regime might not creating a diversification synergy, however it might be materialize when investors combining the stronger and weaker currencies.
- During the global recession and European liquidity crisis period, both JPYTHB and MYRJPY are the most promising combination to be included in the currency investment basket.

In the mist of slowdown Japan's economic recovery, Japanese Yen is able to maintain its strong position in this East Asian territory. This safe haven currency is able to neutralise the unstable currencies like Thailand Bath and Malaysian Ringgit. Although Thailand and Malaysia adopt the dirty float system, yet both central banks interventions may be insufficient to stabilize both currencies values at all time. Hence, by combining the safe haven currency into their foreign reserve basket it may create a good synergy. While for investor perspective, these combinations will create a better diversification synergy.

In a nutshell, investors should aim for Asian Paper Tigers currencies that fall under stable and weak correlations. Next condition, investors should combine the strong currencies with the weak currencies and differ exchange rate regime for an excellent diversification results. These suggestions are solely been made based on the average conditional correlation and volatility perspective. Future researcher should explore the portfolio diversification performance via construction the actual currencies basket and measure the constructed portfolio return throughout the stable and unstable period.

ACKNOWLEDGMENT

The authors gratefully acknowledge University research Grant (RG158-12SBS), University of Malaya, Malaysia for support to conduct this research study. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

APPENDIX A

DCC estimation model:

$$H_t = \begin{bmatrix} h_{ss,t} & h_{sf,t} \\ h_{fs,t} & h_{ff,t} \end{bmatrix} = \begin{bmatrix} h_{s,t} & 0 \\ 0 & h_{f,t} \end{bmatrix} \begin{bmatrix} 1 & Q_t \\ Q_t & 1 \end{bmatrix} \begin{bmatrix} h_{s,t} & 0 \\ 0 & h_{f,t} \end{bmatrix}$$

$$h_{ft} = \gamma_f + \sum_{j=1}^{p} A^*_{22}\, h_{f,t-1} + \sum_{j=1}^{q} B^*_{22}\, \varepsilon^2_{f,t-1}$$

$$h_{st} = \gamma_s + \sum_{j=1}^{p} A^*_{11}\, h_{s,t-1} + \sum_{j=1}^{q} B^*_{11}\, \varepsilon^2_{s,t-1}$$

$$Q_t = \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} = (1 - A - B) \begin{bmatrix} r_s & r_{sf} \\ r_{sf} & r_f \end{bmatrix} + A \begin{bmatrix} \varepsilon_s^2 & \varepsilon_s \varepsilon_f \\ \varepsilon_s \varepsilon_f & \varepsilon_f^2 \end{bmatrix} + B \begin{bmatrix} 1 & \rho_{t-1} \\ \rho_{t-1} & 1 \end{bmatrix}$$

REFERENCES

Baig, T. and I. Goldfajn, 1999. Financial Market Contagion in the Asian Crisis. IMF Staff Papers, 46: 167-195.

Beine, M., A. Cosmo and R. Vermaulen, 2010. The dark side of global integration: Increasing tail dependence. J. Bank. Financ., 34(1): 184-192.

Benediktsdóttir, S. and C. Scotti, 2009. Exchange Rate Dependence: What Drives it? International Finance Discussion Papers, Board of Governors of the Federal Reserve System, US, pp: 969.

Bennett, P. and J. Kelleher, 1988. The international transmission of stock price disruption in october 1987. Fed. Reserve Bank New York Quart. Rev., 13(2): 17-33.

Bollerslev, T., 1990. Modeling the coherence in short-run nominal exchange rates: A multivariate generalized arch model. Rev. Econ. Stat., 72(3): 498-505.

Bong-Han, K., K. Hyeongwoo and M. Hong Ghi, 2011. Reassessing the link between the Japanese Yen and emerging Asian currencies. J. Int. Money Financ., 33: 306-326.

Caillault, C. and D. Guégan, 2007. Empirical estimation of tail dependence using copulas: Application to Asian markets. Quant. Financ., 5(5): 489-501.

Engle, R., 2002. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. J. Bus. Econ. Stat., 20(3): 339-50.

Fortin, I. and C. Kuzmics, 2002. Tail-dependence in stock-return pairs. Intell. Syst. Account. Financ. Manage., 11(2): 89-107.

Hauksson, H., M. Dacorogna, T. Domenig, U. Müller and G. Samorodnitsky, 2001. Multivariate extremes, aggregation and risk estimation. Quant. Financ., 1: 79-95.

King, M. and S. Wadhwani, 1990. Transmission of volatility between stock markets. Rev. Financ. Stud., 3: 5-33.

Kohler, M., 2010. Exchange rates during financial crises. BIS Quart. Rev., 2010(March): 39-50.

Li, W.M., 2011. How do exchange rates co-move? A study on the currencies of five inflation-targeting countries. J. Bank. Financ., 35: 418-429.

Li, L., N. Zhang and T. Willet, 2012. Measuring macroeconomic and financial market interdependence: A critical survey. J. Financ. Econ. Policy, 4(2): 128-145.

Makridakis, S. and S. Wheelwright, 1974. An analysis of the interrelationships among the major world stock exchanges. J. Bus. Financ. Account., 1(2): 195-215.

Melvin, M. and M. Taylor, 2009. The crisis in the foreign exchange market. J. Int. Money Financ., 28: 1317-1330.

Mizuno, T., H. Takayasu and M. Takayasu, 2006. Correlation network among currencies. Physica A, 364: 336-342.

Patton, A., 2006. Modelling asymmetric exchange rate dependence. Int. Econ. Rev., 47: 527-556.

Solnik, B., 1974. The international pricing of risk: An empirical investigation of the world capital market strucutre. J. Financ., 2: 365-378.

Solnik, B., C. Boucrelle and Y. Le Fur, 1996. International market correlation and volatility. Financ. Anal. J., 52: 17-34.

Tamakoshi, G. and S. Hamori, 2013. Dynamic linkages among cross-currency swap markets under stress. Appl. Econ. Lett., 20(4): 404-409.

Tse, T.K. and K.C. Tsui, 2000. A multivariate GARCH model with time-varying correlations. Proceeding of the Econometric Society World Congress 2000 Contributed Papers 0250, Econometric Society.

Zhang, N., 2011. Contagion and the spread of the recent global crisis to Asia: The effect of the transmission on equity markets. Ph.D. Thesis, Claremont Graduate University, Claremont, C.A.

End notes:

1: Australian Dollar, NZ Dollar, Canadian Dollar, Swedish Krone and UK Pound Streling.

2: Due to space constraint we do not include the detailed mean equality test results in this study. The detailed results will be provided upon request.