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EFFECT OF STOCK INDEX FUTURES ON SPOT MARKET BASED ON NOISY FINANCIAL TIME SERIES ANALYSIS

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Abstract. *While much research has been done on the impact of futures trading on the volatility of the stock market, little is interested in the relationship between information flows and volatility on the introduction of futures trading. The objective of this study is to consider the impact of futures trading on information efficiency of stock market. Several cases of stock indices were empirically examined. The application of GJR-GARCH model in time series analysis would help to find a comprehensive solution of the objective in this study. By using Wald tests to compare the structural changes of volatility in pre-futures and post-futures, our results suggest that the introduction of futures has improved information efficiency flowing to the spot market.*
Keywords: Futures trading, Information efficiency, Stock market, Volatility

1. **Introduction.** A long and fierce debate on the issue of financial derivatives trading on financial markets has received considerable attention in recent years, particularly after the financial crash in 2008. The problem what policymakers worried about is whether futures trading may impact positively or negatively on the operation of the underlying spot market. Therefore, it is necessary to analyze the effect of stock index futures on spot market volatility in detail. To measure the impacts of futures on spot market volatility and trading efficiency, Bae et al. empirically apply an event study approach and find that the introduction of KOSPI 200 index futures trading is associated with greater market efficiency with greater volatility in the underlying stock market [1]. Shastri et al. examine whether stock futures contribute to their underlying stocks and find that the quality of the stock market improves substantially after the introduction of futures [2]. Floros and Vougas employ econometric models to discuss the causal relationship between spot and futures markets [3]. The results show that futures markets play a price discovery role, implying that futures prices contain useful information about spot prices and futures markets are more efficient than underlying stock markets. Debasish utilizes the dynamic linear regression model and GARCH models to investigate volatility in NSE Nifty prices both before and after the onset of futures trading [4]. The results imply that futures markets serve their prescribed role of improving pricing efficiency and improve the quality of information flowing to spot markets. Das and Mishra employ GARCH model to examine the impact of index futures trading on the volatility of the index [5]. There is an evidence that the volatility has decreased significantly after the introduction of the index futures. Gahlot and Datta use EGARCH model to capture the asymmetric nature of the volatility and find that bad news has greater impact on the volatility [6]. Yang et al. investigate intraday price discovery and volatility transmission between Chinese stock index and the newly established stock index futures markets in China, and find that the cash market plays a more dominant role in the price discovery process [7]. Mahmoud et al. use approximate entropy to test the presence of bubbles in the Tunisian and French

markets [8]. Lee et al. reveal that futures trading has improved the speed and qualify of information flowing to the spot market [9].

However, all of these references fail to make explicitly the connection between information and volatility following the advent of futures. As is different from them, this paper considers the relationship between information flows and volatility associated with the onset of futures trading. Several global representative stock indices are examined by using the advanced Generalized Autoregressive Conditional Heteroskedasticity (GARCH) named GJR approach. The model decomposes the volatility factors into four terms, including original systematic uncertainties, the impact of recent market-specific news, the impact of old news relating to days prior to the previous day, and asymmetric response. By using Wald tests to compare the structural changes of volatility in pre-futures and post-futures, an important connection is set up that any change in the recent and old information flow will change the volatility of the underlying spot market. The conclusion is that greater impact of recent news and less persistent of information improve the efficiency of the spot markets after the advent of futures trading.

A detailed analysis is available and the rest contents proceed as follows. In Section 2, we describe the GJR-GARCH model that allows for the estimation of the volatility of the stock market. Section 3 presents an elaborate discussion on the evidences from S&P 500, Nikkei 225, HSI and BSE Sensex, including illustrations of the volatility features and the empirical results. Finally, Section 4 comments on our results and offers some concluding remarks.

2. Model Specification.

An appropriate way to capture the time varying nature of volatility is to model the conditional variance as a GARCH process. The GARCH (p, q) process is given by

$$\varepsilon_t|\Psi_{t-1} \sim \mathrm{N}(0, h_t) \tag{1}$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \tag{2}$$

where ε_t denotes a real-valued discrete-time stochastic process, Ψ_t is the information set of all information through time t, ω is the constant term, α is the parameter for the ε_{t-i}^2, and β is the parameter for the h_{t-j}, h_t is the conditional variance since it is a multi-period ahead estimate for the variance calculated based on any past relevant information. Using the GARCH model, it is possible to interpret the current fitted variance h_t. Then, GARCH $(1, 1)$ formula is

$$h_t = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \tag{3}$$

It is widely applied to empirical studies as it can capture important characteristics of the high frequency time series data. The most interesting feature not addressed by this model is asymmetric effect. This effect occurs when a negative shock (bad news) to financial time series is likely to cause volatility to rise by more than a positive shock (good news) of the same magnitude. One popular asymmetric formulation is explained below: the GJR model, named after the authors Glosten, Jagannathan and Runkle. The GJR model is a simple extension of GARCH with an additional term added to account for possible asymmetries. The conditional variance is expressed in this form:

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} + \gamma \mathrm{I}_{t-1} \varepsilon_{t-1}^2 \tag{4}$$

where ω is the constant term, α is the parameter for the ε_{t-1}^2, β is the parameter for the h_{t-1}, and γ is the parameter for the $\mathrm{I}_{t-1}\varepsilon_{t-1}^2$ term in the GJR variance equation where I_{t-1} takes a value of 1 when ε_{t-1} is negative and a value of 0 when ε_{t-1} is positive or zero. The shape of the above GJR news impact curve is indicative of cases with $\omega > 0$, $0 <= \beta < 1$, $0 <= \alpha < 1$, $\gamma > 0$, and $\alpha + \gamma < 1$. The detailed explanations are as follows. h_t is decomposed into four terms.

(1) ω is the long-term average value, indicating original systematic uncertainties.

(2) $\alpha\varepsilon_{t-1}^2$ is the lagged error term relating to the impact of recent market-specific news, i.e., information about volatility during the recent period. Hence, α can be viewed as a "news" coefficient, with a higher value implying that recent news has a greater impact on price changes. The increase in α post-futures suggests that information is being impounded in prices more quickly due to the introduction of futures trading.

(3) βh_{t-1} is the fitted and lagged variance term which reflects the impact of old news relating to days prior to the previous day. β is the coefficient on the lagged variance term and thus to news which arrived before yesterday. The increase in the rate of information flows to be anticipated from the onset of futures trading is expected to lead to a reduction in uncertainty regarding previous news. This in turn will lead to a fall in the persistence of information. In other words, "old news" will have less impact on today's price changes.

(4) $\gamma \mathrm{I}_{t-1}\varepsilon_{t-1}^2$ is the asymmetric response, i.e., the leverage effects exist while the negative return shocks cause higher volatility than positive return shocks and it implies how volatility rose more after a large negative shock than a large positive one.

3. **Empirical Analysis.** The data include daily figures for the price and return series of four stock indices. Figure 1 illustrates the volatility features of S&P 500 index and its return series before and after the introduction of futures trading. Figure 2 illustrates the volatility features of Nikkei index and its return series pre-futures and post-futures. Figure 3 depicts the volatility features of HSI and its return series in two sub-periods. Figure 4 illustrates the volatility features of Sensex index and its return series in two periods.

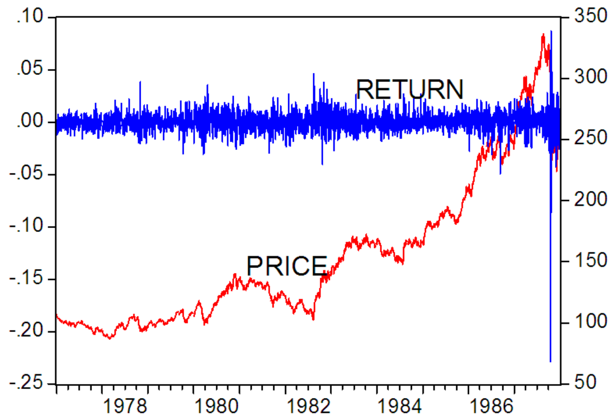

Figure 1. Series of S&P 500

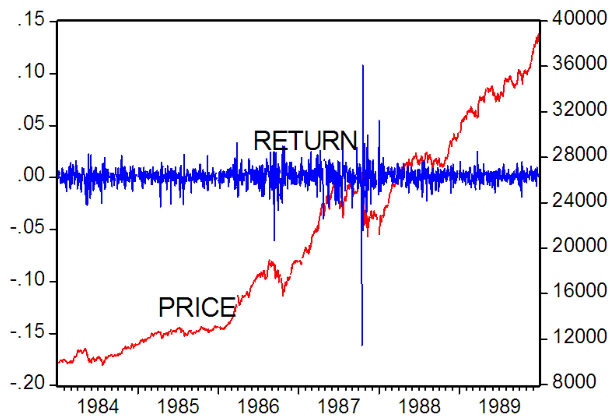

Figure 2. Series of Nikkei 225

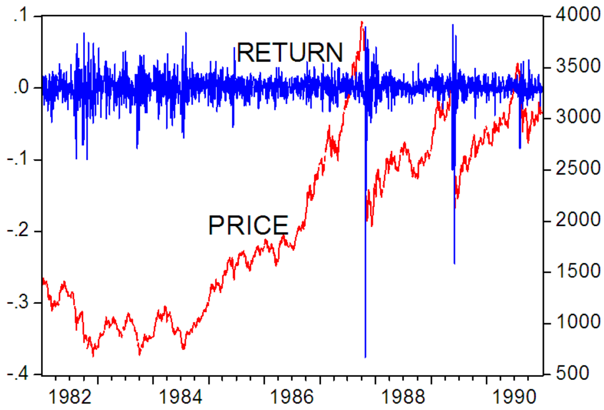

Figure 3. Series of HSI

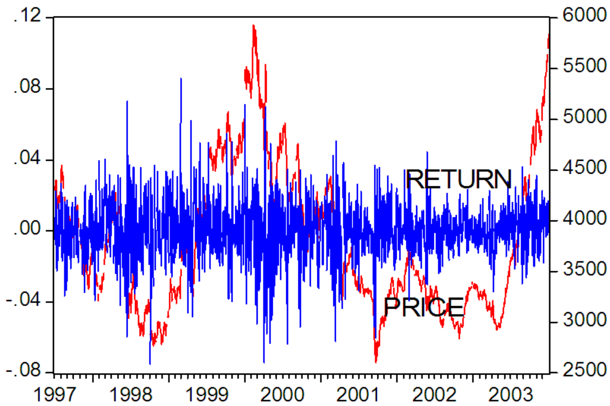

Figure 4. Series of Sensex

By establishing GJR $(1, 1)$ model on return series of all four stock indices, coefficients were estimated using the software of Eviews 5.0. The empirical results were collected in Table 1.

As already explained in Section 2, volatility factors were decomposed into four terms whose weights are now calculated on the long run average, the impact of recent market-specific news (the symmetric news), the impact of old news (the previous forecast), and asymmetric response (the negative news). Almost each coefficient was statistical significant and was satisfied with the constraint conditions of the GJR model. As shown in Table 1, all the coefficients were different from the ones pre-futures. It is possible that there exist effects of futures on the volatility of spot market.

Even though the coefficients are different between the two sub-periods, there needs to be a test which suggests that there has been a structural change in the two sub-periods. A Wald test could be used to test that. The Wald test is a way of testing the significance of particular explanatory variables in a statistical model. If a structural break is suggested it will consolidate the results and we can say that there is indeed a difference emerging due to futures trading. However, if the test suggests that the difference between the two is not significant, then it might not suggest that futures indeed have an effect on the spot. So this test is important to be performed to authenticate the validity of the objective in this paper. In principle, it is possible to proceed by specifying the restrictions $\alpha_{\text{post}} - \alpha_{\text{pre}} = 0$, $\beta_{\text{post}} - \beta_{\text{pre}} = 0$, $\gamma_{\text{post}} - \gamma_{\text{pre}} = 0$ in the Wald test option.

As indicated in Table 2, α_{post} is the coefficient relating to the lagged squared error term in post-futures while α_{pre} is the coefficient relating to the lagged squared error term in pre-futures. It is same to β_{post} and β_{pre}, γ_{post} and γ_{pre}. The software used in this test is Eviews 5.0. It is shown that the restriction is rejected at conventional significance level in

Table 1. Coefficient estimate results on S&P 500, Nikkei 225, HSI and BSE Sensex

Index	Periods	Coefficient	Estimation	StdError	z-Statistic	Prob.
S&P 500	Pre-futures 1/03/1977 -4/21/1982	ω_{pre}	8.75E-07	3.29E-07	2.658499	0.0078
		α_{pre}	0.021769	0.010939	1.990005	0.0466
		β_{pre}	0.948563	0.010704	88.61548	0.0000
		γ_{pre}	0.033322	0.012314	2.705926	0.0068
	Post-futures 4/22/1982 -12/31/1987	ω_{post}	5.25E-06	1.04E-06	5.047270	0.0000
		α_{post}	0.057295	0.01334	4.295059	0.0000
		β_{post}	0.829663	0.01534	54.08518	0.0000
		γ_{post}	0.144065	0.014515	9.925451	0.0000
Nikkei 225	Pre-futures 1/04/1984 -9/03/1986	ω_{pre}	6.99E-06	1.76E-06	3.974837	0.0001
		α_{pre}	0.095781	0.03148	3.042575	0.0023
		β_{pre}	0.726403	0.053246	13.64243	0.0000
		γ_{pre}	0.096535	0.043213	2.233931	0.0255
	Post-futures 9/04/1986 -12/29/1989	ω_{post}	1.32E-05	1.65E-06	8.018934	0.0000
		α_{post}	0.014713	0.025466	0.577774	0.5634
		β_{post}	0.579622	0.026841	21.59503	0.0000
		γ_{post}	0.698528	0.041379	16.88103	0.0000
HSI	Pre-futures 1/04/1982 -5/06/1986	ω_{pre}	1.27E-05	2.55E-06	4.980356	0.0000
		α_{pre}	0.040494	0.014908	2.716275	0.0066
		β_{pre}	0.869464	0.015707	55.35507	0.0000
		γ_{pre}	0.100754	0.019796	5.089711	0.0000
	Post-futures 5/07/1986 -12/31/1990	ω_{post}	1.82E-05	2.39E-06	7.629219	0.0000
		α_{post}	0.127244	0.032429	3.923725	0.0001
		β_{post}	0.610948	0.006911	88.39594	0.0000
		γ_{post}	0.787551	0.040412	19.48822	0.0000
BSE Sensex	Pre-futures 7/01/1997 -6/09/2000	ω_{pre}	3.56E-05	9.81E-06	3.628477	0.0003
		α_{pre}	0.002338	0.016699	0.140024	0.8886
		β_{pre}	0.837672	0.038727	21.63023	0.0000
		γ_{pre}	0.126867	0.038903	3.261081	0.0011
	Post-futures 6/10/2000 -5/13/2003	ω_{post}	1.88E-05	4.26E-06	4.411568	0.0000
		α_{post}	0.059156	0.029597	1.998745	0.0456
		β_{post}	0.742666	0.042971	17.28311	0.0000
		γ_{post}	0.200369	0.045926	4.362860	0.0000

most cases. Accordingly, it is quite obvious that the impact of information on volatility is much greater and less persistent post-futures. The introduction of futures trading leads to an increase in the flow rate of information to the underlying spot market. Although the spot market may be more volatile post-futures, the efficiency of the stock market is improved owing to the advent of futures trading.

4. **Conclusions.** The outcome of detailed analysis can be summarized as follows. First, all the four coefficients are proved significantly different between post-futures and pre-futures by the Wald test. It implies that there exist effects of futures on the volatility of spot market. Second, the increase of α post-futures in most cases, implying that recent news which is attributable to market factors has a greater impact on the spot market following the onset of futures. Thus, information is being transmitted in prices more quickly since the onset of futures trading. Third, the fall of β post-futures suggests reduction in uncertainty regarding pervious news and less persistent of old information

TABLE 2. Wald tests on coefficients in two sub-periods

Index	Null Hypothesis	Wald Test			
		F-statistic		Chi-square	
		Value	Prob.	Value	Prob.
S&P 500	$\alpha_{\text{post}} = \alpha_{\text{pre}}$, $\beta_{\text{post}} = \beta_{\text{pre}}$, $\gamma_{\text{post}} = \gamma_{\text{pre}}$	90.35393	0.0000	271.0618	0.0000
	$\alpha_{\text{post}} = \alpha_{\text{pre}}$	7.092409	0.0078	7.092409	0.0077
	$\beta_{\text{post}} = \beta_{\text{pre}}$	60.07866	0.0000	60.07866	0.0000
	$\gamma_{\text{post}} = \gamma_{\text{pre}}$	58.21242	0.0000	58.21242	0.0000
Nikkei 225	$\alpha_{\text{post}} = \alpha_{\text{pre}}$, $\beta_{\text{post}} = \beta_{\text{pre}}$, $\gamma_{\text{post}} = \gamma_{\text{pre}}$	89.87948	0.0000	269.6384	0.0000
	$\alpha_{\text{post}} = \alpha_{\text{pre}}$	10.13418	0.0015	10.13418	0.0015
	$\beta_{\text{post}} = \beta_{\text{pre}}$	29.90593	0.0000	29.90593	0.0000
	$\gamma_{\text{post}} = \gamma_{\text{pre}}$	211.6475	0.0000	211.6475	0.0000
HSI	$\alpha_{\text{post}} = \alpha_{\text{pre}}$, $\beta_{\text{post}} = \beta_{\text{pre}}$, $\gamma_{\text{post}} = \gamma_{\text{pre}}$	529.9476	0.0000	1589.843	0.0000
	$\alpha_{\text{post}} = \alpha_{\text{pre}}$	7.155842	0.0076	7.155842	0.0075
	$\beta_{\text{post}} = \beta_{\text{pre}}$	1399.044	0.0000	1399.044	0.0000
	$\gamma_{\text{post}} = \gamma_{\text{pre}}$	288.8309	0.0000	288.8309	0.0000
BSE Sensex	$\alpha_{\text{post}} = \alpha_{\text{pre}}$, $\beta_{\text{post}} = \beta_{\text{pre}}$, $\gamma_{\text{post}} = \gamma_{\text{pre}}$	3.021381	0.0291	9.064142	0.0285
	$\alpha_{\text{post}} = \alpha_{\text{pre}}$	3.685437	0.0553	3.685437	0.0549
	$\beta_{\text{post}} = \beta_{\text{pre}}$	4.888265	0.0274	4.888265	0.0270
	$\gamma_{\text{post}} = \gamma_{\text{pre}}$	2.561393	0.1099	2.561393	0.1095

after the advent of futures trading. Finally, the asymmetry response, γ, proves that there exists leverage effect of the information arrival on the volatility.

In conclusion, no matter whether futures trading could increase or decrease the volatility of the underlying spot markets, the efficiency of the stock market is improved owing to the introduction of futures trading. Futures trading can increase the channels through which information is transmitted into prices of the stock market. The investigations of this paper provide no empirical support for policy makers that attempt to curtail trading in pursuit of market stability. From a policymaker perspective, the financial authorities who are hesitate to make a new attempt to the launch of stock index futures should firstly complete basic system and technical preparations for this, and then learn from the corresponding experiences of the mature markets and the emerging markets. This study, however, applies traditional econometric methods to modeling the relationship between information flows and volatility on the introduction of futures trading. Recently some new developed statistic quantification measures of information efficiency in time series data is prior to traditional statistical examination. Further research using the approximate entropy theory to examine the impact of futures trading on information efficiency of stock market would be interesting.

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