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Effect of exchange rate return on volatility spill-over across trading regions

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ABSTRACT

This paper examines the effect of realized exchange rate returns on the volatility spill-over between the euro–US dollar and US dollar–yen currency pairs across the five trading regions: Asia, Asia–Europe overlap, Europe, Europe–America overlap and America. Modelling the interaction between returns and volatility in an autoregressive five-equation system, we find evidence that depreciation of the US dollar against the yen has a greater impact on the US dollar–yen volatility spill-over than appreciation in the subprime crisis period. Appreciation and depreciation of the US dollar against the euro does not appear to have an asymmetric effect on the euro–US dollar volatility spill-over. Our results support the notion that the yen may have been preferred to the euro as a 'safe-haven' currency relative to the US dollar during the subprime crisis period.

1. Introduction

In times of financial crises which have adverse impacts on global economies, investors usually tend to stay away from highly volatile stock markets, and may escape into less risky markets in relatively secure countries. For investors, one alternative would then be to look for 'safe-haven' currencies in the foreign exchange markets. The US dollar has been the dominant 'safe-haven' currency for a very long time. However, the recent emergence of the euro, the Swiss franc and the Japanese yen as potential 'safe-haven' currencies has reduced the domination of the US dollar. Hence, it seems reasonable that one currency may be attractive as a 'safe-haven' currency during certain time periods and not in others. In any case, in times of crisis, investors will be looking for low risk currencies. This was evident during the subprime crisis that originated in the US. During the subprime crisis period, the yen appreciated against the US dollar, suggesting that the yen may be an alternative 'safe-haven' currency relative to the US dollar. A pertinent question here is how to test such a postulation econometrically. In this study we develop an econometric model for testing whether or not the yen served as a 'safe-haven' currency relative to the US dollar during the subprime crisis period. This is done by modelling the effect of the realized US dollar–yen exchange rate returns on the US dollar–yen exchange rate return volatility spill-over across different trading zones.

Previous studies of the volatility spill-over in foreign exchange markets may be classified into two broad categories: those that investigate it across different foreign exchange markets and those that investigate it across different geographical trading zones. A model for investigating the volatility spill-over across foreign exchange market sis proposed by Engle et al. (1990). Engle et al. formulate a model for examining the US dollar–yen exchange rate volatility linkages across different markets, so that the source of volatility may be identified. They investigate two hypotheses of information linkage across foreign exchange markets: heat waves and meteor showers. The heat-wave hypothesis stipulates that the volatility of the exchange rate returns in a given market is influenced by the past volatility of the exchange rate returns in the same market; while the meteor-shower hypothesis assumes the volatility of the exchange rate returns in a given market to be influenced by the spill-over of volatility from the other markets. Engle et al. (1990) test these two hypotheses in the New York and Tokyo foreign exchange markets, and report evidence suggesting the presence of volatility clustering of the meteor-shower type.

Melvin and Melvin (2003) highlight the fact that investigating the volatility transmission using daily opening and closing prices for the Tokyo and New York foreign exchange markets, as Engle et al. (1990) did, is problematic, because one morning and one afternoon observation may not really reflect the trading activity in major foreign exchange trading centres. For high frequency data, Dacorogna et al. (1993) and Andersen and Bollerslev (1997)

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observe that the intra-daily seasonality in foreign exchange volatility is associated with the geographical spread of trading zones across the globe. By taking this observation into account, Melvin and Melvin (2003) examine the volatility spill-over in the trading regions identified through high frequency quote activity. They define five trading regions (Asia, Asia–Europe overlap, Europe, Europe–America overlap and America) across the time zones spanning 24 h, and treat the regions as sequentially operating markets. Melvin and Melvin (2003) report that even though there is statistical evidence of own region and inter-regional volatility spill-over in the Deutsche mark–US dollar and US dollar–yen exchange rate returns, heat waves are more important than meteor showers in terms of economic significance. Cai et al. (2008) investigate exchange rate returns and directions of exchange rate returns separately, allowing for their dependence on past values and the other regions' past values, and report that the informational linkages across the five trading regions (Asia Pacific, Asia–Europe overlap, Europe, Europe–America overlap and America) are weak.

In this study, we investigate whether the realized volatility of exchange rate returns in a given region is associated with the level of realized exchange rate returns and the realized volatility of the exchange rate returns in the other regions. Specifically, we investigate (i) whether the volatility spill-over is more pronounced from some regions than from others, and (ii) whether the volatility spill-over from such regions is influenced by the level of realized exchange rate returns.[1] Through this, we aim to answer the question as to whether the yen served as a 'safe-haven' currency relative to the US dollar in the subprime crisis period. The difference between our study and that of Cai et al. (2008) is that instead of treating exchange rate returns and the volatility of exchange rate returns as independent proxies of information, we model returns and volatility together. This is done by first creating three indicator variables that classify a given trading day as a day of high returns, neutral returns or low returns, depending on the level of the realized exchange rate returns. To investigate the effect of realized exchange rate returns on volatility spill-over, we multiply the volatility by the relevant indicator variable. We hypothesize that the previous period volatility may have an asymmetric effect on the volatility of a subsequent period, depending on the level of the realized exchange rate returns in the previous period. We investigate this issue in the five trading regions described by Melvin and Melvin (2003): Asia (*AS*), Asia–Europe overlap (*AE*), Europe (*EU*), Europe–America overlap (*EA*) and America (*AM*).

In a sample of intra-day exchange rate returns of currency pairs, US dollar–yen and euro–US dollar, over the sample period August 2008 to July 2009, we find strong evidence to support the heat wave hypothesis and the idea that the next most pronounced volatility spill-over is from the nearest region. We dub the volatility spill-over effect from the nearest region the *nearest neighbour syndrome*. Since we find strong evidence supporting the heat-wave hypothesis and the nearest neighbour syndrome in both currency pairs, we investigate the effects of the level of exchange rate returns on the volatility spill-over from the own region and from the nearest neighbour region. The results reveal that the depreciation of the US dollar against the yen influences the volatility spill-over in the regions with overlapping trading hours (*AE* and *EA*) more than when the US dollar appreciates against the yen. However, such an asymmetric effect of the volatility spill-over is not observed in the case of the euro–US dollar currency pair. Our sample period covers the subprime crisis period. During the subprime crisis period, it appears that foreign exchange traders may have preferred the yen to either the euro or the US dollar. It is plausible that the relatively large depreciation of the US dollar against the other major currencies may have put pressure on investors to sell US dollars and invest in a relatively safe currency.

Section 2 develops a model for investigating whether the volatility in a given region is affected by past information from the other regions as well as the own region, and whether such effects are sensitive to the level of exchange rate returns in the previous period. A description of the data and the methodology is also included in Section 2. The results are discussed in Section 3. The paper finishes with concluding remarks in Section 5, after a robustness check of the results in Section 4.

2. Empirical methodology

2.1. Model development

We model the exchange rate returns volatility spill-over across the five trading (market) regions described by Melvin and Melvin (2003): Asia (*AS*), the Asia–Europe overlap (*AE*), Europe (*EU*), the Europe–America overlap (*EA*), and America (*AM*). Our sample spans the period from 01 August 2008 to 31 July 2009. During this sample period, there are two sub-sample periods where the European and American daylight saving time periods overlap, one sub-sample period where daylight saving time applies to neither, and two sub-sample periods where daylight saving time is applicable only to America. Table 1 gives the time zones by sub-sample period and by region, taking into account the daylight saving times in Europe and America.

We begin our analysis with a model where the foreign exchange rate return volatility for a given region is assumed to be dependent on its past volatility and the past volatilities of the other regions. We refer to this model as the benchmark model. Since the trading regions *AS*, *EU*, *AM*, *AE* and *EA* may be considered as opening and closing sequentially, the volatilities of the previously traded regions may be considered to be known. For ease of exposition, we assume that the past information corresponds to a maximum lag of one.[2] In other words, for a given region, the past information may be the current trading day information of some regions and the previous trading day information of the others, including itself. For example, we model the realized volatility for region *EA* on day *t*, denoted by RV_t^{EA}, as

$$RV_t^{EA} = (\beta_{EU,EA},\ \beta_{AE,EA},\ \beta_{AS,EA},\ \beta_{AM,EA},\ \beta_{EA,EA}) \begin{pmatrix} RV_t^{EU} \\ RV_t^{AE} \\ RV_t^{AS} \\ RV_{t-1}^{AM} \\ RV_{t-1}^{EA} \end{pmatrix} + \alpha_{EA} X_t + \varepsilon_t^{EA}, \quad (1)$$

where X is a vector comprised of a dummy to control for holidays[3] and a constant, and ε is an innovation. In our regional time zone set up, *AS* starts the business day (trading day) followed by *AE*, *EU*, *EA* and *AM*, in that order. Therefore, when modelling RV_t^{EA}, the past volatilities of *EU*, *AE* and *AS* will be the volatilities observed on the same trading day, namely t, and the past volatilities of *AM* and *EA* will be those observed on the previous trading day, namely $t-1$.[4]

[1] Ranaldo and Soderlind (2007) reveal that when the S&P500 has negative returns, US bond prices increase, and when currency markets become more volatile, the Swiss franc, Japanese yen and British pound tend to appreciate against the US dollar.

[2] We consider additional lags in the empirical analysis and find our results to be robust. In similar studies, having selected the lags based on the Akaike Information Criterion (AIC), Melvin and Melvin (2003) and Cai et al. (2008) report that their conclusions remain unchanged when the lag structure is altered to be either fewer or more lags than that selected by the AIC.

[3] This variable is unity when the previous day is a holiday.

[4] When modelling the volatility of *AM* on a given trading day, the past volatilities of all of the other regions will be observed from the same trading day.