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Maturity Effect in Commodity Market: Empirical Evidences from Multi-Commodity Exchange (MCX)

Meera Bamba
Department of Commerce, Indira Gandhi University, India
Mamta Aggarwal
Department of Commerce, Indira Gandhi University, India
*Monika Verma**
Department of Commerce, Indira Gandhi University, India

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Abstract

The current paper examines the maturity effect which states that "the futures prices volatility increases as the futures contract approaches its maturity period". As per maturity effect theory, when a contract approaches its delivery date, the flow of information affects the prices. The paper studies the maturity effect in 12 futures commodities (crude oil, natural gas, silver, gold, aluminium, zinc, copper, lead, nickel, cotton, mentha oil and cardamom) belonging to four segments (energy, bullion, base metal and agriculture) of the Indian Commodity Market. This paper examines all the futures contracts that matured during the year 2020. The data has been collected from the official website of the Multi-Commodity Exchange (MCX). This paper applies ordinary least squares (OLS) regression to examine the maturity effect and uses daily settlement prices for the analysis. The empirical results of the relationship of maturity effect and price volatility indicate that there is the influence of maturity effect in the selected commodities for certain maturity periods. In Multi commodity exchange, 22.21 % contracts satisfied the condition for Samuelson hypothesis, and price volatility of these contracts affected by the numbers of days left for its expiration. Empirical evidence also depicts that in base metal futures commodities, all the contracts with a maturity period of 121-150 days' exhibits a maturity effect. The study of volatility concerning time to maturity helps one in constructing a hedging strategy, its effectiveness and deciding a suitable hedge ratio.

Keywords: Price volatility, Commodity futures, Maturity period of futures contract, Samuelson hypothesis

JEL Classifications: C30, E50, G70

* **Corresponding author:** Rewari - Lokri Rd, Meerpur, Haryana 122502, India
Email: monikabarwala00@gmail.com

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1. Introduction

Samuelson (1965) proclaimed that "Price volatility increases as the futures contracts approach to its expiration". This concept is titled the "Maturity Effect". The theory behind the maturity effect is that when a contract approaches its expiration, the flow of information affects the prices (Miller, 1979). Pati (2018) also reported in his study that if there is long time gap in future contract expiry, the prediction of spot price will be more uncertain. On the other hand, as the time gap gets smaller, there will be more relevance, and accurate information will be available, which means? the accuracy of spot price prediction tends to increase. As a result, marketers or traders become more sensitive to the upcoming information which leads to higher volatility.

Price volatility in the commodity futures market is a major issue encountered by traders and manufacturers for purchasing raw materials and other financial transactions. Price volatility is affected by the strong fluctuation in demand and supply (Cavalcanti et al., 2014). Li et al. (2005) reported that volatility in the commodity market is majorly related to the uncertainty of asset prices. Higher volatility means large changes in asset prices, and lower volatility means prices do not fluctuate significantly. Hedgers and traders can gain an advantage through predictions about price volatility and maturity effect. Hedgers and traders can select the contract for a short or long time by determining the nature of the relationship between maturity and price volatility. Duong & Kalev (2008) reported that if maturity effect found, traders can switch to contracts further away from their expiration period. Therefore, the prediction of future price volatility with the use of the Samuelson hypothesis is helpful to the traders because they can roll over their futures contracts before maturity. The above relation is also significant for margin setting. Margin has a direct positive relation to the price volatility of futures contracts. Castelino & Francis (1982) reported that if the futures price variability goes up as the contracts nears maturity, the cash carried by hedgers and traders to cover the margin call also need to be raised.

In India, the government has considered risk management factors and allowed the futures trading of commodities and established two different exchanges; one is National Commodity and Derivatives Exchange of India (NCDEX) and the second is Multi-Commodity Exchange of India (MCX). These are the largest commodity exchange in India, and almost 97% of trading in commodity derivatives execute on these two exchanges. In India, Securities and Exchange Board of India controls these two exchanges (Bhagwat & Maravi, 2015). The current paper examines the maturity effect of twelve commodity futures contracts being traded on Multi-Commodity Exchange (MCX). These commodities are the most traded commodities in MCX in terms of trade value. In the year 2020, the total trade value of all commodities traded on the MCX exchange was 6159919.95 crores (MCX, India, 2020).

Considering the significance of the maturity effect, this paper examines the maturity effect in the energy sector in India. The energy sector is a major driver of industrial growth, as it provides power to other sectors. If terms of volume of trade, crude oil is the one which is being traded the most across the globe. Crude oil is consumed in the entire world, but there are only a few countries in the world which produce a major chunk of crude oil for the entire world's consumption. Countries which have got this gift of nature are Saudi Arabia, Iraq, Iran, Russia and America. India also depends on these countries for its demand. The increase in the volume of energy futures contracts in the last two decades makes it essential to study the relationship between energy futures contracts and time of the maturity. If we talk about the source of energy which is clean and doesn't pollute much compare to other sources, it will be natural gas. India can produce 60% of its demand inhouse and rely on Qatar for rest of its demand. The major producers of natural gas in the world are America, Iran, Russia, Canada and Qatar.

In ancient times, metals are the most valuable materials which were traded in the local markets. Gold and silver were the most precious metals of all. These are traded in the derivatives market as a hedge against risk. In India, gold, silver and diamond are traded in commodities exchange as futures contracts. India launched its first bullion index future contract on MCX BULLDEX on 24 August 2020 (MCX, India, 2020).

Copper, zinc, aluminium, nickel, lead and tin are the most precious and traded base metals, and the major of which are mostly produced by China and the USA. London Metal Exchange (LME) prices are usually recognized prices for the base metals in the whole world and India. In India, future contracts are available for most metals like zinc, lead, copper, aluminium, nickel and brass, an alloy of copper and zinc. After SEBI's permission, futures contracts based on the index were launched on MCX MELTDEX on 19 Oct 2020. India is also the major producer of cotton all over world. It is the second biggest consumer and exporter of cotton in the whole world. There are many numbers of spices on which future contracts are available like jeera, coriander, mentha oil, pepper, turmeric and cardamom which are used as hedging techniques against high volatility in the market.

As financial asset commodity futures are gaining prominence in Indian capital market, there are many studies which empirically analyse the maturity effect in commodity futures. However, the majority of the studies analyses this effect in the metal market, energy market, bullion market and agriculture market separately. There are few studies which analyse the maturity effect on composite basis. Therefore, this study makes an effort to include all types of futures commodities traded on Multi- Commodity Exchange (MCX).

The current paper examines the price volatility of a futures contract when the contract reaches its expiration period. The dataset of the study on commodity futures has been attained from the Multi-Commodity exchange (MCX)'s official website. This study covers daily settlement prices for futures contracts that matured in the year 2020. Data has been collected from four segments: Energy, Bullion, Base metals and Agriculture. This paper studies the maturity effect in 12 futures commodities (crude oil, natural gas, silver, gold, aluminium, zinc, copper, lead, nickel, cotton, mentha oil and cardamom). Maturity effect examines the basis of Ordinary Least Squares (OLS) regression in which the explanatory variables are the time to expiration period and explained variables are the price volatility. The empirical results of the relationship between maturity effect and price volatility indicate that there is an influence of maturity effect in the selected four segments. In Multi- Commodity Exchange, from 14281 futures observations, 3172 contracts satisfied the condition for the Samuelson hypothesis and price volatility of these contracts affected by the number of days left for its expiration. In energy contracts, 21.73 % futures observations, in bullion segment, 25.18 % futures observations, in base metals contracts 28.87 % futures observations and in agriculture segment 12.36 % futures observations support the maturity effect. The empirical evidence also depicts that in all the base metal futures commodities, one thing that is common is all contracts with a maturity period of 121-150 days' exhibit a maturity effect.

The remaining portion of the current study is designed as follows: Section 2 discusses the related literature on the maturity effect, while Section 3 represents the research methodology of the study and given the technique used for the analysis of data. The empirical results regarding the study are presented in Section 4. Summary and conclusion prepared at the final Section 5 of the paper.

2. Literature Review

Numbers of studies have been carried out to examine the maturity effect. Samuelson (1965) claimed that price volatility of futures contracts upsurges when the contracts approaches its maturity period. This occurrence is called the maturity effect.

Chiarella et al. (2016) found the relationship between return and volatility in gold and crude oil futures contracts. Strong evidence has been found in the gold futures rather than crude oil futures contracts. Floros & Vougas (2006) studied the relationship between maturity effect and volatility in Greek markets. The study applied GARCH models and simple linear regressions to analyse the maturity effect. This study used daily settlement data from the Athens Derivatives Exchange. They found that maturity effect was valid, and the volatility showed increases trend as they approached their maturity. Daal et al. (2006) tested the maturity effect with 6805 futures contracts data taken from 61 commodities. This study indicated the maturity effect showed stronger support for commodity futures rather than financial futures contracts. Daal & Farhat (2006 a) analysed the maturity effect in 8451 futures drawn from 4 international exchanges. The empirical results showed maturity effect's strong support for energy and agriculture commodities. Galloway & Kolb (1996) examined detailed dataset of 45 commodities and found that maturity effect was having a significant inverse or negative relationship to monthly returns variance in many agriculture, copper and energy commodities. Serletis (1992) investigated the maturity effect in 129 energy contracts. The study found strong evidence for maturity effect in energy contracts. Kenourgios & Katevatis (2011) supported the maturity effect in Greek index futures market and indicated positive association among volatility and volume, and negative relationship existed among open interest and volatility. Milonas (1986) provided strong evidence of maturity effect in agriculture financial and metal market. The empirical analyses were conducted for maturity effect in 11 futures markets. In his results, he found that ten out of eleven futures market depicted the maturity effect and price variability affected but by the number of days left for its expiration. Corn futures contracts did not support the maturity effect. Akin (2003) analysed the Samuelson hypothesis in financial futures contracts. In the study, 11 futures contracts were analysed using the GARCH model. This study indicated robust proof for the maturity effect in currency futures. Walls (1999) found robust sign of maturity effect in electricity futures contracts. This study analysed 14 electricity futures contracts. As compared to energy commodities, electricity futures showed a significant maturity effect. Verma & Kumar (2010) carried out a study to examine the maturity effect of wheat and pepper in India. The data for pepper and wheat futures was taken from NCDEX. The period was taken from 2004 to 2007, and ordinary least square regression for each contract was run separately. This paper found that the maturity effect supported 45 percent of the pepper and wheat futures contracts. Mukherjee & Goswami (2017) analysed in their study the maturity effect for four commodities which are crude oil, potato, mentha oil and gold. This study used the GARCH technique for analysing the volatility of commodity futures. This study applied the GARCH model and address the maturity effect with the β term. The results found that the maturity effect holds for gold futures. David & Cruickshank (2002) studied the Samuelson hypothesis in 3 futures exchanges (SFE, LIFFE, SIMEX). Energy, electricity and agriculture contracts were analysed in his study. The empirical results indicated that most of the contracts hold true for the maturity effect. Buvaneswari & Rao (2018) studied the maturity effect in aluminium futures contracts. Results indicated that prices fluctuate as the contract approaches its delivery date. Lee et al. (2019) applied the bivariate GARCH model in the study and investigated the significant maturity effect in ETFs. Phan & Zurbruegg (2020) found that the maturity pattern of commodity futures is influenced by asymmetric information. Radhakrishna et al. (2019) concluded in their study that volatility of returns is affected by the maturity effect. Motengwe & Alagidede (2016) studied the maturity effect in the SAFEX market and wheat commodity shows evidence of supporting the maturity effect. Brooks & Teterin (2020) found the strength of maturity effect in 10 US-based futures markets. Ao & Chen (2020) took into consideration 41 commodities from the industrial, agriculture and metal sectors. This study revealed that the maturity effect works only in the agriculture futures market.

Herbert (1995) examined the Samuelson hypothesis in the natural gas futures contract. In his study, he disclosed that there is less maturity effect found in the existence of trading volume. Sakthivel et al. (2014) investigated the maturity effect in NSE futures in India. The study applied GARCH model with daily closing price and analysed ten stock futures. He found that in stock futures, contracts price volatility was not affected by the maturity effect. Watanabe (2001) showed no connection between volatility of price and trading volume in NIKKEI 225 Japanese stock index. Han et al. (1999) found no maturity effect in their study. Grammatikos & Saunders (1986) investigated that there is a relationship existed between maturity effect and trading but no relationship found in price volatility and time to expiration. Ripple & Moosa (2005) analysed maturity effect as hedging instrument. Gurrola & Herrerias (2010) explored the maturity effect in interest rate futures market and found inverse connection between maturity effect and price volatility. When futures approach its expiration period, price volatility decreases. Gupta & Rajib (2012) investigated the maturity effect in MCX, India with eight commodities. The study took inter-day data for futures contracts and applied GARCH models. Results found the majority of commodities do not support the maturity effect, but trading volume affects the volatility of futures contracts. Moosa & Bollen (2001) also found no relationship between price volatility and time to maturity in S&P 500 futures contracts. Liu (2020) investigated the five energy futures contracts traded on NYME. This study found mild signs for the maturity effect in energy futures contracts. Wats (2017) studied that expiration days and weeks in derivatives are primary factors that enhance the volatility of the spot market. Xu et al. (2021) analysed the maturity effect in Stock index futures. Results indicate that after introducing trading restrictions, volatility of futures index decreases as they approach their delivery date.

Bessembinder et al. (1996) gave a new concept about the maturity effect. They found that the maturity effect holds good in those market that shows a negative covariance among net carry cost and spot prices. This framework is called the 'BCSS hypothesis'. Ragunathan & Peker (1997) showed that conditional return is influenced by the lagged futures volatilities of contracts. Pati (2018) examined the maturity effect in gold and copper futures contracts. In his study, he disclosed that trading volume and time to expiration are the foundation for volatility in the futures contract. GARCH model was used for the analysis in his study, and he found evidence for maturity effect in futures contracts. Duong & Kalev (2008) investigated the futures price volatility and examined the Samuelson hypothesis using intraday data. Data regarding metals, agricultural, energy and financial were obtained from 20 futures markets. Results indicated that the maturity effect shows strong support for agricultural futures but no support for financial futures, energy futures, and metals futures.

Based on the above literature, it has been observed that the maturity effect is a basis of variability in futures prices for various commodities. However, some of the studies i.e., Galloway & Kolb 1996; Daal et al. 2006; Verma & Kumar 2010; Buvaneswari & Rao 2018; Ao & Chen 2020 and Brooks & Teterin 2020 support the presence of maturity effect, while studies like Gurrola & Herrerias 2010; Gupta & Rajib 2012; Sakthivel et al. 2014 and Liu 2020 do not support maturity effect. Hence, past empirical studies showed mixed results regarding the maturity effect. Furthermore, the majority of studies focus on individual commodities. Therefore, this study makes an effort to include all types of futures commodities traded on Multi-Commodity Exchange (MCX). This paper expects to find maturity effects in energy futures, bullion futures, base metal futures and agriculture futures traded on MCX.

3. Research Methodology

The purpose of the study is to analyses the maturity effect in Indian commodity futures market based on Samuelson hypothesis. Samuelson (1965) proposed the following hypothesis:

'The maturity effect significantly affects the price volatility of commodity futures contracts'

The present study strives to check whether or not Indian commodity futures market exhibits maturity effect.

The dataset of the study on commodity futures has been attained from Multi-Commodity Exchange (MCX)'s official website. This study covers daily settlement prices of futures contracts that matured during the year 2020. Data has been collected from four segments: Energy, Bullion, Base Metals and Agriculture. Following futures, commodities have been taken for the investigation: 5 Base metal contracts (Copper, Aluminium, Zinc, Nickel and Lead), 2 Bullion contracts (Silver and Gold), 2 Energy contracts (Crude oil and Natural gas), 3 Agriculture contracts (Cotton, Mentha oil and Rubber). In terms of volume, these 12 futures contracts are the major traded futures commodities in the Multi-Commodity Exchange (MCX).

Compound percentage return is calculated using daily close price of futures contracts traded on MCX and taking logarithmic first difference of closing price.

$$\text{Return} = \ln\left(\frac{P_t}{P_{t-1}}\right)*100 \quad (1)$$

Here P_t and P_{t-1} is the closing prices on day t and (t-1) of all the futures commodities traded on multi commodity exchange (MCX).
The maturity effect has been tested by applying the ordinary least squares regression for monthly contracts.

$$\sigma^2_{m,t} = \beta o + \beta_1 \lambda_{m,t} + \varepsilon_t \quad (2)$$

Here $\sigma^2_{m,t}$ denotes price volatility and λ denotes the number of days left to its expiration period. The hypothesis is that if the coefficient β_1 value comes to negative, maturity effect will be present.

On the basis of expiry periods, contracts are divided into twelve parts, and beta value is calculated. If the coefficient beta value is negative and significant than maturity, effect is present in that particular period futures contracts. Logarithm of daily futures price is a basic unit of observation for the studies showing maturity effect. The factor driving for considering the logarithm difference is that as the price level moves, one can assume the dispersion of prices to move in a similar direction. Using log differences or percentage changes helps in adjusting for this kind of source of the non-stationarity. One can use the classical estimator of the logarithm of price relatives to measure the volatility. Using the log of relative daily prices ranging from t-1 to t day, the price relative change will be calculated.

$$f_{m,t} = \text{Log}\left(\frac{R_{m,t}}{R_{m,t-1}}\right) \tag{3}$$

Here $R_{m,t}$ denotes the close prices for futures contracts m on the day t. For the contract m, volatility of daily price relative shall be designed as

$$\sigma^2{}_{m,t} = \left(\log\left(\frac{R_{m,t}}{R_{m,t-1}}\right)\right)^2 \tag{4}$$

Table 1: Descriptive Information on Sample futures commodities

Commodity	Segment	Futures Observation	Months that contracts mature
Crude oil	Energy	1542	1,2,3,4,5,6,7,8,9,10,11,12
Natural Gas	Energy	772	1,2,3,4,5,6,7,8,9,10,11,12
Gold	Bullion	1501	1,2,3,4,5,6,7,8,9,10,11,12
Silver	Bullion	1251	1,2,3,4,5,6,7,8,9,10,11,12
Aluminium	Base metals	833	5,6,7,8,9,10,11,12
Copper	Base metals	1284	1,2,3,4,5,6,7,8,9,10,11,12
Zinc	Base metals	833	5,6,7,8,9,10,11,12
Nickel	Base metals	1284	1,2,3,4,5,6,7,8,9,10,11,12
Lead	Base metals	833	5,6,7,8,9,10,11,12
Cotton	Agriculture	1475	1,2,3,4,5,6,7,8,9,10,11,12
Mentha oil	Agriculture	1388	1,2,3,4,5,6,7,8,9,10,11,12
Cardamom	Agriculture	1285	1,2,3,4,5,6,7,8,9,10,11,12

Source: Multi-Commodity Exchange, India

Most of the commodity futures markets around the world have contracts which expires ranging from one week to three months. If we talk about India, there are certain contracts which expire in four months and five months, and the cases of one-year expiry contracts are also available. Almost all the future contracts having an expiry equal to or more than one month expire on the last Thursday of every month. Table 1 presents descriptive information regarding each commodity containing the commodity segment, the number of observations taken for analysis and probable maturity months for the commodity futures contracts. As presented in Table 1, energy commodities represent 2314 futures observations or 16% of samples taken. Bullion commodities denote 19% of the samples. Base metals commodities represent 5067 futures observations which are 36% of the samples, and finally, agriculture commodities represent the remaining 4148 futures observation or 29% of the samples. Aluminium, zinc and lead expire in 7 months; May, June, July, August, September, October, November and December. In contrast, natural gas, crude oil, gold, silver copper, nickel, cotton, cardamom, mentha oil can expire in all twelve months of the year. Table 2 in the appendix shows descriptive information about the commodity futures, including the instrument type, month, segment, year, traded contracts and the total value of the contracts.

4. Empirical results

The current study dataset consists of the daily settlement price of 12 commodities (crude oil, natural gas, silver, gold, aluminium, zinc, copper, lead, nickel, cotton, cardamom and mentha oil) from four segments (energy, bullion, base metal and agriculture). The present study includes all the futures contracts that matured during the year 2020. Descriptive statistics are calculated using the daily futures returns for the 12 selected commodities using Equation 1. Table 3 presents the descriptive statistics including mean (X), median (M), standard deviation (σ), maximum and minimum value, probability value, skewness and kurtosis. If we study the average daily return of these commodity contracts futures, we can see that ADR (average daily return) comes nearly zero, or it will be below zero for the complete time interval of study. Using descriptive statistics, we can find that there is skewness in returns towards the negative side. As the coefficients used for Skewness are other than zero, distributions of returns will be non-symmetric. If we take the normality test of Skewness and Kurtosis, we can say that these are non-normal.

Table 3: Descriptive statistics for twelve futures commodities

Commodity	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Probability
Crude oil	-0.272	0.000	14.056	-315.715	8.262	-36.121	1379.291	0.000
Natural Gas	-0.001	-0.001	0.071	-0.050	0.014	0.403	5.564	0.000
Gold	0.045	0.057	2.693	-3.168	0.500	-0.580	8.030	0.000
Silver	0.030	0.045	3.296	-5.169	0.879	-0.832	9.452	0.000
Aluminium	0.063	0.056	1.774	-1.396	0.398	0.149	5.020	0.000
Copper	0.023	0.041	2.802	-7.832	0.594	-2.422	30.278	0.000
Zinc	0.072	0.109	5.518	-3.207	0.765	0.190	8.388	0.000
Nickel	0.004	0.004	3.169	-4.988	0.694	-0.303	6.890	0.000
Lead	0.019	0.014	14.642	-7.859	0.915	4.787	102.620	0.000
Cotton	-0.021	0.000	6.004	-7.104	0.475	-1.497	72.567	0.000
Mentha oil	0.000	0.000	0.133	-0.067	0.013	3.703	40.377	0.000
Cardamom	-0.043	0.000	7.106	-6.812	1.014	0.426	15.022	0.000

Source: Author's compilation

Price volatility is based on daily close price and previous close price of particular futures contracts. On the basis of expiration period, all the futures contracts are divided into 12 categories. The first category includes those contracts that matured within 30 days. The second category includes contracts that matured with 31-60 days trading cycle. The third category includes those contracts that matured with 61-90 days trading cycle. The fourth category includes those contracts that matured with 91-120 days trading cycle. The fifth category includes those contracts that matured with 121-150 days trading cycle. The sixth category includes those contracts that matured with 151-180 days trading cycle. The seventh category includes those contracts that matured with 181-210 days trading cycle. The eighth category includes those contracts that matured within 211-240 days trading cycle. The ninth category includes those contracts that matured with 241-270 days trading cycle. The tenth category includes those contracts that matured within 271-300 days trading cycle. The eleventh category includes those contracts that matured within 301-330 days trading cycle. The twelfth category includes those contracts that matured with 331-360 days trading cycle.

Crude oil futures contracts work with a 1-6-month maturity trading cycle and natural gas futures contracts work with a 1-3-month maturity trading cycle. Ordinary Least Squares Regression is applied to each category. The empirical results came from the Ordinary Least Squares Regression in which the explanatory variables are the time to expiration period, and explained variables are the price volatility. Table 4 presents the results regarding the OLS regression of maturity effect for crude oil and natural gas futures contracts. Maturity effect is calculated based on β value and the level of significance. If the results found a significant negative β value, the futures contract dataset supports the maturity effect. Most of the crude oil and natural gas futures contracts results indicate insignificant β values. Therefore, the contracts which showed insignificant β values do not support the maturity effect. Crude oil contracts with maturity period of 121-150 days and 151-180days show β value is negative and significant at a 5% and 10% level of significance. These crude oil futures contracts support the Samuelson hypothesis at a 5% and 10% level of significance. The volatility of the prices significantly affected by the number of days to maturity. Natural gas futures contract β value is insignificant and does not support the maturity effect. Therefore, the price volatility of natural gas futures contracts does not support the Samuelson hypothesis, and price volatility does not affect by the number of days until maturity. Therefore, in the energy sector, 503 futures satisfy the condition for the Samuelson hypothesis. In the energy segment, 21% of futures contracts support the maturity effect while the remaining 79% of futures do not hold the maturity effect.

Table 5 presents OLS regression results of maturity effect for silver and gold futures contracts. These futures contracts work with a 1-12-month maturity trading cycle. Gold futures contracts with maturity periods of 210-240 days, 271-300 days and 301-330 days' show β value is negative, and these futures contracts are significant at a 5% and 10 % level of significance. Therefore, these contracts support the maturity effect, and the volatility of the price is significantly affected by the number of days to maturity. Silver contracts with a maturity period of 0-30 days are significant at a 10% level of significance, but their β value is positive, so the maturity effect does not hold in these contracts. Silver contracts with maturity periods of 181-210 days, 271-300 days and 301-330 days show negative β values and are also significant at 5% and 10% levels of significance. In the Bullion segment, 381 futures from gold and 312 futures observation from silver satisfy the condition of the Samuelson hypothesis. Therefore, in bullion 25.18 % of futures observation reflect the maturity effect. For maturity intervals ranging between 271days to 300days and for intervals 301 days to 330 days, the bullion futures contract can be seen supporting the maturity effect, and price volatility of these futures contracts increases when contracts near their expiration period.

Table 6 presents the Ordinary Least Squares results for the Base metals futures contract. Base metal futures contracts (copper, lead, Aluminium, nickel and zinc) are functioning with a 1 to 6-month maturity trading cycle. In aluminium futures, maturity effect holds for contracts with 91-120 days and 121-150 days expiring cycle. In aluminium, 319 futures observation satisfied the condition for the Samuelson hypothesis. These contracts are significant at 5% and 10% levels of significance with negative β values. Copper futures contracts with a maturity period of 121-150 days hold the maturity effect at a 10 % level of significance. In copper, 251 observations fulfil the situation for the Samuelson hypothesis. Lead future contracts hold Samuelson hypothesis with a maturity period of 91-120 days and 121-150 days. In lead contracts, 319 futures observation holds for the Samuelson hypothesis. These contracts are significant at a 5% level of significance. Zinc futures contracts hold good for maturity effect. The maturity period of 61-90 days, 91-120 days and 121-150 days are significant at 5% and 10 % levels of significance. In Zinc contracts, 323 futures observation depicts maturity effect. Nickel futures contracts support the maturity effect with a maturity period of 121-150 days at a 5% level of significance. In nickel contracts, 251 futures observation fulfil the condition for the Samuelson hypothesis. All the base metal futures contracts 1463 or 28.81% futures observation satisfy the condition for the Samuelson hypothesis, and these contracts become volatile when these approaches their expiration period. In all the base metal futures, one thing that is common is all contracts with a maturity period of 121-150 days exhibit the maturity effect.

As compared to other segments in agriculture future contracts, less evidence was found for the Samuelson hypothesis. All Agriculture futures contracts work with various maturity trading cycles. Table 7 presents the Ordinary Least Squares results for agriculture (cotton, mentha oil, cardamom) futures contract. Cotton futures contracts work with 1to 8-month expiration cycle. In cotton, those contracts hold for maturity effect which is working with 0-30 days expiring cycle. In cotton contracts, 245 futures observations fulfil the condition for the Samuelson hypothesis and reflect the maturity effect. Mentha oil and cardamom futures contracts function with a 1-6-months trading cycle. Cardamom futures contracts do not support the maturity effect. Cardamom contracts with a maturity period of 0-30 days and is significant at a 5% level of significance, but its β value is positive, so the maturity effect does not hold in these contracts. Mentha oil futures contracts with a maturity period of 0-30 days support the maturity effect at a 5% level of significance. In mentha oil contracts, 268 futures observations satisfy the condition for the Samuelson hypothesis and become volatile when contracts approach its expiration. In the Agriculture sector, 513 or 12.36% futures observation depict maturity effect. Therefore, these contracts support the maturity effect, and the volatility of the prices significantly affect by the number of days to its expiration.

Table 4: Ordinary Least Squares results for crude oil and natural gas futures contract

Energy Futures				
Commodity	**Crude Oil**		**Natural Gas**	
Days to maturity	β value	p-value	β value	p-value
0-30	-0.00694407	0.10012546	-0.00000381	0.33425272
31-60	-0.00000135	0.87153166	-0.00000074	0.78526963
61-90	-0.00000352	0.58166334	-0.00000014	0.92527636
91-120	-0.00001037	0.17160997	-0.00012067	0.67280236
121-150	-0.0000229	0.016642915*	-	-
151-180	-0.0000196	0.09361540**	-	-
181-210	-0.00038138	0.70856057	-	-

Source: Author's compilation
*Significant at 5% level of significance
**Significant at 10% level of significance

Table 5: Ordinary Least Squares results for gold and silver futures contract

Bullion Futures				
Commodity	**Gold**		**Silver**	
Days to maturity	β value	p-value	β value	p-value
0-30	0.000000615	0.232933711	0.000005519	0.070144927**
31-60	0.000000494	0.462477179	-0.000001139	0.741438676
61-90	0.000000354	0.476714105	-0.000001906	0.471684836
91-120	0.000000496	0.432566481	0.000005742	0.152351453
121-150	0.000000859	0.368335841	-0.000002825	0.116507079
151-180	-0.000000529	0.101119622	0.000003056	0.333577557
181-210	-0.000001305	0.117694159	-0.000002533	0.051152993**
210-240	-0.000000638	0.092320139**	-0.000000763	0.194967969
241-270	-0.000001114	0.307294192	0.000000056	0.984867496
271-300	-0.00000091	0.008391732**	-0.000004602	0.003654315*
301-330	-0.000002038	0.015353122*	-0.000002003	0.000701794*
331-360	-0.000000427	0.249759525	-0.000000767	0.383761757

Source: Author's compilation
*Significant at 5% level of significance
**Significant at 10% level of significance

Table 6: Ordinary Least Squares results for Base metals futures contract

Base Metals Futures						
Commodity	**Aluminium**		**Copper**		**Lead**	
Days to maturity	β value	p-value	β value	p-value	β value	p-value
0-30	-0.00000	0.12599	-0.00000	0.11372	-0.00000	0.10433
31-60	0.00000	0.23786	0.00000	0.74490	0.00000	0.98798
61-90	-0.00000	0.76953	0.00000	0.68860	-0.00000	0.34021
91-120	-0.00000	0.01140*	-0.00000	0.71418	-0.00002	0.01015*
121-150	-0.00000	0.06914**	-0.00000	0.08002**	-0.00004	0.03479*
151-180	0.00002	0.81315	-0.00005	0.29193	-0.00006	0.20678

Source: Author's compilation
*Significant at 5% level of significance
**Significant at 10% level of significance

Table 6: Ordinary Least Squares results for Base metals futures contract (continued)

Base metals Futures				
Commodity	**Zinc**		**Nickel**	
Days to maturity	β value	p-value	β value	p-value
0-30	-0.00000	0.19692	-0.00000	0.18016
31-60	-0.00000	0.49111	0.00000	0.84690
61-90	0.00000	0.75361	0.00000	0.74716
91-120	-0.00001	0.00004*	0.00000	0.17617
121-150	-0.00001	0.00467*	-0.00000	0.00074*
151-180	-0.00012	0.08914**	-0.00004	0.50635

Source: Author's compilation
*Significant at 5% level of significance
**Significant at 10% level of significance

Table 7: Ordinary Least Squares results for Agriculture futures contract

Agriculture Futures						
Commodity	**Cotton**		**Mentha oil**		**Cardamom**	
Days to maturity	β value	p-value	β value	p-value	β value	p-value
0-30	-0.00000	0.03638*	-0.00002	0.00000*	-0.00000	0.30525
31-60	-0.00000	0.83901	0.00000	0.33737	0.00000	0.04082*
61-90	-0.00000	0.68499	0.00000	0.38029	-0.00000	0.20893
91-120	-0.00000	0.29617	0.00000	0.84287	0.00000	0.66505
121-150	-0.00000	0.13917	-0.00000	0.60709	0.00000	0.13671
151-180	-0.00000	0.26514	0.00000	0.58130	0.00008	0.17047
181-210	-0.00000	0.92599	-	-	-	-
210-240	-0.00000	0.10090	-	-	-	-

Source: Author's compilation
*Significant at 5% level of significance

5. Summary and Conclusion

This study analyses the maturity effect in the Indian commodity market. This paper examines the Samuelson hypothesis in futures contracts traded in Multi-Commodity Exchange (MCX). Samuelson's hypothesis claims that the price variability of future contracts rises as the contracts approaches its maturity period. The volatility in the commodity market is majorly related to the uncertainty of asset prices. The higher volatility means large changes in asset prices, and the lower volatility means prices do not fluctuate significantly.

This study strives to check whether or not the Indian commodity futures market exhibits a maturity effect. The objective of the current study is to analyse the maturity effect in the Indian commodity futures market based on the Samuelson hypothesis. Therefore, this paper analyses the maturity effect for 12 futures commodities from four sectors traded on Multi-Commodity Exchange (MCX) in India. Following are the selected futures contracts; 5 Base metal contracts (Copper, Aluminium, Zinc, Nickel and Lead), 2 Bullion contracts (Silver and gold), 2 Energy contracts (Crude oil and Natural gas), 3 Agriculture contracts (cotton, mentha oil and rubber). Data has been collected for those futures contracts which expire in the year 2020.

Maturity effect has been examined on the basis of Ordinary Least Squares (OLS) regression in which the explanatory variables are the time to expiration period, and explained variables are the price volatility. The results indicate that there is evidence of maturity effects in bullion, base metals, energy and agriculture segments. The empirical results depict that some of the crude oil futures contracts have maturity effect and price volatility rises when the particular futures contract approaches its maturity period. This study found that the maturity effect exists in crude oil futures contracts with maturity period of 121-150 days and 151-180 days. In natural gas futures contract, the empirical results found no support for maturity effect, and their price volatility is not affected by the time to expiration. Gold futures contracts with maturity periods of 210-240 days, 271-300 days and 301-330 days hold true for the maturity effect. Silver contracts with maturity periods of 181-210 days, 271-300 days and 301-330 days support the maturity effect. For maturity intervals ranging between 271days to 300days and for intervals 301 days to 330 days, the bullion futures contract can be seen supporting the maturity effect, and price volatility of these futures contracts increases when contracts are near their expiration period. In aluminium futures, the maturity effect holds true for contracts with 91-120 day and 121-150day expiring cycles. Copper futures contracts with a maturity period of 121-150 days support the maturity effect. Lead future contracts hold the Samuelson hypothesis with a maturity period of 91-120 days and121-150 days. Zinc futures contracts hold good for the maturity effect with the maturity periods of 61-90 days, 91-120 days and 121-150 days. Nickel futures contracts support the maturity effect with a maturity period of 121-150 days. In all the base metal futures, one thing that is common is that all contracts with a maturity period of 121-150 days support the maturity effect. As compared to other segments in agriculture future contracts, less evidence was found for the Samuelson hypothesis. In cotton, those contracts hold for maturity effect, which is working with a 0-30day expiring cycles. Cardamom futures contracts do not support the maturity effect. Mentha oil futures contracts with a maturity period of 0-30 days hold true for the maturity effect.

In energy contracts, 21.73 % of futures observations show the maturity effect. In the bullion segment, 25.18 % of futures hold for the maturity effect. In base metals contracts, 28.87 % of futures observations exhibit maturity effect, and price becomes volatile when these contracts approach their expiration period. As compared to other segments in agriculture future contracts, less evidence was found for maturity effect. In this segment, 12.36 % of futures observations fulfil the condition for maturity effect. From 14281 futures observations, 3172 or 22.21 % contracts satisfy the condition for the Samuelson hypothesis, and price volatility of these contracts affected by the number of days left for its expiration. After examining the maturity effects of 12 commodities belonging to four segments, it can be determined that the maximum maturity effect is found in base metal futures commodities, and the minimum maturity effect is found in agriculture commodities. The empirical evidence also depicts that in all the base metal futures commodities, one thing that is common is all contracts with a maturity period of 121-150 days' exhibit maturity effect.

The study of volatility with respect to time to maturity helps one in building a hedging strategy, its effectiveness and choosing a suitable hedge ratio. Understanding the maturity effect is beneficial for traders who deal with commodity futures, so they can roll over their contracts further away from their expiration period. The present study considers only the maturity effect for price variability of futures contracts. There are also other variables like volume, spot price and open interest which may affect the price volatility of futures contracts. The scope for further research work lies in the area of more agricultural commodities traded on other exchanges.

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Appendix

Table 2. Descriptive features on Sample futures contracts

Instrument Type	Month	Year	Segment	Commodity	Traded Contract (Lots)	Total Value (Lacs)
FUTCOM	JAN	2020	Energy	Crude Oil	8500141	35132144.73
FUTCOM	FEB	2020	Energy	Crude Oil	9969551	36117628.07
FUTCOM	MAR	2020	Energy	Crude Oil	9641626	24847419.94
FUTCOM	APR	2020	Energy	Crude Oil	4021657	5962601.23
FUTCOM	MAY	2020	Energy	Crude Oil	2774943	5854644.1
FUTCOM	JUN	2020	Energy	Crude Oil	2924880	8416668.01
FUTCOM	JUL	2020	Energy	Crude Oil	2217346	6752046.03
FUTCOM	AUG	2020	Energy	Crude Oil	1577546	4983888.17
FUTCOM	SEP	2020	Energy	Crude Oil	1769288	5138829.02
FUTCOM	OCT	2020	Energy	Crude Oil	1803646	5234020.7
FUTCOM	NOV	2020	Energy	Crude Oil	2113611	6414471.8
FUTCOM	DEC	2020	Energy	Crude Oil	590793	2028633.82
FUTCOM	JAN	2020	Energy	Natural Gas	3290800	5994264.51
FUTCOM	FEB	2020	Energy	Natural Gas	2995205	4982028.14
FUTCOM	MAR	2020	Energy	Natural Gas	3257183	5355399.03
FUTCOM	APR	2020	Energy	Natural Gas	1836621	3199506.24
FUTCOM	MAY	2020	Energy	Natural Gas	3453145	6045012.28
FUTCOM	JUN	2020	Energy	Natural Gas	3645716	5936716.2
FUTCOM	JUL	2020	Energy	Natural Gas	4215433	7023756.32
FUTCOM	AUG	2020	Energy	Natural Gas	3349615	7317028.16
FUTCOM	SEP	2020	Energy	Natural Gas	5499013	12010405.68
FUTCOM	OCT	2020	Energy	Natural Gas	5100800	13468052.83
FUTCOM	NOV	2020	Energy	Natural Gas	4870236	13161549.62
FUTCOM	DEC	2020	Energy	Natural Gas	4593131	10991676.14
FUTCOM	JAN	2020	Bullion	Gold	374757	15059487.25
FUTCOM	FEB	2020	Bullion	Gold	327626	13645383.92
FUTCOM	MAR	2020	Bullion	Gold	465471	19569728.69
FUTCOM	APR	2020	Bullion	Gold	140258	6425387.91
FUTCOM	MAY	2020	Bullion	Gold	268669	12472199.07
FUTCOM	JUN	2020	Bullion	Gold	291052	13760591.08
FUTCOM	JUL	2020	Bullion	Gold	364432	18239518.92
FUTCOM	AUG	2020	Bullion	Gold	355749	18783924.36
FUTCOM	SEP	2020	Bullion	Gold	309858	15736805.36
FUTCOM	OCT	2020	Bullion	Gold	244050	12358783.36
FUTCOM	NOV	2020	Bullion	Gold	293109	14719268.32
FUTCOM	DEC	2020	Bullion	Gold	233549	11598821.31
FUTCOM	JAN	2020	Bullion	Silver	4114469	12279166.60
FUTCOM	FEB	2020	Bullion	Silver	3478360	10673488.63
FUTCOM	MAR	2020	Bullion	Silver	5299786	12172204.98
FUTCOM	APR	2020	Bullion	Silver	2259160	5118728.77
FUTCOM	MAY	2020	Bullion	Silver	5058075	12740048.93
FUTCOM	JUN	2020	Bullion	Silver	6728964	17830001.31
FUTCOM	JUL	2020	Bullion	Silver	10669670	32631145.42
FUTCOM	AUG	2020	Bullion	Silver	10688468	36905052.94
FUTCOM	SEP	2020	Bullion	Silver	7549554	21983518.84
FUTCOM	OCT	2020	Bullion	Silver	7231257	19582349.05
FUTCOM	NOV	2020	Bullion	Silver	7036918	19633076.56
FUTCOM	DEC	2020	Bullion	Silver	7939364	21088740.65
FUTCOM	JAN	2020	Base Metals	Aluminium	102	144.57
FUTCOM	FEB	2020	Base Metals	Aluminium	14	19.44
FUTCOM	MAR	2020	Base Metals	Aluminium	209	281.55
FUTCOM	APR	2020	Base Metals	Aluminium	35078	46836.31
FUTCOM	MAY	2020	Base Metals	Aluminium	104833	184100.91
FUTCOM	JUN	2020	Base Metals	Aluminium	41938	284762.27
FUTCOM	JUL	2020	Base Metals	Aluminium	41421	287368.96
FUTCOM	AUG	2020	Base Metals	Aluminium	49533	360653.84

Instrument Type	Month	Year	Segment	Commodity	Traded Contract (Lots)	Total Value (Lacs)
FUTCOM	SEP	2020	Base Metals	Aluminium	43965	318660.12
FUTCOM	OCT	2020	Base Metals	Aluminium	47025	351937.63
FUTCOM	NOV	2020	Base Metals	Aluminium	53925	430316.70
FUTCOM	DEC	2020	Base Metals	Aluminium	64818	533694.63
FUTCOM	JAN	2020	Base Metals	Copper	278689	3093968.05
FUTCOM	FEB	2020	Base Metals	Copper	290594	3121477.51
FUTCOM	MAR	2020	Base Metals	Copper	324857	3274641.06
FUTCOM	APR	2020	Base Metals	Copper	152513	1513747.98
FUTCOM	MAY	2020	Base Metals	Copper	250452	2549147.59
FUTCOM	JUN	2020	Base Metals	Copper	381856	4226405.68
FUTCOM	JUL	2020	Base Metals	Copper	475879	5873029.53
FUTCOM	AUG	2020	Base Metals	Copper	456455	5889212.78
FUTCOM	SEP	2020	Base Metals	Copper	452425	5926906.89
FUTCOM	OCT	2020	Base Metals	Copper	418465	5486966.76
FUTCOM	NOV	2020	Base Metals	Copper	365957	4990567.92
FUTCOM	DEC	2020	Base Metals	Copper	356473	5334564.23
FUTCOM	JAN	2020	Base Metals	Lead	197	300.60
FUTCOM	FEB	2020	Base Metals	Lead	32	47.02
FUTCOM	MAR	2020	Base Metals	Lead	402	547.36
FUTCOM	APR	2020	Base Metals	Lead	66185	89151.68
FUTCOM	MAY	2020	Base Metals	Lead	215388	364481.47
FUTCOM	JUN	2020	Base Metals	Lead	93905	660372.32
FUTCOM	JUL	2020	Base Metals	Lead	87277	640432.27
FUTCOM	AUG	2020	Base Metals	Lead	91932	707811.55
FUTCOM	SEP	2020	Base Metals	Lead	97807	728461.61
FUTCOM	OCT	2020	Base Metals	Lead	90410	670390.52
FUTCOM	NOV	2020	Base Metals	Lead	65581	507366.07
FUTCOM	DEC	2020	Base Metals	Lead	79390	629717.08
FUTCOM	JAN	2020	Base Metals	Zinc	201	370.47
FUTCOM	FEB	2020	Base Metals	Zinc	233	379.89
FUTCOM	MAR	2020	Base Metals	Zinc	4433	6378.15
FUTCOM	APR	2020	Base Metals	Zinc	210549	318091.85
FUTCOM	MAY	2020	Base Metals	Zinc	676910	1328781.82
FUTCOM	JUN	2020	Base Metals	Zinc	233691	1891604.96
FUTCOM	JUL	2020	Base Metals	Zinc	268159	2321488.61
FUTCOM	AUG	2020	Base Metals	Zinc	273447	2624793.16
FUTCOM	SEP	2020	Base Metals	Zinc	273993	2641459.92
FUTCOM	OCT	2020	Base Metals	Zinc	259731	2549465.12
FUTCOM	NOV	2020	Base Metals	Zinc	239546	2555172.40
FUTCOM	DEC	2020	Base Metals	Zinc	235557	2576501.18
FUTCOM	JAN	2020	Base Metals	Nickel	431752	6495492.48
FUTCOM	FEB	2020	Base Metals	Nickel	314330	4437727.23
FUTCOM	MAR	2020	Base Metals	Nickel	337864	4564590.05
FUTCOM	APR	2020	Base Metals	Nickel	117974	1629314.59
FUTCOM	MAY	2020	Base Metals	Nickel	249835	3485265.31
FUTCOM	JUN	2020	Base Metals	Nickel	306005	4449636.09
FUTCOM	JUL	2020	Base Metals	Nickel	380965	5789551.40
FUTCOM	AUG	2020	Base Metals	Nickel	345500	5686257.89
FUTCOM	SEP	2020	Base Metals	Nickel	308342	5075627.99
FUTCOM	OCT	2020	Base Metals	Nickel	328446	5561489.79
FUTCOM	NOV	2020	Base Metals	Nickel	306346	5455298.01
FUTCOM	DEC	2020	Base Metals	Nickel	299010	5685816.47
FUTCOM	JAN	2020	Agriculture	Cotton	53065	262115.66
FUTCOM	FEB	2020	Agriculture	Cotton	49124	234421.96
FUTCOM	MAR	2020	Agriculture	Cotton	53811	235599.62
FUTCOM	APR	2020	Agriculture	Cotton	21934	89885.56
FUTCOM	MAY	2020	Agriculture	Cotton	25078	98610.85
FUTCOM	JUN	2020	Agriculture	Cotton	25800	104101.44
FUTCOM	JUL	2020	Agriculture	Cotton	23372	94127.31
FUTCOM	AUG	2020	Agriculture	Cotton	9765	41006.48
FUTCOM	SEP	2020	Agriculture	Cotton	4509	20126.45
FUTCOM	OCT	2020	Agriculture	Cotton	9713	47026.76

Instrument Type	Month	Year	Segment	Commodity	Traded Contract (Lots)	Total Value (Lacs)
FUTCOM	NOV	2020	Agriculture	Cotton	17035	85303.99
FUTCOM	DEC	2020	Agriculture	Cotton	26680	135482.47
FUTCOM	JAN	2020	Agriculture	Cardamom	633	2469.55
FUTCOM	FEB	2020	Agriculture	Cardamom	460	1538.76
FUTCOM	MAR	2020	Agriculture	Cardamom	320	758.62
FUTCOM	APR	2020	Agriculture	Cardamom	129	236.26
FUTCOM	MAY	2020	Agriculture	Cardamom	49	79.13
FUTCOM	JUN	2020	Agriculture	Cardamom	39	55.41
FUTCOM	JUL	2020	Agriculture	Cardamom	17	24.26
FUTCOM	AUG	2020	Agriculture	Cardamom	0	0.00
FUTCOM	SEP	2020	Agriculture	Cardamom	3	4.64
FUTCOM	OCT	2020	Agriculture	Cardamom	10	14.82
FUTCOM	NOV	2020	Agriculture	Cardamom	6	8.81
FUTCOM	DEC	2020	Agriculture	Cardamom	0	0.00
FUTCOM	JAN	2020	Agriculture	Metha oil	10951	49274.77
FUTCOM	FEB	2020	Agriculture	Metha oil	11562	48917.65
FUTCOM	MAR	2020	Agriculture	Metha oil	8083	33315.22
FUTCOM	APR	2020	Agriculture	Metha oil	1456	6437.96
FUTCOM	MAY	2020	Agriculture	Metha oil	415	2563.52
FUTCOM	JUN	2020	Agriculture	Metha oil	1381	15112.05
FUTCOM	JUL	2020	Agriculture	Metha oil	1440	14868.76
FUTCOM	AUG	2020	Agriculture	Metha oil	1851	19844.03
FUTCOM	SEP	2020	Agriculture	Metha oil	1710	17646.74
FUTCOM	OCT	2020	Agriculture	Metha oil	1196	12161.29
FUTCOM	NOV	2020	Agriculture	Metha oil	845	8671.88
FUTCOM	DEC	2020	Agriculture	Metha oil	1160	12362.34

Source: Multi-Commodity Exchange, India