Impacts of Derivative Markets on Spot Market Volatility and their Persistence

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Abstract: In this article, we investigate the impacts of futures and options markets on the volatility of the underlying market. Unlike earlier studies, focus is given to their persistence over time. Tests on Hang Seng Index yield several interesting results that often contrast with previous findings. Empirical results suggest that the quality of new information generated by derivatives trading determines the impacts on the spot market volatility. Futures market provides new, material information reducing spot market volatility. Options market, on the other hand, generates noisy information and distorts price, which is followed by increase in volatility and decrease in its sensitivity to price change. While the impact by futures persists, that of options mostly disappears as the market matures. Our conjecture is that futures market is mainly driven by informed, experienced participants, while options market attracts new, inexperienced investors.

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1 Introduction

There has been a long debate over the impact of futures market on its underlying market. Futures market is generally believed to attract more traders

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and increase information flow,[1] but how this increased information affects the volatility of the spot market is inconclusive. Those who support stabilising function of futures market hypothesise that speculators and market makers enhance efficiency and liquidity of spot market, and therefore reduce price volatility. Grossman and Miller (1988), for example, argue that market makers in futures market stabilise spot market by providing liquidity. Empirical studies supporting this hypothesis include Edwards (1988), Seguin and Bessembinder (1992), Bologna and Cavallo (2002), Thenmozhi (2002), and Bandivadekar and Ghosh (2004).

On the other hand, another group of researchers claim that futures market can increase the volatility of spot market. Stein (1987) argues that futures market improves risk sharing and increases liquidity by introducing new speculators, but spot price can become noisier if these new speculators are less informed than the traders already in the market. Ross (1989) shows that the variance of price change should be equal to the variance of information flow in an arbitrage free economy. According to Ross (1989), if futures market does increase information flow, the volatility of spot market should increase following inception of futures market. Studies that find increase in spot market volatility due to futures trading include Harris (1989), Jagadeesh and Subrahmanyam (1993), Antoniou and Holmes (1995), Gregory and Tucker (1996), and Sakthivel (2002).

Many studies find no evidence for any discernible change in the volatility of spot market: Froewiss (1978), Simpson and Ireland (1982), Becketti and Roberts (1990), Hodgson and Nicholls (1991), and Kamara *et al.* (1992), to list a few. Others obtain mixed results in their studies. For example, Lee and Oak (1992) test several markets using a multivariate GARCH model and find increase in the volatility in the USA, the UK, and Japan, no change in Australia, and decrease in Hong Kong. Shang (2001) also examines multinational effects. He reports that the volatility of stock returns in the USA, France, and Australia increased sharply in the post-introduction periods. However, no evidence showed that there was any fluctuation in the Hong Kong and UK markets. Siopis and Lyroudi (2007) employ different GARCH models in their study of Athens stock exchange. They observe a significant change of volatility after the introduction of futures market but the direction of change is inconsistent among different GARCH models.

Contrary to the abundant research on futures market, study of the impact of options market on spot market volatility has been rare. One reason is perhaps because options market is known to be lagged behind spot market. See Stephan and Whaley (1990), for example. However, being lagged does not necessarily imply that it should have no impact on the spot market. One related research is carried out by Fedenia and Grammatikos (1992). They find that risk hedging by market makers using options reduces the bid-ask

[1]See Cox (1976), for example.

spread of spot price and lowers its volatility. On the other hand, Wei *et al.* (1997) reports an increase in volatility after the opening of an options market in their investigation of the US over-the-counter (OTC) stocks. Bollen (1998) finds no evidence of volatility change due to introduction of options market.

Previous researches only focus on the impacts of the derivative markets on the underlying market and does not look into persistence of those impacts. One hypothesis that could be made regarding persistence of the impacts is that a derivative market, at its earlier stage, is immature and has only limited impact on the spot market. Another plausible scenario is that many inexperienced investors, attracted by low transaction cost and leverage of the derivative market, enter the market when it is first introduced. These investors disturb the spot market and distort its price, therefore obscuring material information already contained in the price. Under the first scenario, derivative market will have little or no impact on the spot market in the early period, but its influence will become more evident as the market matures. According to the second scenario, derivative market will increase uncertainty in the spot price and raise the level of volatility in the early period. This initial unrest then gradually cool down over time as those inexperienced traders are either dropped out or "experienced", and the market becomes more efficient.

The aim of this article is to revisit the subject, the impacts of derivative markets on the volatility of spot market, and addresses the unanswered or not clearly answered questions raised above by employing new methods. More specifically, this study adds value onto previous studies through the following distinguished works. First, the impacts of both futures and options markets of Hang Seng Index (HSI) on the spot market volatility are investigated. The Hong Kong market, covered by more influential markets such as the US market, has not received much attention, although it has grown rapidly and become important as it acts as a gate to the Chinese market for international investors. To the best of our knowledge, there are only few researches on the impact of HSI futures and none on HSI options. Indeed, research on the impact of options market is hardly found even for bigger markets. Secondly, the post-opening period of each derivative market is divided into two sub-periods—pre-maturity and post-maturity, in order to assess the effect of maturation of the market on the persistence of impacts. As demonstrated in the next section, this analysis reveals new findings that are not previously captured. The findings in this research suggest new insights on the impacts of the derivative markets on the underlying market and the cause of the impacts, and question some of the conclusions made in earlier researches.

The rest of the article is organised as follows. In Section 2, the data and the methodology employed for empirical study are described. Then, empirical results from the futures market are presented, which is followed

by empirical results from the options market. The implications of the results from both markets are analysed at the end of the section. Concluding remarks and suggestions are offered in Section 3.

2 Empirical Studies

2.1 THE DATA AND THE MODEL

The Hong Kong Stock Exchange was established on November 24th 1969. Hang Seng Index (HSI), a market capitalisation-weighted index, is a representative index of the market. The futures market for HSI opened on May 6th 1986, and the options market on March 1st 1993.

The impacts of derivative markets are tested using ten year data around the introduction of each market: Daily closing price of HSI is collected from May 4th 1981 to May 1st 1991 for futures and from March 2nd 1988 to February 27th 1998 for options. The proxy variable—to be illustrated below—MSCI World Index is also collected during the same periods. Both indexes are obtained from Thomson Reuters Datastream.

A GARCH model is employed for the volatility time series estimation. GARCH model is a favoured method for this study because it focuses on the heteroscedasticity of the data. After repeated tests, GARCH(1,1) of the following form is chosen.

$$\begin{aligned} r_t &= a_0 + a_1 r_{Mt} + e_t, \quad e_t|\psi_{t-1} \sim N(0, h_t) \\ h_t &= \alpha_0 + \alpha_1 e_{t-1}^2 + \beta_1 h_{t-1} + \gamma DF. \end{aligned} \tag{1}$$

where r_t and r_{Mt} are return on HSI and return on the proxy variable, respectively, and DF is a dummy variable which has value 1 from the inception of the derivative market in concern. Returns are defined as log return.

Obviously, there are other factors but derivatives trading that affect the volatility of spot price, and it is critical to eliminate the effects caused by those factors in order to evaluate the effects caused solely by derivatives trading. This can be done by adding a proxy variable in the mean equation that captures market wide variation but is free from impacts caused by derivative markets. Antoniou and Holmes (1995) use Unlisted Securities Market (USM) index as a proxy in their study for FTSE100. USM consists of the shares which do not meet the normal requirements and cannot be placed in the main stock exchange. Growth Enterprise Market (GEM) index, a Hong Kong version of USM index, could serve well as a proxy for this study. However, it turns out to be unsuitable as it is available only from March 2000. Alternatively, a proxy that captures global economic trend is considered. Three candidates, S&P500, MSCI World Index (MSCIWRLD), and MSCI Pacific Index (MSCIPCF), are compared and MSCIWRLD is adopted based on its highest R-squared value (0.81) when regressed against

HSI. Figure 1 displays the time series of HSI and MSCIWRLD during the sample period.

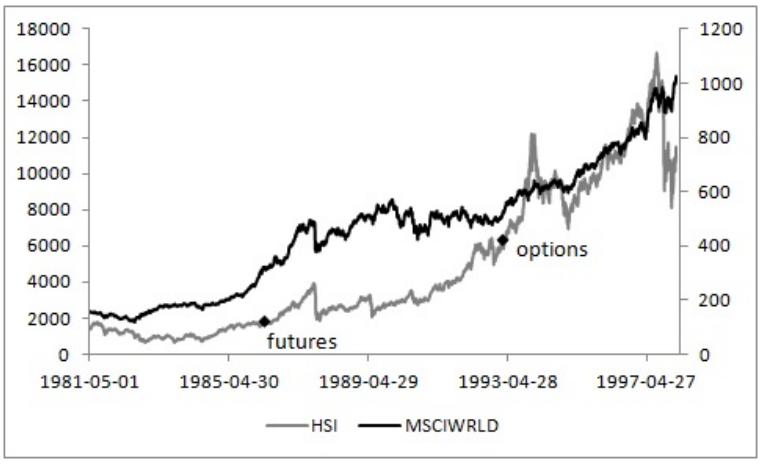

Figure 1: Hang Seng Index (HSI) and MSCI World Index (MSCIWRLD) time series during May 4th 1981 to February 27th 1998.

2.2 IMPACTS OF FUTURES MARKET

The impact of the futures market on the volatility of HSI is first discussed. Sample mean and variance of HSI and MSCIWRLD are calculated in each period and reported in Table 1. In the first column of the table, Whole Period, Pre-Opening, Post-Opening, Pre-Maturity, and Post-Maturity respectively refer to ten year around the inception of the market, five year before the inception, five year after the inception, the period between the inception and the maturity of the market (defined below), and the rest of the sample period after the maturity. The variances of both indexes increase in the post-opening period. As you can see from the sub-periods, this is mainly due to the 1987 market crash. As the variance of HSI and that of MSCIWRLD move in the same direction in all periods, weather the introduction of futures market increases or decreases the volatility cannot be inferred from these values.

Regression results of Equation (1) are reported in Table 2. The second column presents the regression result without the proxy variable in the mean equation and the third column is the result with the proxy variable. In both results, the coefficient of the dummy variable, γ, is negative and significant indicating that the futures market reduces the volatility of the spot market. This is consistent with the finding of Lee and Oak (1992), who also observe reduced volatility in the Hong Kong market. To examine the cause of this volatility shift, separate regressions are run on the periods prior to and post introduction of the futures market. The results are reported in the third

and the fourth columns of Table 2. α_1 increases from 0.131 to 0.239, and β_1 decreases from 0.832 to 0.788 after the futures market is introduced. This implies that the latest price change has a greater impact on the volatility of the spot market in the post-opening period. This result is a contrast to the result of Antoniou and Holmes (1995), who report increase in α_1 and decrease in β_1 associated with increased volatility. Their interpretation is, based on the theoretical work of Ross (1989), that futures trading results in increased information content in the price, which in turn increases the volatility of the spot market. The contrasting result in this study can be viewed as a signal that either greater influence of the latest price change on volatility does not necessarily mean more information content in the price or the hypothesis that increase in information flow results in higher volatility is not valid. This will be further discussed later in this section with the results from the options.

Table 1: Sample mean and variance of Hang Seng Index (HSI) and MSCI World Index (MSCIWRLD) during the periods around the opening of the HSI futures market. Pre-Opening: 5 years before the opening date (May 6th 1986) of the futures market, Post-Opening: 5 years after the opening date, Pre-Maturity: from the opening date to market maturity date (assumed as January 18th 1988), Post-Maturity: from the maturity date to the end of the sample period.

Period		N	HSI		MSCIWRLD	
			Mean	STD	Mean	STD
Whole Period	1981-1991	2608	0.00036	0.01889	0.00045	0.00806
Pre-Opening	1981-1986	1306	0.00019	0.01860	0.00054	0.00678
Post-Opening	1986-1991	1302	0.00052	0.01918	0.00037	0.00916
Pre-Maturity	1986-1988	444	0.00062	0.02500	0.00052	0.01130
Post-Maturity	1988-1991	858	0.00047	0.01534	0.00029	0.00784

The futures market could be immature in the early period of its opening. There may be insufficient trading volume to have a significant effect on the underlying market, or many uninformed, inexperienced traders enter the market and act against market efficiency. If any of these were the case, the futures market would show different impacts on the underlying market as it matures. The effect of market maturation is examined by adding another dummy variable that divides the post-opening period into pre- and post-maturity periods. Maturity of a market could be defined as the time when average trading volume reaches a certain level and remains stable. Unfortunately, this definition of maturity cannot be applied since the trading volume of HSI futures is available only from January 18th 1988. We measured trends in moving average of trading volume using different sample

Table 2: GARCH(1,1) estimation results with samples around the opening of the HSI futures market. Parameters are defined in Equation (1), and periods are described in Table 1. Whole Period1(2) represents regression results without(with) the proxy variable.

	Whole Period1	Whole Period2	Pre-Opening	Post-Opening
a_0	1.59E-3	6.90E-4	5.41E-4	7.40E-4
	(0.000)	(0.003)	(0.238)	(0.004)
a_1		0.649	0.390	0.702
		(0.000)	(0.000)	(0.000)
α_0	1.14E-5	1.37E-5	1.41E-5	5.14E-6
	(0.000)	(0.000)	(0.000)	(0.000)
α_1	0.197	0.197	0.131	0.239
	(0.000)	(0.000)	(0.000)	(0.000)
β_1	0.806	0.795	0.832	0.788
	(0.000)	(0.000)	(0.000)	(0.000)
γ	-4.17E-6	-6.88E-6		
	(0.002)	(0.000)		
R^2	-0.004	0.070	0.025	0.118

periods but could not find any stabilising pattern since this date, which implies that the market had been matured before this date. We tested different maturation periods around January 18th 1988, which is about 20 months from the market inception, and, though not reported here, obtained qualitatively similar results from all cases. Therefore we simply choose January 18th 1988 to divide the post-opening period into pre-maturity and post-maturity periods. This choice of maturity date has an effect of eliminating the impact of the 1987 market crash from the post-maturity period, even though the market crash, when tested using a dummy, does not alter the overall results considerably. The results are reported in Table 3. When the maturity dummy, δ, is present, the futures dummy, γ, is no longer significant. Both γ and δ are negative and their sum (-8.37E-6) is larger in magnitude than γ (-6.88E-6) without the maturity dummy. This indicates that volatility is reduced further in the post-maturity period. This is confirmed by the result of the regression run without pre-maturity period (last column of Table 3). It is also notable that even though the pre-maturity period contains the 1987 market crash and the overall variance is larger than other periods, γ, though insignificant, has a negative value. One might think that this is merely because the Hong Kong stock market has become more integrated with the global market. However, as demonstrated in the test for the options market, this may not be the case. Another remarkable,

and more important result is the change in the values of α_1 and β_1 in each period: α_1 increases after the inception of the futures market, and then returns almost to its pre-opening level in the post-maturity period, while β_1 decreases and then returns almost to its pre-opening level. This means the latest price change or new information embedded in the price has a greater impact on the volatility in the earlier period of the futures market, but this structural change of volatility dynamics incurred by the introduction of the futures market does not persist in the long term. Nevertheless, the level of volatility remains low, in fact, becomes lower after the futures market matures. This suggests that the degree of influence of the latest price change on the volatility, measured by α_1, cannot explain the volatility shift adequately. α_1 should be interpreted as a measure of "volatility of volatility" but not a determinant of "level of volatility".

Table 3: GARCH(1,1) estimation results with samples around the opening of the HSI futures market, with consideration of market maturation. Parameters are defined in Equation (1), and periods are described in Table 1. The last column is a regression result without pre-maturity period.

	Whole Period	Pre-Opening	Post-Opening	Post-Maturity	No Pre-Maturity
a_0	6.81E-4	5.41E-4	1.56E-3	6.32E-4	6.09E-4
	(0.003)	(0.238)	(0.015)	(0.036)	(0.018)
a_1	0.645	0.390	0.787	0.609	0.545
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α_0	1.46E-5	1.41E-5	1.05E-5	6.02E-6	1.52E-5
	(0.000)	(0.000)	(0.027)	(0.000)	(0.000)
α_1	0.195	0.131	0.321	0.162	0.146
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_1	0.791	0.832	0.736	0.813	0.817
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
γ	-2.84E-6				
	(0.239)				
δ	-5.53E-6				-8.66E-6
	(0.007)				(0.000)
R^2	0.070	0.025	0.139	0.091	

2.3 IMPACTS OF OPTIONS MARKET

The same regression analyses are conducted during the periods around the inception of the HSI options market, with dummy variables indicating the introduction of the options market and its maturity. The results are reported in Table 4, 5, and 6.

With the widely accepted view that options market is lagged behind the spot market, one might expect that introduction of options should not have any material impact on the underlying market volatility. At first glance, the results seem to contrast with this hypothesis. If you compare the variance of HSI with that of MSCIWRLD reported in Table 4, the variance of HSI increases after the options market opens, while that of MSCIWRLD decreases. This indicates that the options market might increase the volatility of the spot market. The results in Table 5 also support this view: the options market appears to increase the underlying market volatility with γ being positive (1.41E-6) and significant at 5% level. The changes of α_1 (0.150 to 0.088) and β_1 (0.799 to 0.906) indicate a structural shift of volatility dynamics since the inception of the options market. Volatility becomes more persistent and less sensitive to the latest price change. This is opposite to what we observe in the futures market; decreased volatility associated with increased α_1 and decreased β_1. If a maturity dummy is added, however, this seemingly evident impact almost entirely disappears after the options market becomes mature. α_1 returns almost to its pre-opening level (from 0.150 to 0.050 and back to 0.135) and β_1, though at a lesser degree, also returns toward its pre-opening level (from 0.799 to 0.937 and back to 0.856). At the same time, the two dummy variables, γ (6.69E-6) and δ (-6.70E-6) sum to 0, which means the options market is no longer influential to the spot market volatility. These results combined together suggest that when the options market is first introduced, the level of the spot market volatility rises, while its sensitivity to recent price change is reduced, but both the level of volatility and its sensitivity to price change are reversed to their normal level as the market matures. An exposition for this would be that the options market, with low transaction cost and leverage, attracts new, uninformed, and inexperienced investors. These investors, rather than providing additional information, distort the price and obscure the information content in the price. The market (its volatility), recognising this, reacts less responsively to the latest price change. Also, since the market will bear more uncertainty, the overall level of volatility will rise. This structural change of volatility, however, is eased as the options market matures and becomes more efficient. Therefore, the impact of the options market on the spot market volatility eventually disappears.

Putting all together, the results can be summarised by the points:

- Increase in the spot market volatility is associated with decrease in its sensitivity to the latest price change, and *vice versa*.
- Introduction of futures market reduces spot market volatility and increases its sensitivity to price change. Volatility is further reduced as the market matures.
- Introduction of options market increases spot market volatility and

Table 4: Sample mean and variance of Hang Seng Index (HSI) and MSCI World Index (MSCIWRLD) during the periods around the opening of the HSI options market. Pre-Opening: 5 years before the opening date (March 1st 1993) of the options market, Post-Opening: 5 years after the opening date, Pre-Maturity: from the opening date to market maturity date (assumed as March 1st 1995), Post-Maturity: from the maturity date to the end of the sample period.

Period		N	HSI		MSCIWRLD	
			Mean	STD	Mean	STD
Whole Period	1988-1998	2608	0.00059	0.01635	0.00032	0.00668
Pre-Opening	1988-1993	1303	0.00073	0.01449	0.00011	0.00751
Post-Opening	1993-1998	1305	0.00045	0.01801	0.00054	0.00573
Pre-Maturity	1993-1995	522	0.00052	0.01713	0.00037	0.00527
Post-Maturity	1995-1998	783	0.00041	0.01859	0.00065	0.00602

reduces its sensitivity to price change. But this is reversed as the market matures.

And from these findings, the followings are inferred:

- The more is the price driven by new, credible information, the more sensitively does its volatility react to price change. Also, since the market will be more efficient, the overall level of volatility becomes lower. On the other hand, if the price is disturbed by noisy information, the opposite becomes the case.
- Futures market enhances the spot market efficiency and reduces volatility by providing credible information through activities of informed market participants.
- Options market, at its early stage, destabilises the spot market and increases volatility by obscuring the information contained in the price through activities of uninformed, inexperienced traders. This negative effect, however, disappears as the market matures.

3 Concluding Remarks

The impacts of a derivative market on its underlying market volatility have long been under debate. We address this issue from different perspectives in order to assess the roles of derivative markets in the Hong Kong stock market. The Hong Kong stock market, despite its growing importance as a gate to Chinese market for foreign investors, has been widely ignored in the researches of this topic. While previous studies mainly focus on futures

Table 5: GARCH(1,1) estimation results with samples around the opening of the HSI options market. Parameters are defined in Equation (1), and periods are described in Table 4. Whole Period1(2) represents regression results without(with) the proxy variable.

	Whole Period1	Whole Period2	Pre-Opening	Post-Opening
a_0	1.21E-3	7.30E-4	8.96E-4	4.87E-4
	(0.000)	(0.001)	(0.001)	(0.127)
a_1		0.641	0.584	0.827
		(0.000)	(0.000)	(0.000)
α_0	9.75E-6	5.69E-6	8.89E-6	2.57E-6
	(0.000)	(0.000)	(0.000)	(0.001)
α_1	0.144	0.128	0.150	0.088
	(0.000)	(0.000)	(0.000)	(0.000)
β_1	0.818	0.845	0.799	0.906
	(0.000)	(0.000)	(0.000)	(0.000)
γ	8.60E-7	1.41E-6		
	(0.304)	(0.043)		
R^2	-0.001	0.104	0.082	0.138

market, We investigate both futures market and options market, and compare their impacts on the spot market volatility. Also, persistence of these impacts, i.e., weather they weaken or strengthen over time, is examined.

Empirical studies yield several interesting results that often contrast with previous findings. In both markets, reduction in volatility is associated with increase in its sensitivity to the latest price change or news, and *vice versa*. This is a sharp contrast to some of earlier findings; e.g., Antoniou and Holmes (1995) observe increase in volatility associated with increase in sensitivity, which they attribute to increased information flow. Based on the empirical results, We hypothesise that what is important is not the quantity of new information, but rather the quality of new information. If price change is caused more by credible information, it will affect volatility at a greater degree, and as the market will be more efficient, the overall level of volatility will be lower. Under this hypothesis, empirical results suggest that futures market provides new, significant information and reduces spot market volatility. This effect turns out to be persistent, indeed tends to be strengthened as the market matures. Options market, on the contrary, generates noisy information and distorts price, which is then followed by increase in volatility and decrease in its sensitivity to news. This negative impact, however, weakens and mostly disappears as the market matures. We conjecture that the reason for the different impacts of futures and options

Table 6: GARCH(1,1) estimation results with samples around the opening of the HSI options market, with consideration of market maturation. Parameters are defined in Equation (1), and periods are described in Table 4. The last column is a regression result without pre-maturity period.

	Whole Period	Pre-Opening	Post-Opening	Post-Maturity	No Pre-Maturity
a_0	7.41E-4	8.96E-4	2.69E-4	6.19E-4	7.99E-4
	(0.000)	(0.001)	(0.675)	(0.097)	(0.018)
a_1	0.642	0.584	0.998	0.768	0.623
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α_0	6.43E-6	8.89E-6	3.71E-6	3.97E-6	6.69E-6
	(0.000)	(0.000)	(0.112)	(0.000)	(0.000)
α_1	0.130	0.150	0.050	0.135	0.146
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_1	0.836	0.799	0.937	0.856	0.824
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
γ	6.69E-6				-9.95E-7
	(0.000)				(0.990)
δ	-6.70E-6				
	(0.000)				
R^2	0.104	0.082	0.120	0.145	

is because futures market is mainly driven by informed, experienced participants, while options market attracts new, inexperienced investors seeking the jackpot, who is likely to be dropped out or experienced eventually.

The empirical results indicate that increased flow of information due to an introduction of a derivative market does not always lead to a more efficient market and lower volatility: Uninformed traders from the derivative market can add noise to the spot market and increase its volatility. However, this kind of negative impacts on market efficiency seems to be short lived and should not harm the market in the long run.

In this study of Hang Seng Index and its derivatives, contrasting roles of futures and options in determining underlying asset volatility are witnessed. It is also found that the impacts of these derivatives on the spot market volatility change over time. It must be worth revisiting other markets with the methods employed in this study and testing validity of the conclusions made in previous studies.

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