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International Comparison of Local Currency Effects on Stock Market Volatility Asymmetry in Asian Markets

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Abstract. The aim of the paper is to study the effect of currency exchange rate changes on the stock market volatility asymmetry, based on the 14 country sample of Asian markets. We calculate time series of stock market volatility asymmetry using APARCH model and using both local currency returns and the USD returns to compare the results. We find that the effect from the exchange rates to the equity market volatility asymmetry is statistically not significant but short periods exist when currency rates can affect equity market volatility asymmetry.

Keywords: Volatility asymmetry; exchange rate; APARHC model; wavelet models.

1. Introduction

Volatility in equity markets appears to be asymmetric which is a well documented empirical finding. Although even experimental setups have shown that volatility asymmetry (higher volatility when prices go down when compared to volatility when prices go up) exists in artificial markets, not that much attention has been turned to the exchange rate volatility. There are still a number of papers investigating the volatility asymmetry of exchange rates, generally with the results that for some currencies the asymmetry is present and for some it is not the clear case ([12] and [16]). Still, the asymmetric nature of volatility remains an important topic for asset pricing and volatility forecasting. The underestimation of volatility asymmetry can very easily lead to underestimation of risks [10].

Previous studies (e.g. [1]) have shown that asymmetry from the equity markets can affect the foreign exchange rates but not much support has been found for volatility transmission in the opposite direction ([13]). Still, an important question remains whether possible volatility asymmetry from the currency markets can affect the volatility asymmetry in the equity markets and to what extent. Current paper adds to the literature providing a detailed comparison using a sample of Asian countries (as it contains both large and small developed and emerging markets) to test whether and to what extent can changes in foreign exchange rates affect volatility asymmetry in equity markets.

We approach the problem from the equity market side, using the methodology of [15] by adopting an APARCH model complemented with wavelet based jump detection and kernel weighting function to repeatedly estimate volatility asymmetry for 14 country stock markets to obtain time series of volatility asymmetry estimates. Repeating the same procedure with stock market returns measured in the local currency and in the US dollars, we can isolate the effect of currency exchange rates to the volatility asymmetry. This enables to compare whether currency exchange rates can contribute to the volatility asymmetry present in most of the sample countries.

We find that the effect from the exchange rates to the equity market volatility asymmetry is minimal. Standard statistical tests do not find significant effect for any of the 14 countries. Comparison of the obtained detailed

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volatility asymmetry time series enables to distinguish short periods when currency rates can affect equity market volatility asymmetry. But even advanced wavelet based semblance analysis of [7] does not enable to spot any significant effects from the currency rates and correlation of the asymmetries obtained in the returns measured in the local currency or in the USD, remain near 90% for most of the countries and the whole sample on average.

2. Related literature

Volatility in equity markets tends to be asymmetric. [3] present an overview of the various studies documenting the effect and in a more recent work [15] show that asymmetric volatility exists in most of the stock markets. The causes of the volatility asymmetry still need further studying as the first studies (e.g. [4]) attempt to explain the asymmetry with leverage effect, meaning that a drop in the value of the stock increases financial leverage by reducing the value of equity, which makes the stock riskier and increases its volatility. Further studies like [14] find that leverage can only explain a small part of the movements in volatility.

There is no clear consensus about the volatility asymmetry in the foreign exchange markets. Early evidence in [5] doesn't find much support for that. Among papers finding support for exchange rate volatility are [12], [13]. For example [16] find volatility asymmetry of AUD, GBP, and JPY against USD but no volatility asymmetry in EUR trade weighted indices against USD.

The causes for exchange rate volatility asymmetry can be a little different than for equity. According to [12] one of the possible explanations is the direction and size of central bank interventions that can cause volatility asymmetry. Other explanations that they propose is the base-currency effect in which the base currency is used for profit and loss calculation, making the variations in the bilateral rate to be a risk of the other currency. As [2] show that contrarian and herding investors can cause asymmetric volatility in equity markets, according to [16] this can be also the case for foreign exchange markets as similar trading patterns are present there.

In the asset market approach to the exchange rate determination [6] causality runs from equity markets to the exchange rates. In the goods market approach the causality is the opposite [9]. Among studies investigating the linkage between stock market and exchange rate volatility [11], [18] and [17] found evidence of the spillover effect from equity market, whereas [18] found an asymmetric effect from the stock market to the foreign exchange market. [13] finds that the volatility of stock returns affects the volatility of exchange rates but no evidence of the volatility transmission in the opposite direction.

3. Methodology

At first the volatility asymmetry is estimated by using the returns of MSCI indexes which are measured as the log difference of the price in the USD. Then all the procedures are repeated and the models are estimated once again with the returns measured as the log difference of the price in local currency of the MSCI index. Data is obtained from Thomson's Datastream for 14 Asian counties. The sample starts from 1980 for developed countries and from 1987 or later for emerging markets and expands till the end of 2008.

The paper uses the same methodology as [15] where the asymmetric power GARCH (APARCH) model of [8] coupled with skewed Student's t-distribution is used to estimate volatility of all markets. The choice of the model is the APARCH(1,1) model without constants and ARMA orders which enabled to obtain results with quite a small number of observations (1001 observations for each rolling time window) and relatively stable results. Another advantage of using the APARCH (1,1) model is an easier interpretation of the model as the APARCH equation becomes:

$$\sigma_t^{\delta} = \alpha(|\varepsilon_{t-1}| - \gamma\varepsilon_{t-1})^{\delta} + \beta\sigma_{t-1}^{\delta} \quad (1)$$

where α, γ, β and δ are parameters to be estimated. The conditional standard deviation is given by σt and γ reflects volatility asymmetry where a positive value means that past shocks ε(t-1) have a larger impact on current conditional volatility when the shocks are negative compared to shocks being positive.

To compare asymmetric volatility in different countries, we estimate the time series of the APARCH model parameters for each country. As proxy for the volatility asymmetry, we use the time series of gamma from Equation 1. We also perform an adjustment and compute an adjusted gamma as done in [15]. This is done for both estimation procedures, i.e. stock market returns measured in USD and local currency.

We still use median values of the non-adjusted gamma for each country and also calculate volatility asymmetry measures using the whole sample of returns for each country. The resulting gamma estimate is referred to as "the whole period gamma".

To summarize the estimations done in the paper to measure volatility asymmetry, we use a rolling time window of 1001 observations for each country. We move the time window by a step of 5 observations and repeatedly estimate the used APARCH model to obtain a time series of volatility asymmetry estimates (gamma). With the obtained time series of gamma, which still contains some noise, we calculate a base value of volatility asymmetry for each country (referred as "adjusted gamma") and also median value for the time series ("median gamma") as well as median values for every year of the observed time period. For further comparison we estimate the same APARCH model only once for each country with all data for the particular country to obtain another estimate of the base volatility asymmetry ("whole period gamma"). Our approach of obtaining time series of volatility asymmetry estimates has clear advantages of only computing a whole period asymmetry as the latter doesn't take into account time-varying characteristics of the volatility asymmetry.

4. Results

Using the described methodology, we obtain a time series containing about 1200 estimates for each country (having data starting from 1980) and with about 800 observations (for the countries having data starting from 1987). We repeat the procedure with returns in the local currency and with returns in the USD (results presented in Table I). This enables us to run standard tests to see whether the obtained asymmetry estimates differ depending on the currency used to measure the stock market returns.

We compute t-statistics to test the difference of the obtained asymmetry measures for the whole sample. We do not find statistical difference in the results for any of the asymmetry measures (average gamma, median gamma and adjusted gamma) depending on the currency used. Furthermore, the correlation between the asymmetry measures in different currencies reaches 96% for average gamma and remains over 92% for all other measures (even when eliminating China and Hong Kong where the local currency is pegged to the USD). It should be noted that also other currencies (like Singapore dollar) of the sample can be partially pegged to the USD or a basket of currencies containing the USD but taking that into account and eliminating those counties from the tests does not change the results.

As the t-tests run so far show results only for the whole sample, we calculate median gamma values for each country for every year of the sample period. This enables us to run t-test on individual countries. The results of such testing confirm the abovementioned finding as we do not find statistically significant difference in any of the countries in the sample, although the p-values for individual countries (ranging from 0.17 to 0.98 compared to p-values of around 0.8-0.95 for the whole sample) imply that on country level there is a higher probability for possible differences in the volatility asymmetry affected by currency exchange rates. But such a difference is still very far from statistically significant for a great majority of the sample.

We still run some additional robustness checks. As our first whole sample median gamma test showed no statistical difference, we only had one observation for each country representing the true median of the volatility asymmetry. This approach can under certain circumstances underestimate the variability of the volatility asymmetry. Thus for a robustness check, we use the previously calculated median gammas for each year of the sample for each country. Taking the average of the median gammas still gives us the same clear result of no statistical difference of the volatility asymmetry depending on the currency exchange rate changes.

One could question the obtained time series estimates of the gamma (volatility asymmetry measure) as at certain times the obtained standard errors for the asymmetry measures can be quite high. Thus we use the same APARCH model and estimate it only once for each country with all data points available (still repeating that with both returns in the local currency and the USD) to get smaller standard errors. We also repeat the whole period gamma estimation twice, once with returns containing jumps (original data) and secondly with data used for obtained volatility asymmetry time series estimation that has jumps removed. Both t-tests and correlation of over 96% still shows that the results do not depend on the calculation method of the volatility asymmetry measures and confirms the previously noted finding.

So far all of our test have used somehow aggregated data which can arise a question whether there in fact can be periods where currency exchange rates affect volatility asymmetry of the stock markets even if the average effect is very small. Traditional statistical methods lack very good methods to compare time series similar to higher frequency data containing noise. Our volatility asymmetry time series still contains noise despite using jump detection and input weighting for the APARCH model which significantly improved the stability of our obtained model estimates. In order not to start removing the noise, we use a wavelet based method of [7] to conduct semblance analysis of the obtained time series.

Wavelet-based approaches provide the ability to account for temporal (or spatial) variability in spectral character [7]. Semblance analysis is calculated as a function of both scale (or wavelength) and time (or position) which enables the changing phase relationships of the two datasets to be visualized and analyzed. Although [7] propose the use of the semblance analysis for geophysical datasets, they also demonstrate the use of the method on financial data.

The results of the semblance analysis (for Australia and Singapore) is brought in Figure 1-2, where red color indicates a large positive amplitude and dark blue indicates a large negative amplitude. The results of semblance analysis confirm the previous results that if differences exist in the asymmetry measures caused by the currency exchange rates, the differences are minimal and exist only for short periods of time. For most of the time even the time series of asymmetry measures follow the same pattern regardless of the currency exchange rate movements.

5. Conclusions

The results from 14 Asian stock markets show that the effect from the exchange rates to the equity market volatility asymmetry is minimal. Standard statistical tests do not find significant effect for any of the sample countries. Comparison of the obtained detailed volatility asymmetry time series enables to distinguish short periods when currency rates can affect equity market volatility asymmetry but even wavelet based semblance analysis does not enable to spot any significant effects from the currency rates. We conclude that volatility asymmetry of the sample stock markets is statistically not significantly nor economically significantly affected by currency exchange market. Current results and work could be extended by using even a larger sample of countries to conduct similar analysis on.

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Table 1 Volatility Asymmetry Measures

	Returns measured in the local currency				
Country	**Average gamma**	**Median gamma**	**Adjusted gamma**	**WPG (jumps)**	**WPG (no jumps)**
Australia	0.278	0.281	0.422	0.161	0.132
China*	0.275	0.212	0.243	0.131	0.117
Hong Kong*	0.172	0.171	0.246	0.155	0.128
Indonesia	0.109	0.120	0.109	0.092	0.037
India	0.141	0.138	0.143	0.093	0.092
Japan	0.364	0.324	0.383	0.275	0.221
Korea	0.166	0.168	0.169	0.167	0.144
Sri Lanka	0.057	0.067	0.055	0.051	0.040
Malaysia	0.183	0.157	0.197	0.164	0.127
New Zealand	0.076	0.084	0.095	0.110	0.113
Pakistan	0.006	0.008	0.007	0.028	-0.003
Singapore	0.192	0.167	0.209	0.129	0.105
Thailand	0.104	0.074	0.077	0.129	0.098
Taiwan	0.224	0.208	0.233	0.167	0.144
	Returns measured in the USD				
Country	**Average gamma**	**Median gamma**	**Adjusted gamma**	**WPG (jumps)**	**WPG (no jumps)**
Australia	0.228	0.185	0.324	0.161	0.140
China*	0.277	0.215	0.246	0.130	0.116
Hong Kong*	0.171	0.162	0.248	0.157	0.125
Indonesia	0.110	0.109	0.111	0.084	0.038
India	0.159	0.143	0.179	0.104	0.104
Japan	0.287	0.269	0.350	0.232	0.197
Korea	0.179	0.173	0.179	0.170	0.149
Sri Lanka	0.067	0.083	0.071	0.070	0.056
Malaysia	0.159	0.138	0.161	0.165	0.119
New Zealand	0.105	0.121	0.107	0.129	0.108
Pakistan	-0.002	-0.002	-0.003	0.012	-0.003
Singapore	0.221	0.186	0.260	0.141	0.130
Thailand	0.122	0.079	0.098	0.132	0.110
Taiwan	0.220	0.218	0.229	0.158	0.147
T-test p-value	0.919	0.813	0.953	0.982	0.875
Correlation	0.959	0.927	0.959	0.968	0.979

The table presents different volatility asymmetry measures for all countries in the sample. The upper panel presents the results of returns measured in the local currency and the lower panel with the returns measured in the USD. The last two rows present the p-values of some of the conducted t-tests on the whole sample and correlation of the volatility asymmetry measures presented in the upper pane and lower pane. (*China and Hong Kong are not included in the t-tests and in correlation calculations presented in the table because of closely pegged currencies to the USD. It should be noted that also other currencies (like Singapore dollar) of the sample can be partially pegged to the USD or a basket of currencies containing the USD, but taking that into account and eliminating those counties from the tests does not change the results.) WPG stands for the "whole period gamma".

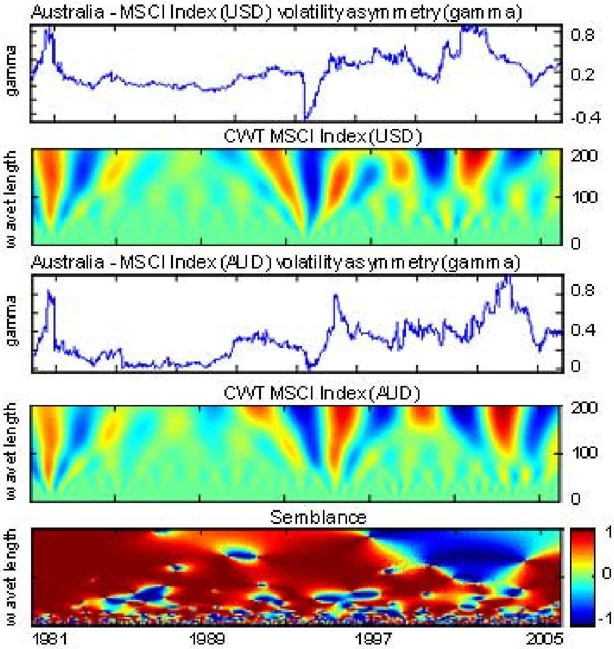

Fig.1. Volatility asymmetry in Australia and semblance analysis results (CWT - continuous wavelet transform).

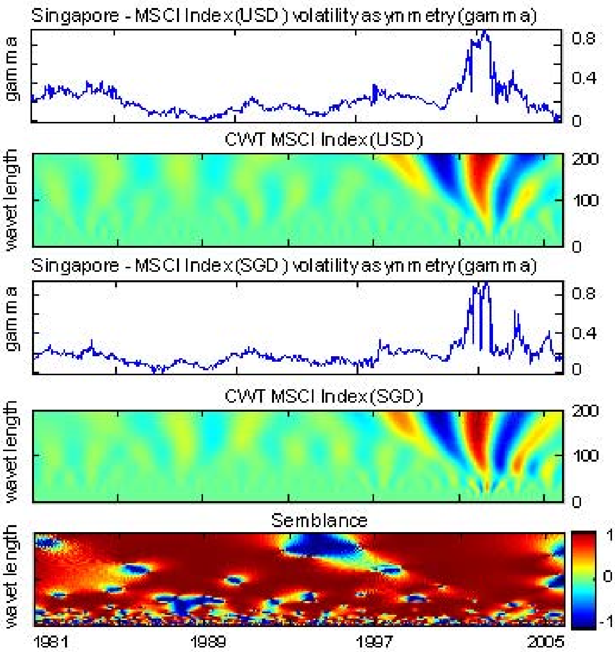

Fig.2. Volatility asymmetry in Singapore and semblance analysis results (CWT - continuous wavelet transform).