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An Examination of the Maturity Effect in the Indian Commodities Futures Market

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Abstract

This paper has examined the Samuelson's hypothesis which states that the price volatility increases as the contract nears its maturity. It has also examined the BCSS hypothesis which provides that negative covariance between the spot price and net cost of carry explains the maturity effect. The study has examined these hypotheses on the data for wheat and pepper futures contract traded at NCDEX from the date of listing of the contract to 31st March 2007 and the maturity effect has been examined for each contract individually. The study has indicated that maturity effect is present in around 45 per cent of the wheat and pepper contracts. Evidence supporting the BCSS hypothesis is present more strongly in the case of wheat as compared to pepper and 79 per cent of the contracts having maturity effect have depicted negative covariance in the case of wheat. Thus, it can be concluded that maturity effect is present and it is explained to a large extent by the negative co-variance between spot price and net carry cost. The study has observed that there is further scope for research in this area in relation to other agricultural commodities and also metals. Further studies can also be undertaken to find the informational efficiency and the reaction of informational flow to identify the reasons for the presence or absence of maturity effect.

Introduction

Samuelson (1965) proposed a hypothesis called as the 'maturity effect' which deals with the functional relationship between volatility and time to maturity. It states that volatility is a function of time to maturity and due to this the volatility increases as the contract approaches its maturity. He argued that most of the relevant information was revealed when the contract was nearing its maturity. The intuition for this is that not much is known about the future spot price of the underlying asset when there is still a long time to the expiry date and due to this, the future price does not respond significantly to the new information about the commodity coming into the market. As the future contract approaches its maturity, the price must converge to the spot price and therefore, it tends to respond more strongly to new information, which implies that the spot price changes will affect the short-dated contracts more significantly as compared to long-dated contracts. A number of studies have been done

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to examine the volatility term structure in future prices. The reason for such interest in investigating the time pattern of future price volatility is because of the importance of the relationship between time to maturity and volatility in various respects. According to Board and Sutcliffe (1990), this relationship is important for margin setting and the desired margin is set on the basis of future price volatility and specifically, margin is a positive function of price volatility. Variability is important for both the hedgers and speculators. Hedgers adjust the hedge ratio based on the variability in the future prices so as to offset their position in the spot market. Depending upon the positive or negative relationship, the hedgers should choose between futures contract with a short or long time to maturity to minimize the price volatility. Speculators on the other hand, are interested in price volatility in order to identify the profitable opportunities and in the process, provide liquidity to the market. Option pricing has an important input in the form of volatility and the relationship between volatility and maturity should be taken into consideration when pricing options on futures. This

relationship also gives an idea as to whether the market is under-reacting or over-reacting to information. The manner in which the information flows is a key condition for the success of Samuelson hypothesis (1965).

Anderson and Danthine (1983) provided a new interpretation to the maturity effect. The time pattern of future price volatility has been explained by them through state variable hypothesis. According to this hypothesis, it is not the time to expiry which determines the volatility, but the degree to which the uncertainty is revoked on account of the flow of information to the market. Most information flows into the market near the maturity period, leading to a greater extent of volatility and the Samuelson hypothesis becomes operative and therefore, it is a special case. If the information flow resolves the uncertainty at earlier stages of the contract, then the volatility will increase at that stage of the life-cycle of the contract.

Bessembinder *et al.* (1996) have given a new theoretical framework to maturity effect which is popularly called as 'BCSS hypothesis' (based on Bessembinder, Coughenour, Seguin and Smoller) and is an extension of the Samuelson hypothesis. They have tried to identify the key condition which must be present if there is a maturity effect in a futures contract. They have given a futures term structure wherein the maturity effect is more likely to be present in those contracts where the co-variance between spot prices and net carry cost is negative. As the negative co-variance is supposed to hold for real assets and not for financial assets, the Samuelson hypothesis is more likely to hold for commodity futures than financial futures. They were of the opinion that the maturity effect is more likely to be present in commodity futures and found that maturity effect was strongly present in agricultural markets, weakly present in the metals market and was totally absent from financial futures markets. According to this hypothesis, the two conditions, information gets clustered near the delivery dates and future price is an unbiased predictor of delivery date spot price are not necessary preconditions for maturity effect to be present.

In view of the importance and implications of the maturity effect discussed above, this paper has examined the application of Samuelson's hypothesis and BCSS hypothesis in the Indian commodity futures market. The Indian commodity derivatives markets are still evolving, though historically the markets existed as

early as in 1875, which through a number of legislations ceased to function post-independence. India being one of the top five producers in many of the commodities, the government ultimately realizing the need for risk management, permitted the futures trading in commodities and the two prominent exchanges established are: Multi-Commodity Exchange of India (MCX) and National Multi-Commodity and Derivatives Exchange of India (NCDEX). This paper has examined the presence of maturity effect in the case of wheat and pepper traded at NCDEX. India is the second largest producer of wheat in the world and, on an average, produces around 75 million tonnes wheat per year, which is around 12 per cent of the world production. It is grown in the northern belt and the major wheat producing states are: Uttar Pradesh, Haryana and Punjab. Wheat is important from the development perspective since it is the staple diet of millions of people in India. There is a huge demand-supply gap and the demand for wheat is going to increase in future. Pepper is one of the most popular spices in the world. India has the largest area under cultivation for pepper which accounts for 46 per cent of the world area and Kerala accounts for 90 per cent of India's total pepper production. India also happens to be the largest consumer of pepper in the world. Keeping in view the importance of these two commodities in agriculture, the research has been undertaken for these two commodities.

Review of Literature

A number of studies have been carried out on the financial, interest rate and commodity futures markets for the developed countries. Clark (1973) studied the volume and price volatility and proposed the Mixture of Distribution Hypothesis (MDH), which states that trading volume and price volatility are on account of the rate of information arrival in the market. As the information arrival rate is not constant, the price changes tend to be stochastic in nature. This leads to the overall change in price and volume of trade increases on account of the changes in prices and volume within the period. Rutledge (1976) examined four commodities, namely, silver, cocoa, wheat and soybean oil and found that the maturity effect was present only in silver and cocoa. Dusak-Miller (1979) found the presence of maturity effect in live cattle futures contracts. Anderson and Danthine (1983) found that there is no increase in volatility as the time to

maturity approaches and they formulated a state variable hypothesis. Anderson (1985) concluded that future price volatility is better explained by seasonal effects than the maturity effect. Milonas (1986) found the maturity effect to exist in most of the markets examined by him. Kenyon *et al.* (1987) found that volatility in corn, soybean and wheat futures was due to seasonal effect. According to them, the change in information flows is the cause which consequently gets reflected in the form of maturity effect. Barnhill *et al.* (1987) found support for maturity effect in treasury bond futures market.

Khoury and Yourougou (1993) carried out a study on six agricultural commodities in the Canadian markets for a nine year period and found evidence of maturity effect in all the commodities examined by them. Noisy Rational Expectation model of Shalen (1993) attributes the correlation between price volatility and volume to the type of traders, the kind of information these traders possess and the manner in which they act in the futures market. In such a market the uninformed traders misinterpret the position taken by hedgers as a signal of liquidity, who then adjust their position causing volatility in the market.

Galloway and Kolb (1996) found that there was no maturity effect in metals but it was substantially present in agricultural contracts. In the case of financial markets, Grammatikos and Saunders (1986) examined the maturity effect for volume and price volatility for currency futures for the period March 1978 to March 1983 and found strong support in case of volume. Galloway and Kolb (1996) covered a long period from 1969 to 1992 and did not find evidence in support of maturity effect in financial futures. Beaulieu (1998) has examined the maturity effect by replacing basis with the future prices. Basis is defined as the difference between the current spot price and the price of a future contract for a particular commodity and it can be negative or positive and will be different for various contracts based on their different maturity dates. Beaulieu (1998) used the data for two equity indices from September 1985 to December 1991 and each contract of three months was examined individually rather than the traditional method of linking of the various contracts. The study concluded that maturity effect was present as the standard deviation of the basis decreased when the contract approached towards its maturity.

Daigler and Wiley (1999) concluded that the volatility in the financial futures markets increase due to the participation of general investors and decreases due to the participation of traders. This happens because the traders are in a better position to read the market signals as compared to the general public. Chen *et al.* (1999) examined the Nikkei-225 index contracts traded on the Osaka Stock Exchange from November 1988 to June 1996. The study also looked at the hedge ratios in both the scenarios, i.e., with and without the maturity effect. The findings revealed that the volatility in fact decreased as time to maturity decreased and the effectiveness of hedging strategy was dependent upon the maturity and GARCH effects. Hennessy and Wahl (1996) examined volatility in the context of the demand and supply inflexibilities arising out of the decision taken by the producers and suppliers. They carried out the study with an assumption that neither the time to expiry nor the resolution of uncertainty in any way explains the maturity effect. The supply and demand are constrained near the expiry and therefore, the volatility increases. Their findings supported the presence of maturity effect at Chicago Board of Trade. Allen and Cruickshank (2000) examined the maturity effect on the Sydney Futures Exchange, London International Financial Futures & Options Exchange and the Singapore International Monetary Exchange. The data sets were analyzed using regression and fitting the ARCH models. Of the twelve contracts examined, ten had maturity effect and on fitting ARCH models to the data set, seven out of ten contracts which exhibited ARCH effects, also indicated the maturity effect. Chang *et al.* (2000) attributed the increased volatility to increase in the hedging activities of the market participants. Akin (2003) examined eleven types of financial futures contracts spanning over a period of nineteen years using the GARCH framework. She found strong presence of maturity effect in currency futures and a lesser degree of such presence in equity index and interest rate futures. The study also found that volume and open interest played a mixed role for equity index and interest rate futures. The findings of this study are significantly different from the earlier studies and one of the reasons for this could be the extensive data sets used in this study.

Bryant *et al.* (2006) have investigated the causal mechanism which governs the relationship between volume and volatility. They have also investigated the impact of the participation of informed traders on price

volatility. Their empirical findings did not support the theory that price volatility is affected positively or negatively by the kind of traders participating in the market. They have concluded that there are some unidentified causes for volatility in the market. Duong and Kalev (2006) have examined the maturity effect and the presence of negative covariance between spot price and cost of carry for contracts having maturity effect using intra-day commodity prices. They have applied the Jonckhaer-Terpstra test using the data of five commodity futures markets outside the United States. They have found the presence of maturity effect for wheat, bean and soybean markets and overall, the hypothesis was applicable more in case of agriculture than financial futures markets. Their findings also supported the state variable hypothesis and they have concluded that maturity effect may be present even without the assumption of information flow. Daal *et al.* (2006) have used a methodology different from the previous studies and have examined each contract individually. They have used extensive data sets and have examined 6805 futures contracts spread over sixty-one commodities. Their findings do not support the maturity effect and there is a very weak evidence in support of the BCSS hypothesis. The literature is scant in relation to the emerging markets and as far as the Indian markets are concerned, one of the reasons for lack of literature is that the derivatives markets have evolved of late and therefore, the data for longer periods are not available. The only study which specifically deals with maturity effect is of Pati (2006), who has examined the maturity effect on Nifty Index futures traded at NSE. The data used were from January 2002 to December 2005 and methodology adopted the aggregation of data and use of ARMA, ARCH and ARMA-EGARCH models. The findings have indicated the absence of Samuelson's hypothesis in the Indian stock market. The study has concluded that volume and open interest and not time to maturity, determine the extent of volatility.

Methodology

In this study, the methodology followed by Daal *et al.* (2006) was adopted and each contract was examined individually for the maturity effect and for the negative covariance between the spot price and net carry cost. In many academic studies on future prices, the data have been aggregated in order to create a time series by linking the prices of the various

contracts. This methodology often biases the results due to aggregation and extreme regression coefficients. Therefore, to overcome these limitations, each contract was examined individually. The data consisted of the logarithm of the daily settlement prices of wheat and pepper futures contracts at NCDEX. The reason for taking the log differences is that the dispersion of the price level change would change in the same direction as the change in the price level and using percentage changes or log differences would take care of this source of non-stationarity. The period covered is from July, 2004 (the date the trading of wheat futures contract started at NCDEX) to April 2007. In the case of pepper, the period covered is from April 2004 to April 2007. The price relative change was computed as the logarithm of daily prices from previous day ($t-1$) to next day (t), i.e.

$$f_{j,t} = \ln \left(\frac{F_{j,t}}{F_{j,t-1}} \right) \quad \dots(1)$$

where, $F_{j,t}$ was the futures closing price of the contract j on the day t and $F_{j,t-1}$ was the futures closing price of contract j on the day $t-1$.
 $\sigma_{j,t}^2 = \left[\ln \left(\frac{F_{j,t}}{F_{j,t-1}} \right) \right]^2$
 Volatility of the daily price relative was calculated as per Equation (2):

$$\dots(2)$$

where, $\sigma_{j,t}^2$ was the variance of the price relative of the contract j on the day t .

Net carry cost on a daily basis was calculated using Equation (3):

$$C_{j,t} = \frac{\ln(F_{j,t}) - \ln(S_{j,t})}{\tau} \quad \dots(3)$$

where, $C_{j,t}$ was the net carry cost of the contract j on the day t , $\ln(S_{j,t})$ was the spot price on the day t and τ was the time to maturity.

The maturity effect was examined by running the OLS regression for each contract individually, wherein the daily volatility was the dependent variable and time to maturity was the independent variable. The regression equation was:

$$\sigma_{j,t}^2 = \beta_0 + \beta_1 \tau_{j,t} + \varepsilon_t \quad \dots(4)$$

For the BCSS hypothesis, the net carry cost was the dependent variable and spot price was independent variable and the OLS regression performed was:

$$\dots(5)$$

While examining the maturity effect generally the prices in the last month of the contract are not taken as the futures and spot prices tend to converge in the last month of the contract. In this study, the analysis has been done excluding the prices for the last month of the contract and by including the last month of the contract (the last day of the contract was ignored as the prices were same on that day) to find out how the findings change with and without the prices of the last month.

Results and Discussion

Table 1 presents the findings of the OLS regression for maturity effect for wheat contracts with and without the inclusion of the prices for the last month. In all, thirty-two contracts were examined for wheat, of which fourteen have significant F values at 5 per cent when the data for the last month were excluded and included. In other words, the price changes have not behaved differently even in the last month which is generally excluded in the analysis as the futures and spot prices converge in this period. The number of contracts having non-significant value was eighteen for wheat with and without the inclusion of the price relative for the last month. In percentage terms, the maturity effect was present in 44 per cent contracts and was absent in 56 per cent contracts. This also indicates that the results for the maturity effect remain unaffected by the inclusion of the prices for the last month. Table 2 presents the findings of maturity effect for pepper contracts. Of the thirty-five contracts analysed, sixteen have maturity effect and nineteen do not have the maturity effect. However, the results vary marginally if the prices of the last month are included. In that case, the number of contracts having a significant F value at 5 per cent is fourteen and having a non-significant F value is twenty-one. In percentage terms, the percentage of contracts having a maturity effect when the last month prices are excluded is 46 per cent and it is 40 per cent when the last month prices are included.

For examining the BCSS hypothesis, the covariance between the spot price and net carry cost needs to be examined. The results of covariance between the spot price and net carry cost for wheat contracts are presented in Table 3. The results indicate that nine (28%) contracts have positive covariance and twenty three (72%) contracts have negative covariance. In the case of inclusion of the last month prices, the number of contracts having negative covariance is twenty-four (75%). The covariance results for pepper are presented in Table 4 and these indicate that nineteen (54%) contracts have positive covariance and sixteen (46%) contracts have negative covariance. The number of contracts having negative covariance is twenty (57%) when the last month prices are included. The covariance results for pepper are not consistent with the general observation that agriculture commodities tend to have

Table 1. Wheat contracts with maturity effect

Particulars	Inclusive of last month		Exclusive of last month	
	No.	Percentage (%)	No.	Percentage (%)
Significant at 5%	14	44	14	44
Non-significant	18	56	18	56
Total	32	100	32	100

Note: Percentages have been rounded-off in all the tables

Table 2. Pepper contracts with maturity effect

Particulars	Inclusive of last month		Exclusive of last month	
	No.	Percentage (%)	No.	Percentage (%)
Significant at 5%	14	40	16	46
Non-significant	21	60	19	54
Total	35	100	35	100

Table 3. Covariance between spot price and net carry cost for wheat contracts

Particulars	Inclusive of last month		Exclusive of last month	
	No.	Percentage (%)	No.	Percentage (%)
Positive	8	25	9	28
Negative	24	75	23	72
Total	32	100	32	100

Table 4. Covariance between spot price and net carry cost for pepper contracts

Particulars	Inclusive of last month		Exclusive of last month	
	No.	Percentage (%)	No.	Percentage (%)
Positive	15	43	19	54
Negative	20	57	16	46
Total	35	100	35	100

high negative covariance due to the convenience yield. In the case of agriculture commodities due to the presence of convenience yield, the covariance tends to be negative.

To support the BCSS hypothesis, two conditions need to be satisfied, one, the maturity effect should be present in majority of the contracts and, the second, the contracts which exhibit the maturity effect should have negative covariance. Table 5 presents the results of the maturity effect and negative covariance for various wheat contracts. It shows the total number of contracts with and without the maturity effect and the covariance of such contracts. Eleven (34%) contracts have maturity effect and negative covariance and twelve (38%) contracts with negative covariance have no maturity effect. The results are almost the same even

Table 5. Maturity effect and covariance for wheat contracts

Particulars	No. of contracts (Inclusive of last month prices)		No. of contracts (Exclusive of last month prices)	
	No.	Percentage (%)	No.	Percentage (%)
Contracts having maturity effect and negative covariance	12	38	11	34
Contracts having maturity effect and positive covariance	02	2	03	9
Contracts having no maturity effect and positive covariance	06	19	06	19
Contracts having no maturity effect and negative covariance	12	3	12	38
Total	32	100	32	100

Table 6. Covariance of wheat contracts exhibiting maturity effect

Particulars	No. of contracts (Inclusive of last month prices)		No. of contracts (Exclusive of last month prices)	
	No.	Percentage (%)	No.	Percentage (%)
Contracts having maturity effect and negative covariance	12	86	11	79
Contracts having maturity effect and positive covariance	02	14	03	21
Total	14	100	14	100

after the inclusion of the last month prices. In order to analyze whether the BCSS hypothesis is supported in the case of wheat and pepper, one needs to examine the variance given the maturity effect. Table 6 shows the covariance of the wheat contracts which have exhibited maturity effect. It is observed that 79 per cent of the contracts having maturity effect have negative covariance, in other words, eleven out of the fourteen contracts exhibit negative covariance. Thus, the BCSS hypothesis is supported in the case of wheat and the conclusions remain the same with the inclusion of last month prices. Table 7 presents the maturity effect and covariance for various contracts for pepper. Eight contracts (23%) having maturity effect have negative covariance and eight contracts (23%) with negative covariance have no maturity effect. Looking at Table 8, which gives the details of covariance of those pepper contracts which have maturity effect, one can say that the BCSS hypothesis is not so strongly supported as eight (47%) out of seventeen contracts have negative covariance. But by inclusion of the last month prices, the BCSS hypothesis is more strongly supported.

Concluding Observations

This paper has examined the maturity effect for wheat and pepper being traded at NCDEX. It has been

Table 7. Maturity effect and covariance for pepper contracts

Particulars	No. of contracts (Inclusive of last month prices)		No. of contracts (Exclusive of last month prices)	
	No.	Percentage (%)	No.	Percentage (%)
Contracts having maturity effect and negative covariance	9	26	08	23
Contracts having maturity effect and positive covariance	05	14	09	25
Contracts having no maturity effect and positive covariance	10	29	10	29
Contracts having no maturity effect and negative covariance	11	31	08	23
Total	35	100	35	100

Table 8. Covariance of pepper contracts exhibiting maturity effect

Particulars	No. of contracts (Inclusive of last month prices)		No. of contracts (Exclusive of last month prices)	
	No.	Percentage (%)	No.	Percentage (%)
Contracts having maturity effect and negative covariance	9	64	08	47
Contracts having maturity effect and positive covariance	05	36	09	53
Total	14	100	17	100

found that the maturity effect is present in nearly half of the contracts. The negative covariance between the net carry cost and spot price for pepper contracts is comparatively less as compared to what is generally observed in the agricultural commodities. The findings also indicate that BCSS hypothesis is supported in these two commodities, more strongly for wheat than for pepper. There is further scope for research in this area in relation to other agricultural commodities and also metals. Further studies can also be undertaken to find the informational efficiency and the reaction of informational flow to identify the reasons for the presence or absence of maturity effect.

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