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Modeling volatility linkages between Shanghai and Hong Kong stock markets before and after the connect program

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ABSTRACT

Based upon ARMA-*t*-BEKK-AGARCH models, this paper investigates the volatility linkages between Shanghai and Hong Kong stock market before and after the Program. Shocks spillover is found to be unidirectional from Hong Kong to Shanghai market before the Program and after the Program. Volatility transmission persistence bears the major change of volatility linkage between the two markets; it changes from being significantly bidirectional before the Program to be insignificant thereafter. Asymmetries of shocks spillover are also identified between the two markets both before and after the Program. Dynamic conditional variance and covariance matrices are examined and used to construct hedge ratios and portfolio weights. Finally, correspondent suggestions are given for investors and policy makers.

1. Introduction

Shanghai-Hong Kong Stock Connect (hereafter the Program) is a program initialed as a trial on April 10, 2014 and formally executed on Nov 17, 2014 by Chinese government for an aim of closer tie between Shanghai and Hong Kong stock markets. The Program is one of the most important measures in the government's efforts of opening its capital market to the world. After the Program, the volatility linkage between the two markets becomes a more practical issue for investors with hedging and portfolio strategies in the two markets and for the policy makers as well.

As such, there is a growing literature on the effect of the Program on each of the two markets and on the linkage of stock markets in Shanghai and Hong Kong. Some scholars focus on the effects of the Program on the two markets respectively, e.g. Liu and Liu (2015) investigate the effect of the Program on the efficiency of Shanghai stock market. They argue that Shanghai stock market has an obvious long term memory which, along with short-term memory, declines significantly after the Program. Yan et al. (2015) compare the announcement effect of the Program on the two markets and find that Hong Kong stock market with more exceptional turns and higher volatility is more responsive to the announcement.

The majority of existing literature focuses on the linkage of Shanghai and Hong Kong stock markets before and after the Program. Yang and Zhang (2015) adopt Barndorff-Nielsen's volatility decomposition model with which the spillover of continuous volatility is found to be unidirectional (from Hong Kong stock market to Shanghai stock market) before the Program and bidirectional after the Program. Cai and Wang (2015) apply a mixed copula model to examine whether the Program has significant influence upon the linkage among Shanghai, Hong Kong and the U.S. stock markets. They conclude that the long term linkage between Shanghai and Hong Kong markets undergoes significant changes after the Program, and the upper tail relationship becomes higher. Xu et al. (2015) have a similar conclusion that the Program strengthens the upper tail relationship between Shanghai and Hong Kong market, and they further point out that the upper tail relationship is bigger than the lower tail relationship. With Granger causality tests and a BEKK-GARCH model, Feng and Duan (2016) argue that the implementation of the Program strengthens the linkage, and that the volatility spillover from Shanghai stock market to Hong Kong has been significantly enhanced . .

With the achievements of existing literature related to the volatility linkage between Shanghai and Hong Kong stock markets, a major issue found to be overlooked by most studies is the asymmetric effect of volatility spillover. With asymmetric effect added into account, some arguments of preceding works could be doubted and new questions may arise and deserve further investigation.

In the present paper, we intend to have a further comparative research on the volatility linkage before and after the Program. With asymmetric effect of spillover added into account, we thus divide volatility linkages into three aspects: shocks spillover, asymmetry of shocks spillover, and volatility transmission persistence. The first two aspects are short-term issues while the last is long-term concerns.

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Shocks spillover is the inter-market ARCH effect; it refers to the short-term effect which shocks (including positive and negative shocks, but not concerning asymmetric effect) in one market may have upon the volatility of another market. Asymmetry of shocks spillover is inter-market leverage effect; it could be negative or positive. If not indicated, asymmetry of shocks spillover in this article is referred to be negative. Negative asymmetry of shocks spillover refers to the situation where the negative shocks in one market tend to increase the volatility of another market more than positive shocks do. In other words, bad news rather than good news in one market produces stronger spillover to another market. Volatility transmission persistence is the inter-market GARCH effect; it measures the long-term persistence of the impacts of volatility in one market upon the volatility in another market.

Based upon the above definitions and with much reference to the asymmetry of shocks spillover which is neglected in most existing researches, we have the following concerns for further studies:

First, what is the causality of volatility in Shanghai and Hong Kong markets before and after the Program, unidirectional or bidirectional? This question will be examined in our current paper with an overall view of inter-market ARCH effect, GARCH effect and asymmetric effect, while most existing works look into the causality of volatility with only reference to the former two effects.

Second, which effect(s) is (or are) more significant after the Program, the short-term volatility spillover effects (shocks spillover effect and asymmetric effect) or the long-term persistent effect? The answer for this question relates to the efficiency of inter-market transmission of shocks or news, and would endorse meaningful suggestions both for investors and market supervisors. Yet, with or without asymmetric effect concerned, we might come to different conclusions.

Third, both markets of Shanghai and Hong Kong may have bad news or good news dominating some periods of time, hence more reliable arguments about asymmetry of shocks spillover should be based upon different combinations of the signs of shocks in the two markets. For example, the spillover effect of negative shocks from Shanghai to Hong Kong stock market may be weak or strong according to shocks of different signs in Hong Kong stock market.

With Based upon bivariate ARMA-BEKK-*t*-AGARCH models, this paper examines the volatility linkage between Shanghai and Hong Kong stock markets in two steps: parameter significance and Wald test; news impact surface (NIS) analysis. Thus the rest of this paper is organized as follows: Section 2 describes the methodology of the ARMA-BEKK-*t*-AGARCH and NIS method. Section 3 presents the dataset and its preliminary Statistics. Section 4 is for the empirical results, including the analysis of volatility linkage with reference to the significance tests of parameter estimates and a further study of volatility linkage with NIS approach. Section 5 constructs the hedge ratios and optimal portfolio weights with conditional covariance matrix. Section 6 is the stability tests of the models applied. Section 7 is a summary of the empirical findings for this paper.

2. Methodology

Our aim is to investigate the volatility linkages between Shanghai and Hong Kong markets; therefore a bivariate GARCH setup is appropriate. The BEKK (after Baba, Engle, Kraft and Kroner) specification of the variance-covariance matrix defined in Engle and Kroner (1995) is chosen in the present paper. The BEKK model has three main advantages. First, the number of parameters to be estimated by the model is considerably reduced. Second, the model ensures the positive definiteness of the time varying covariance matrix. Third, a BEKK model in unrestricted form presents a clearer picture of the spillover of shocks across markets.

Consider a bivariate sequence of data r_t consisting of Shanghai and Hong Kong market index returns. We employ an ARMA form of the mean models:

$$r_t = \mu + \sum_{i=1}^{p} \alpha_i r_{t-i} + \sum_{i=0}^{q} \beta_i \varepsilon_{t-i};\ \ \varepsilon_t = H_t^{1/2} v_t \tag{1}$$

where r_t is the vector of the index returns of the two markets at time t, ε_t is the error term. r_{t-i} and ε_{t-i} are the elements of AR (p) and MA (q) process respectively with order p and q. μ is the vector of constant terms, v_t is a vector of standardized residuals (*i.i.d*) and H_t is the conditional covariance matrix.

With the above specification, a bivariate BEKK-*t*-AGARCH model, with the conditional covariance matrix, can be represented as follows:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon_{t-1}'A + B'H_{t-1}B + D'\varphi_{t-1}\varphi_{t-1}'D \tag{2}$$

where C is the constant term represented by a lower triangular matrix[1] whose outer product is used. A, B and D are unrestricted 2×2 parameter matrices. The asymmetry term is expressed by the last part of Eq. (2), with $\varphi_t = \min(0, \varepsilon_t)$.

The diagonal elements in matrix A and B measure the effects of lagged shocks and lagged volatility on the conditional volatility in each market itself. The diagonal elements in matrix D have similar implication for the intra market asymmetric effect. The off-diagonal elements in matrices A, B and D helps to capture the inter- market shocks spillover, volatility transmission persistence and asymmetric effect.

But due to the quadratic forms of BEKK models, just as Martin and Kustrim (2013) mentioned, it is not easy to render the volatility linkage properly. Some of the crucial details of volatility linkage, such as inter-market asymmetry of shocks spillover, may have to be overlooked if one simply relies on the statistical significance of the off-diagonal elements in the parameter matrices A, B and D. To overcome this problem, we will first comment the parameter estimates as usual in literature and then apply news impact surface (NIS), a methodology proposed by Kroner and Ng (1998), for a further investigation. Setting H_{t-1} matrix at its unconditional mean values and using the innovations for news arriving to a market (Engle and Ng 1993), the NIS for the conditional covariance matrix is expressed as follow:

$$\sigma_{ij,t} = \sigma_{ij}(\varepsilon_{i,t-1}, \varepsilon_{j,t-1}; H_{t-1} = \gamma) \tag{3}$$

where γ is the mean of unconditional H matrix.

3. Data and preliminary statistics

We use the daily closing prices of SSE Composite Index and Hang Seng Index which both are the benchmark indices in Shanghai and Hong Kong Stock markets respectively. The datasets are obtained from WIND database. The whole sample covers the time period from July 01, 2007 to Oct 31, 2016. Data with different dates due to holidays are excluded, thus yielding 2195 observations for each market. Since the Connect Program was initialed as a trial run on April 10, 2014, we divide the whole sample into two subsamples, namely pre-subsample from July 01, 2007 to April 9, 2014 and after-subsample from April 10, 2014 to Oct 31, 2016. For convenience, LSSE and LHS stand for the log value of SSE Composite Index and Hang Seng Index, while RS and RH, calculated from the first order difference of the LSSE and LHS, are the Logarithmic returns expressed in percentage.

Due to locating in the same time zone, stock exchange in Shanghai opens only half hour earlier than that in Hong Kong, hence the information shocks embedded in the indices are synchronous in essence, and the daily stock market correlations for the two exchanges are not affected by the usual issue of discrepancy in the opening hours of exchanges around the world.[2]

[1] This is often represented as an upper triangular matrix, yet the resulting product matrix will be the same.

[2] Martens and Poon (2001) argued that the daily stock market correlations are affected by the use of non-synchronous data.