Modeling Volatility Spillovers in Iran Capital Market

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ABSTRACT

This paper investigates the conditional correlations and volatility spillovers between the dollar exchange rate return, gold coin return and crude oil return to stock index return. Monthly returns in the 144 observations (2005 - 2017) are analyzed by constant conditional correlation, dynamic conditional correlation, VARMA-GARCH and VARMA-AGARCH models. So this paper presents interdependences in conditional volatilities across returns in each market. The purpose of this study is to identifying volatility spillover on the capital market in order to managing financial volatility, in addition to policy making and risk management. The evidence of this study confirms the asymmetric volatility spillovers of the dollar exchange return and also conditional shocks from gold coin and crude oil returns to the stock index that ignoring the asymmetries effects in in the model will exaggerate the returns and shocks spillover. In addition to these results, dynamic model gives the statistically significant estimates for all returns with most impact shocks from dollar exchange return and gold coin returns.

Keywords:

Volatility Spillover, Dynamic conditional correlation, Financial returns.

1. Introduction

The degree of correlation between stock market prices is generally taken as evidence of the level of market integration. However, such an approach has been found to be flawed since there found time-varying properties of returns such as short-term noises and long term fundamental relationships, which are not captured by simple correlation technique. Subsequent studies have measured the interdependencies between stock markets through examining the spillover of volatilities between them (Engle et al, 1995).

The motivation for the study comes from the following interesting inquiry: How stock markets, which are structurally and functionally different from each other, get affected by other’s important markets volatility? What is the effect of different shocks of other markets on the capital market? A clear understanding of the mechanism of volatility transmission across financial markets is important for its implication on monetary policies, resource allocation, risk hedging, capital requirements and asset valuation. The facilitation of transactions of cash flows, the convergence and dynamics of financial relations will require an inclusive approach in adopting appropriate financial policies and making more efficient decisions.

Over the years, researchers working in the domain of volatility spillover have tried to address the above query and establish the underlying economic cause for such phenomena. However, the inquiries have been rather restricted to either certain markets (mostly developed) or specific periods (financial crises). A localized investigation in this context, examining the mechanism of volatility spillover across markets, is missing and needs to be studied. However, the missing link seems to be the lack of volatility maps on a strategic scale. A volatility map will capture all past trends of volatility transmission (in terms of both magnitude and direction) between different markets. The outputs of this research have the dimensions of policy making in order to pay attention to macroeconomic plans and management of financial distress in order to increase financial resilience in the country.

Researchers have investigated the extent of the transmissions across different markets during a specific event such as a financial crisis (Hooy et al., 2004; Fernández-Izquierdo and Lafuente, 2004; Caporale et al., 2006; Neaime, 2012). Several recent studies (such as Diebold & Yilmaz, 2012; Mensi, Hammoudeh, & Yoon, 2013; Aboura, & Chevallier, 2015) confirmed the effects of volatility spillover between stock and commodity markets. The distinction of this research can be seen in the broad data, specific methodology for measuring relationships and outputs applied.

This paper aims to examine the volatility characteristic, asymmetric effect of positive and negative shocks, and volatility spillovers to Iranian stock markets to manage the portfolio risk and returns. For modeling purpose, the interdependence of volatility and transition mechanisms between selected time series, used constant conditional correlation (CCC), dynamic conditional correlation (DCC) and VARMA-(A)GARCH models.

2. Literature Review

In financial literature, Fluctuation of a variable over a period of time is an indication of the volatility of that variable, and the deviation from an expected value is often used to describe volatility (Ezzati, 2013). Financial volatility is defined as a measure of variation of price of a financial instrument over time. Financial volatility is important as it is one indication of the level of risk. Volatility is synonymous with measurement of risk. Volatility measures are of two kinds: unconditional volatility (such as variance) and conditional volatility (temporal dependence of second order moments). Literature which deals with spillovers of volatility (also termed as shock) has examined whether conditional variances of stock returns in one market is affected by additional information in the form of squared innovations occurring in other markets (Engle et al., 1993). Spillover effects are economic events in one context that occur because of something else in a seemingly unrelated context. For example, externalities of economic activity are non-monetary effects upon non-participants. Over the past decades, many researchers examined the volatility spillover effect. By definition, spillover effects are externalities of economic activity or processes that affect those who are not directly involve, exploring and exhibiting the linkages between two or more economic variables. This means there are volatility linkages and spillovers across the markets (Yang & Doong, 2004).

The financial literature has recently focused on the study of stock markets interdependence and especially volatility spillover, particularly after the multiplicity of financial crises such as Mexico1994, Asia1997, Brazil 1998, Turkey 2001, and the recent 2008 subprime crisis as the mostly affecting on emerging markets.

Advocators of volatility-based models argue that if two markets are integrated then they get affected by each other’s volatility. Thus empirically measuring the magnitude of volatility transfers between markets can give the level of integration between them. A study of empirical literature such as Bernard and Durlauf (1996) suggests that one way to assess the convergence (or divergence) in prices of interdependent markets is by performing pair-wise stationary tests on the price differences of the two series. The difference of the price series of two stock markets should not contain any unit root to meet the convergence criteria. The Augmented Dickey Fuller (ADF) test and the Kwiatkowski Phillips Schmidt and Shin (KPSS) test are generally used to test for convergence between the prices series of two stock markets. However, using stationary property for testing of price convergence has some bugs because the stationary of price differentials only imply for convergence and do not mention the level of integration. Secondly, the Augmented Dickey Fuller tests lack robustness in the presence of outliers and may wrongly rejects the convergence hypothesis (Zachmann, 2008). Another way to measure market integration involves the detection of co-integration relationships in the price series between two stock markets with direct interconnections. in the markets that are well integrated, the individual markets imperfections and the resultant friction that push the prices towards divergence gets offset by the arbitrage opportunities that are created thus moving towards one price. Johansen’s co-integration test or Engle and Granger (1987) co-integration test are usually used to detect for any evidence of integration between two markets. However, one implicit assumption of co-integration methodology is that the co-integrating vector is constant over the period of study (Barret and Li, 2002). However, in reality it is very much possible that the long-run relationship between the underlying variables change. Shifts in the co-integrating vector can occur due to any systemic change such as socio-political, economic, legal or environmental. This is particularly likely to be the case if the observation period is long. Hence, while using co-integration tests care should be taken during interpretation of long run equilibrium relationships. The most popular way of gauging the level of integration is to measure the magnitude of spillover of volatility between two markets. The rationale for taking spillover of volatility between markets as a proxy for market integration is quite intuitive. When markets are economically integrated via trade and investments then it is expected that their capital markets, the movement of which is largely governed by economic factors, also show interdependence. Spillover models such as ARCH, GARCH developed respectively by Engle (1982) and Bollerslev (1986) and their various extensions test market integration and interdependence by capturing the extent of spillover of volatility from one market to another. Recent advances in empirical literature in the field of volatility and its spillover for assessing the level of integration between markets, presents a strong argument in favor of spillover models as a preferred methodology. Not only these models present a robust methodology, they are also stable in terms of state-space-time dimensions and are fairly generalizable. Hence, for the purpose of our study, we have adopted volatility-based models to measure the extent of interdependence between world markets and its evolution over time.

Literature identifies at least three ways in which exchange rates affect stock market. The first way is via the goods market. Dornbusch and Fischer (1980) argue that changes in the exchange rate affect the competitiveness of multinational firms and hence their earnings and eventually their stock prices. However, this is not only confined to multinational firms; a second way, as Adler and Dumas (1984) observe, even firms that may not have a large market in international trade, but if their input prices, output prices or demand for products are exposed to exchange rate movements, may display fluctuations in their stock prices in congruence with exchange rate movements. Finally, from the asset pricing perspective, if the economy can be described by a set of pervasive risk factors, one of them being the exchange rate risk, then price of an asset (or a portfolio of assets) will be sensitive to such risks and some premium has to be accounted for, in order to mitigate them. Thevolatility spillover of exchange rate to other markets has always been at the center of attention of financial actors in countries with a floating rate regime. Exchange rate fluctuations can affect stock prices by influencing investors' decisions, and, on the other hand, they may not be able to ignore the effect of the stock price stimulus on the exchange rate. The volatility spillover from the gold market to other financial markets is a longstanding issue. Because the pricing of this expensive metal is global, such factors as war, boycott, internal unrest and geopolitical tensions, and in economic terms, factors such as oil price changes, exchange rates, interest rates of Libor, domestic interest rate and so on Affect it (Tully & Lucey, 2007). Since gold plays an important role in the economy (saving and maintaining the value of money for households as an attractive investment option) and its diverse consumption is undeniable, the volatility modeling for this market can be a valuable outcome for investors and planners. Ultimately, oil has diverse fluctuations and convergence effects in different countries. For oil-exporting countries, price shocks increase national income, public spending, and investment that cause stock prices are expected to increase. Some also believe that oil prices do not have a significant effect on the stock market. It is argued that monetary and fiscal policies are effective on inflation and macroeconomic variables in which oil prices are included (Apergis & Miller, 2009) Modeling the volatility of the oil and capital market is important from several perspectives. First, oil is the focus of political and economic movements in the exporting countries. Secondly, the mechanisms for transferring oil price shocks seem to be different. Thirdly, the stock market of countries has a significant difference in terms of volume, depth and efficiency. Therefore, modeling this can help investors to make appropriate financial decisions and help economic decision makers make better decisions.

3. Methodology

A widely range of conditional volatility models are used to estimate the volatility and volatility spillovers with symmetric and asymmetric effects in financial markets. The multivariate conditional volatility model, namely CCC, DCC, VARMA-GARCH and VARMA-AGARCH, are used in this paper to capture the characteristic of the volatility on Iranian capital market. Bollerslev (1986) generalized ARCH(r) to the GARCH (r,s), model as follows:

$$h_t = \omega + \sum_{j=1}^{r} \alpha_j \varepsilon_{t-j}^2 + \sum_{i=1}^{s} \beta_i h_{t-i} \qquad (1)$$

where $\varpi > 0$, $\alpha_j \geq 0$ for j = 1,…,r and $\beta_i \geq 0$ for i = 1,…,s are sufficient to ensure that the conditional variance $h_t > 0$. The α_j represents the ARCH effect and β_i represents the GARCH effect.

GARCH (r,s) shows that the volatility is not only effected by shocks but also effected by lag of itself. The model also assumes a positive shock ($\varepsilon_t > 0$) and negative shock ($\varepsilon_t < 0$) has the same impact on the conditional variance.

The constant conditional correlation (CCC) model of Bolerslev (1990) assumes that the matrix of conditional correlations is given by $E(\eta_t \eta_t') = \Gamma$. As given in equation (2), the CCC model does not have volatility spillover effects across different financial assets. Moreover, CCC also does not allow conditional correlation coefficients of the returns varying over time.

$$h_{it} = \omega_i + \sum_{k=1}^{p} \alpha_i \varepsilon_{i,t-k} + \sum_{l=1}^{q} \beta_i h_{i,t-l} \qquad (2)$$

Engle (2002) proposed the Dynamic Conditional Correlation (DCC) model. The DCC model allows for two-stage estimation of the conditional covariance matrix. In the first stage, univariate volatility models have been estimated and obtain h_t of each of assets. Second stage, asset returns are transformed by the estimated standard deviations from the first state. Then it is used to estimate the parameters of DCC. The DCC model can be written as follows:

$$y_t \mid F_{t-1} \sim (0, Q_t), \quad t = 1, ..., T \qquad (3)$$

$$Q_t = D_t \Gamma_t D_t, \qquad (4)$$

Where $D_t = \text{diag}(h_{1t}, \ldots, h_{mt})$ is a diagonal matrix of conditional variances, with m asset returns, and F_t is the information set available to time t. The conditional variance is assumed to follow a univariate GARCH model as follows:

$$h_{it} = \omega_i + \sum_{k=1}^{r} \alpha_{i,k} \varepsilon_{i,t-k} + \sum_{l=1}^{s} \beta_{i,l} h_{i,t-l} \qquad (5)$$

When the univariate volatility models have been estimated, the standardized residuals, $\eta_{it} = y_{it} / \sqrt{h_{it}}$, are used to estimate the dynamic conditional correlations as follows:

$$Q_t = (1-\phi_1-\phi_2)S + \phi_1\eta_{t-1}\eta'_{t-1} + \phi_2 Q_{t-1} \tag{6}$$

$$\Gamma_t = \left\{(diag(Q_t)^{-1/2}\right\} Q_t \left\{(diag(Q_t)^{-1/2}\right\}, \tag{7}$$

Where S is the unconditional correlation matrix of the ε, equation (7) is used to standardize the matrix estimated in (6) to satisfy the definition of a correlation matrix. The VARMA-GARCH model of Ling and McAleer (2003) assumes symmetry in the effects of positive and negative shocks on conditional volatility. Let the vector of returns on m (≥ 2) financial assets be given by:

$$Y_t = E(Y_t \mid F_{t-1}) + \varepsilon_t \tag{8}$$

$$\varepsilon_t = D_t \eta_t \tag{9}$$

$$H_t = \omega + \sum_{k=1}^{r} A_k \vec{\varepsilon}_{t-k} + \sum_{l=1}^{s} B_l H_{t-l} \tag{10}$$

Where

$H_t = (h_{1t}, ..., h_{mt})'$,

$\varpi = (\varpi_1, ..., \varpi_m)'$,

$D_t = diag(h_{i,t}^{1/2})$,

$\eta_t = (\eta_{1t}, ..., \eta_{mt})'$,

$\vec{\varepsilon}_t = (\varepsilon_{1t}^2, ..., \varepsilon_{mt}^2)'$, A_k and B_l are $m \times m$ matrices with typical elements α_{ij} and β_{ij}, respectively, for i,j = 1,…,m, I(η_t) = diag(I(η_{it})) is an $m \times m$ matrix, and F_t is the past information available to time t. Spillover effects are given in the conditional volatility for each asset in the portfolio, specifically where A_k and B_l are not diagonal matrices. Based on equation (9), the VARMA-GARCH model also assumes that the matrix of conditional correlations is given by $E(\eta_t \eta'_t) = \Gamma$.

An extension of the VARMA-GARCH model is the VARMA-AGARCH model of McAleer et al(2008). It assumes asymmetric impacts of positive and negative shocks proposed the following specification of conditional variance.

$$H_t = \omega + \sum_{k=1}^{r} A_k \vec{\varepsilon}_{t-k} + \sum_{k=1}^{r} C_k I_{t-k} \vec{\varepsilon}_{t-k} + \sum_{l=1}^{s} B_l H_{t-l} \tag{11}$$

Where C_k are $m \times m$ matrices for k = 1,…,r and I_t = diag(I_{1t},…,I_{mt}), so that

$$I = \begin{cases} 0, \varepsilon_{k,t} > 0 \\ 1, \varepsilon_{k,t} \leq 0 \end{cases}$$

From equation (10) if m = 1, it reduces to the asymmetric univariate GARCH or GJR. If $C_k = 0$ for all k, it reduces to VARMA-GARCH.

4. Results

In this study monthly logarithmic yield of data was used during the period 2005-2017. The reason for choosing the year 2005 as the origin date is the change in the securities market law and the creation of new structures in the capital market. For the capital market, the monthly return of the total index is used. Regarding other markets, the OPEC basket price, the price of major foreign exchange market sales in the free market of Tehran (from CBI Database and the Economic Indicators Report). The volatility of the stock market was lower than oil and gold markets, but more than dollar returns. The returns of the examined markets have a small average with high variance. In Fig. 1, the logarithmic yield charts for the period of 12 years are presented for the 4 time series of the stock index (RCAP), the dollar (RDOL), gold (RGOL) and oil (ROIL). An indication of the clustering nature of the volatility in the prices of the time series examined. This means that volatility trends tend to follow their prior trends in their prior developmental trends and inertia trends.

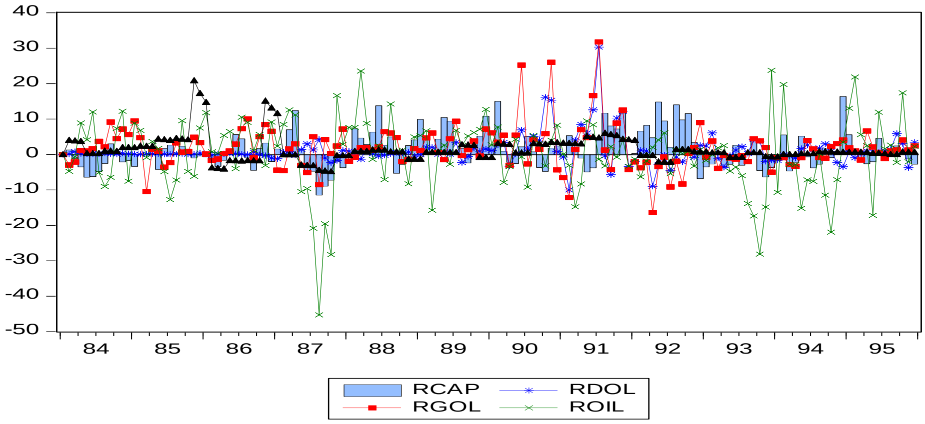

Figure 1. Return's volatility of four Markets

White's test considers the most extreme state that is very sensitive to the Heteroscedasticity variance (usually when using White's test, which does not know the distribution of the variance of the error terms). The output of the White test and the effect of Arch, confirms the existence of Heteroscedasticity of variance in the model.

The correlation between each pair of series at a given time point can be created by dividing conditional covariance by conditional deviations. One of the alternative approaches can be modeling dynamics directly by correlation. In the fixed conditional correlation model (CCC), assuming that conditional covariance is not constant, it is possible to associate the variance with constant conditional correlations. Output of the results of the fixed conditional correlation model is presented in Table (2). In this model, there is no fixed conditional correlation between stock returns and oil price performance.

A dynamic conditional correlation model is performed with two estimation steps in which each variable in the system are firstly modeled as a single-variable GARCH process. Here θ_1 represents the effect of past shocks on conditional correlations, θ_2 represents the effect of past dynamic conditional correlation and θ_3 represents cross-sectional correlations. The significance of θ values indicates that conditional correlations are not constant.

The output of Table 3 indicates that the effect of past shocks is the dollar exchange rate of dollars and oil return prices; the pervious dynamic conditional between dollar exchange rates and gold coin return, finally, a cross conditional correlation between gold returns and stock index.

Finally, the VARMA_GARCH model is used to investigate the volatility spillover among the four markets examined. The output of these two models is summarized in Table (4). The output from the table shows that there is volatility spillover between the capital market and the foreign exchange market, gold market and oil market.

The evidence of asymmetric effects of negative and positive shocks of equal magnitude on the conditional variances suggests that VARMA-AGARCH is superior to VARMA-GARCH and CCC especially between dollar exchange rate returns and stock index returns.

Table 1. white Heteroscedasticity test

F-statistic	3.8511	Prob. F(44,99)	0.0000
Obs*R-squared	122.0000	Prob. Chi-Square(44)	0.0000
Scaled explained SS	166.9564	Prob. Chi-Square(44)	0.0000

Table 2. Covariance specification: Constant Conditional Correlation

Method: ML ARCH - Generalized error distribution (GED)				
GARCH(i) = M(i) + A1(i)*RESID(i)(-1)^2 + B1(i)*GARCH(i)(-1)				
Variable	**Coefficient**	**Std. Error**	**Statistic -z**	**Prob**
C(1)= RCAP	0.782297	0.556644	1.40538	0.1599
C(2)= RDOL	0.167554	0.024829	6.748252	0
C(3)= RGOL	1.019672	0.47933	2.127285	0.0334
C(4)= ROIL	0.438511	0.900939	0.486727	0.6265

Table 3. Dynamic conditional correlation

market	θ	Type of dynamic impact of conditional correlation
Dollar return	θ(۱) وθ(۲)	The impact of Past shocks on current conditional correlation and the impact of pervious dynamic conditional correlation
Gold return	θ(۲) وθ(۳)	and the impact of pervious dynamic conditional correlation and the impact of cross conditional correlation
Oil price return	θ(1)	and the impact of Past shocks on current conditional correlation

Table 4. VARMA_GARCH model for three markets

VARMA_GARCH(RCAP - RDOL) GARCH(MV=CC,VARIANCES=VARMA-SPILLOVER,ASYMMETRIC)				
Variable	**Coefficient**	**Std. Error**	**Statistic -z**	**Prob**
Mean(1)	1.06474	0.02592	41.03203	0
Mean(2)	0.21353	0.00281	75.62319	0
Mean(3)	0.25441	0.00262	96.528.3	0
Mean(4)	0.21732	0.00586	3686937	0
VARMA_GARCH(RCAP - RGOL) GARCH(MV=CC,VARIANCES=VARMA-SPILLOVER)				
Variable	**Coefficient**	**Std. Error**	**Statistic -z**	**Prob**
Mean(1)	1.36348	0.096066	14.19164	0
Mean(2)	1.84842	0.02747	67.2561	0
Mean(3)	1.36341	0.09606	14.19174	0
Mean(4)	1.84844	0.02748	67.2561	0
VARMA_GARCH(RCAP - ROIL) GARCH(MV=CC,VARIANCES=VARMA-SPILLOVER)				
Variable	**Coefficient**	**Std. Error**	**Statistic -z**	**Prob**
Mean(1)	1.7067	8.4068	203.012	0
Mean(2)	1.301	4770285	272.7301	0
Mean(3)	-0.17956	0.0002	-870.2943	0
Mean(4)	-457.2962	14.05134	-32.54472	0

5. Discussion and Conclusions

The results of the research on the four markets examined can be summarized as follows. First, the volatility spillover from the foreign exchange market to the stock exchange is asymmetrically confirmed by constant conditional correlation model (CCC). Also, the dynamic conditional correlations model indicates the impact of Past shocks on current conditional correlation and the impact of pervious dynamic conditional correlation between those markets.

Secondly, the volatility spillover from the gold coin returns to the stock exchange is symmetrically confirmed. It should be mentioned, the dynamic interaction between the two gold and stock markets based on the dynamic models can be derived from past conditional dynamic correlations and the effects of cross-correlation between gold market and capital market.

Third, the volatility spillover from the oil market to the stock exchange is symmetrically confirmed. However, the existence of a conditional correlation relationship based on the constant conditional correlation model (CCC) between these markets cannot be verified. Therefore, the dynamic interaction of two oil and stock markets based on the DCC model can be derived from the correlation between the past shocks between the oil market and the capital market. Therefore, confirmation of short-term shocks from oil and currency markets, long-term shocks, foreign currency and gold; also cross-sectional shocks of gold on the stock index can confirm the volatility spillover context to the Iran capital market. Since investors' access to two foreign exchange and gold markets is direct, access to the oil market is not possible directly and in line with the business cycle. Therefore, the impact of the oil price volatility is due to the time taken to convert the dollar from the sale of oil to the Rial and turn it into liquidity.

The results from the application of the VARMA_GARCH model provide evidence of volatility spillover resulting from the effect of conditional volatility on stock returns. Among the experimental results obtained from the research literature, one can confirm the existence of a volatility clustering theory and a leverage effect on the stock index, which is showed the McAleer VARMA_GARCH model (2004) can be more effective in adapting the random variables in this regard. Also, as the positive and negative shocks have asymmetric effects on conditional variance (Glosten et al, 1993: Nelson & foster, 1994). The asymmetric spillover volatility among dollar and stock index return means that bad news is more effective than good news between the two markets. The asymmetry feature is an important component in creating financial contagion.

The results of this study are important from the point of view of application for fundamental analysts and investment institutions in the field of portfolio risk management. In addition comprehensive and accurate explanation of the relations between the capital market and the three strategic markets should be considered in the macroeconomic policy makers as well as the capital market authorities.

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