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Efficiency of the Black-Scholes Option Pricing Model in the Pricing of Palm-Oil Futures in Nigeria's Physical Market.

Dr. Okaro, Celestine Sunday Ogonna[1], Okeke, Chukwunonso Kingsley[2], Dr. Uzondu, Chikodiri Scholastica[3]
[1,2]Department of Banking and Finance, Nnamdi Azikiwe University, Awka, Nigeria.
[3]Anambra State Polytechnic, Mgbakwu, Anambra State, Nigeria.

Abstract : *This study tested the efficiency of the Black-Scholes Options model for suitability in determining contract prices of palm-oil futures in Nigeria's physical market. The effects of the constant volatility and efficient market assumptions of the model was examined for a seasonal commodity in an unstructured market as recommended in recent literatures reviewed, on the model's effectiveness. The study used primary sample data from an over- the- counter, palm-oil physical market in Nkwo-Nnewi, Anambra State, Nigeria. The approach involved generating the model's implied contract prices using historical prices of the commodity at the seasonal peak and dip periods for ten years. These contract prices were compared with the assessed unit profit/loss margins of the same historical periods and correlated with Pearson's Coefficient. Findings showed a fairly strong positive and significant correlation between the generated contract prices and the actual historical margins. The study concluded that the model is suitable to be employed as a base for pricing unstructured over-the-counter seasonal commodity contracts and recommended that seasonality adjustments and increased stochastic factors should be included to the model for more accurate pricing and application in Nigeria's physical market.*

Keywords: Black-Scholes, Pricing Model, Palm-Oil, Nigeria, Physical Market

1. INTRODUCTION

The use of commodity derivatives has a long history. Back, Prokopczuk, and Rudolf (2010) described documented and published accounts of Options trading in Aristotle's book dating back 322 BC, proving that this type of financial transactions have been in practice informally since time. However, academic literature has mainly focused on the dynamics of markets with formal structured trading Exchanges, and these works are mostly from developed countries with advanced and efficient markets. Recently, some developing countries have started advancing their commodity markets for example China added two commodity Option Exchanges at the end of 2016 and India has been expanding its Futures commodity market since 2001. Nigeria restructured and privatised its commodity Exchange in 2014 to reposition it for advancement in derivatives trading amongst other objectives. Most of these new Exchanges of developing countries are yet to meet expectations and studies investigating these markets are emerging. Hong (2017), Inani (2017), Gupta (2014) and many others have tested popular derivatives models on Chinese or Indian commodity markets, however there are limited empirical works that record evidences from Nigeria's commodity markets.

Recurring amongst all commodity derivatives works, is the issue of Option price models investigations, while amongst works from developing economies/markets are issues in the agricultural futures market. However, common amongst works from underdeveloped markets is the issue of developing reliable commodity Exchanges, especially for agricultural products. Nigeria has a commodity market platform (the Nigerian Commodity Exchange NCX) but it is hardly functional. The volume of trade on this platform is inconsequential compared to that on the physical market. Perhaps it is assumed that a reliable price investigation cannot be achieved from countries with the informal, unregulated, over the counter commodity OTC markets. Tests to provide evidences from such unstructured markets will not only contribute to knowledge in developing suitable pricing frameworks for these types of markets but also measure the efficacy of known models in such market situations.

For a relatively unknown market to be tested, it requires a well-known model that is universally accepted for determining the price of derivatives contracts. Fortune (1996) describes the Black-Scholes Option Pricing Model (BSOPM) as the best known option pricing model. Black and Scholes (1973) published "the pricing of options & corporate liabilities" where they introduced, the model that went on to become arguably, the most cited model for pricing derivatives of traded securities. The BSOPM is an equation that determines the future call price as a function of the present stock price, derived from the absence of profitable arbitrage assuming that the stock price follows a random walk, with a constant mean and variance of the rate of return. Despite being conceived for European derivative instruments, it is renowned for being usable in pricing all derivatives contracts, from simple Forwards to complex Exotics. Most other effective models have either been modified or derived from its basic concepts.

The inherent conceptual issues, revealed by contemporary literatures on the efficiency of the BSOPM in determining implied volatility of security prices, is that the assumptions of the model may affect its effectiveness in appraising agricultural commodities price volatility. The seasonal characteristics of agricultural commodities create conditions that are against some of the assumptions of the model. Several works reviewed in this study, treated and gave empirical evidence on errors created by the lognormal distribution and the efficient market assumptions of the BSOPM in evaluating contract prices for agricultural commodities (Ladislav & Miloslav, 2013; Gordon, 2014; Woodard & Sproul, 2016). More so the effect of the constant volatility assumption, argued to be the most important assumption (Stack, 2012), has witnessed limited research when applied to agricultural commodities contracts which usually have relatively longer duration. Palm Oil was selected as the research commodity as it satisfies the conditions required in the review for a suitable underlie (Moles, 2004).

With respect to context of earlier studies, that there hardly works providing evidence from underdeveloped market economies from the market practitioner's perspective. Majority from the sample works reviewed reveals that the BSOPM and most other price models were tested in efficient markets with near perfect liquidity, and since most OTC markets do not possess either of these requirements especially for agricultural commodities market in developing countries, hence there is need to know the effectiveness of these models in an unstructured OTC market. This becomes more imperative as nearly half of all works reviewed found that market efficiency is the determining factor of model efficiency.

Also on the findings of earlier studies, there is no clear consensus as whether the BSOPM is satisfactorily accurate or not as there almost equal number of works that conclude that the BSOPM is adequate as to those that disagree from the sample studied. With respect to time frame of earlier studies, there is no clear trend in the acceptance of the BSOPM efficiency with time of study, although majority of the most recent studies tend to recommend the BSOPM as efficient. In addition, with respect to methodologies applied, there are scanty works testing the model's efficiency with the market type and its peculiar form and the studies found are only just recent. Therefore there is a gap in research providing evidences to determine the impact of underdeveloped market on the efficiency of the price model.The broad objective of the study is to test the suitability of the BSOPM in the pricing for palm-oil futures in Nigeria. The specific objectives are to evaluate the BSOPM implied contract prices of the historical peak and dip prices of palm-oil in an unstructured OTC physical market and to determine the historical relationship between the evaluated unit BSOPM contract forward price and the unit profit/loss margin for Palm-oil commodity trading. The hypotheses of the study are as follows: H_0 1- The BSOPM implied contract prices are not effective in an undeveloped unstructured OTC physical commodity futures market. H_o 2- The BSOPM is not efficient for pricing agricultural commodities futures as the historical relationship between its evaluated contract prices and the generated profit/loss margin in the seasonal trading of the commodity is weak.

The study covered the primary sourced details of historic prices of the yearly periodic seasonal palm oil futures between 2007 and 2016 and the deduced transaction dynamics as well as the market prices at the Nkwo- Nnewi market (Palm Oil Section) sampled to represent the local unstructured OTC Nigerian agricultural commodity market.

2. Literature Review

Conceptual Review: Black-Scholes as a testing Model

The argument on why BSOPM may not be efficient in pricing agricultural commodities futures contracts stem mainly from the assumptions of the model itself. Gordon (2014) discussed the considerations in models to be used in predicting agricultural commodities futures owing to its seasonal peculiarities. These considerations are not in line with the BSOPM basic assumptions. Stack (2012) explained the concepts behind these assumptions and the features to each, in relation to the implied volatility of agricultural commodities futures, are summarized as follows:

Constant volatility has been described as the most significant assumption by many authors. BSOPM assumes that volatility, which measures how much a commodity is expected to move in the near-term, is a constant over time. While volatility can be relatively constant in very short term, it is never constant in longer term, (Stack, 2012). Some advanced option valuation modellers have substituted Black-Schole's constant volatility with stochastic-process generated estimates (Lordkipanidze & Tomek, 2014).

Efficient market is an assumption of the BSOPM that suggests that people cannot consistently predict the direction of the market or an individual security. The BSOPM assumes stocks move in a random walk manner. Meaning that at any given moment in time, the price of the underlying security can go up or down with the same probability, (Stack, 2012), that is the price of a security in time t+1 is independent from the price in time t.

No dividend is another assumption that suggests the underlying security does not pay dividends during the option's life. In the real world, it is possible for earnings to be made from holding commodities futures before expiry. Although, the BSOPM has been adjusted for dividends, and so there is a work around for this assumption as it relates to the formula. A common way of adjusting the model for dividends is to subtract the discounted value of a future dividend from the security price.

Interest rates are constant and known: Like the volatility, interest rates are also assumed to be constant in the BSOPM. The model uses the *risk-free* rate to represent this constant and known rate. In the real world, there is no such thing as a risk-free rate (Stack, 2012). But it is possible to use the government Treasury Bills short term rates. However, these treasury rates can also change within the life of the contract.

Lognormally distributed returns: BSOPM assumes that returns on the underlying security are normally distributed. This assumption may be reasonable in the real world for certain stocks but for it is not for agricultural commodities.

The empirical results of Gordon (2014) conclude that several agricultural futures markets logarithmic price changes do not follow the normal distribution.

European-style options: BSPOM assumes European-style options which can only be exercised on the expiration date. Most agricultural futures contracts can handle this assumption because they are usually designed with fixed duration to expire at seasonal peak or dip periods. However, the American-style options are more valuable due to their greater flexibility.

No commissions and transaction costs: BSOPM assumes that there are no fees for buying and selling options and security and no barriers to trading. Again, authors have suggested that the discounted values of security prices could be used as a way out.

Liquidity: BSOPM assumes that markets are perfectly liquid and it is possible to purchase or sell any amount of stock or options or their fractions at any given time. For agricultural commodities market, this assumption is unrealistic in the real world, but it is also so for most other markets that are traded OTC and most other models makes the same assumptions.

Palm Oil as a Commodity for testing.

In weighing the appropriateness of the selected commodity as underlier for the study, Moles (2004) description of a suitable Underlier was reviewed and the summary of the properties required were highlighted as being: naturally traded from normal business transactions; widely traded in business transactions; familiar to everybody; not requiring expert knowledge; readily obtainable; cheap per unit; and basic to life. Palm oil as it is traded in Nigeria performs satisfactorily with all of these criterions.

In addition to these, Palm oil also satisfies the conditions of the recommendations of authors prescribing theories on the developmental needs of the Nigerian derivatives market. Osuoha (2013) concluded that for Nigeria to develop its derivatives market the traded underlier has to be in line with the developmental policies of the country and the underlier has to be real commodities and agricultural commodities. Osuoha (2013) also declared that derivatives of Palm Oil have been traded over the counter OTC for decades in Nigeria without any formal structures yet market participants have clearly managed volatility in prices. It is imperative to understand the existing informal measurements of volatility, as applying formal figures from structured market index may not be appropriate. Rather, there is need to review the already existing informal Futures traded OTC suggesting that development should go from known to unknown, from existing to modified. This is with a view to maintain the natural flow of development and to carry along the acceptance of existing market participants.

Poku (2002) analysed small scale Palm oil processing in Africa and the summary of findings are as follows. Palm Oil is an extract of palm kernel nuts and it is sold locally in wholesale units of 25 liters Jerry cans. Uses include cooking, manufacturing of drugs, manufacturing of animal feed, and exportation. It's a very seasonal commodity, abundantly available in periods of January to April (Supply exceed demand -dip period) and scarce from July to October (Demand is in excess of supply- Peak period) depending on when the rains come. However the fundamental factor to note is that in a year the peak month is almost always ahead of the burst month by six months. Quality is an essential factor but doesn't affect market prices as much as supply. Palm Oil can last for up to 2 years without getting spoilt if stored properly.

2.2 Theoretical Framework

Wikipedia (2016) described Pricing as the most fundamental aspect of any financial model. Derman and Wilmott (2008) highlighted that its clear inputs, and engineering mean and its robustness makes the BSOPM the most convenient available option pricing model to academics, practitioners, and regulators. Boudreaux (2003) highlighted the features of the BSOPM in its application that supports the pricing of agricultural commodities futures to include:

That there can only be two underlying security prices in the period of a contract. These are the Spot price, which describes the market price on the valuation date and the Strike or exercise price, which describes the price level at which the option holder has the right to buy or sell the underlying asset. For illiquid agricultural commodities, the spot price may be challenging to estimate, however under normal circumstances the closing market price are usually used. The strike price other the hand is a more straightforward input;

That it can handle multiple- period call/expirations. Where the strike price of the former period may be used as the next period's spot price and a new strike price is inputted. This characteristic of the model enables it to make up for the perceived efficiency advantages of the Simple Continuous Probability Pricing model.

Hinz, and Fehr (2010) in studying the effect of storability on risk neutral commodity price modeling, declared that unlike derivatives of financial contracts, commodity options exhibit distinct particularities owing to physical aspects of the underlying and they suggested a simultaneous dynamical management of the effect of storability through interest rate modeling.

Mole (2004) describe fair value of handling cost the risk interest cost of the commodity for the period, assuming no storage costs and Sofos (2013) argued the price of a forward commodity contract would not be fair, if it did not include or could not hedge. Clearly, it would be an expectation at time t of the forward spot prices ST. He expressed the fair value as

Fvalue = E_t(ST) = $S_o\, \boldsymbol{e^{rt}}$

or in the case that there is also a storage cost U

the fair value will be given by

Fvalue = E_t(ST) = (S_o + U) $\boldsymbol{e^{rt}}$

where E_t is the expectation at time t, S_o is commodity price at t= 0, U is the storage cost of the commodity at t = 0 and over the life of a forward contract. If some or all of the cost is not spent at t = 0, and that this future cost should be discounted at the risk-free rate.

However, Botoş and Ciumaş (2012) in analyzing the use of the BSOPM in the field of weather dependent derivatives concluded the model is not suitable for use in pricing individual weather derivatives contract due to manifestations of theoretical and mathematical/economical inconsistencies. Bozic, (2010) also concurred on causal role of weather and storage inconsistencies. These inconsistencies make the use of the BSOPM model hardly preferable for seasonal commodities and they recommended the model feasible to be put in use for weather derivatives only when they are part of a portfolio. But in the recent Weatherall (2017) theoretical review of "The Peculiar Logic of the Black-Scholes Model", he acclaims that it is because the BSOPM model fails that it turns out to be so useful. It is also note worthy that Black (1976) himself also worked on the BSOPM to adjust for commodities and Mitra (2012) confirms that this adjustment performed better in price valuation in Nifty commodity Futures index.

2.3 Empirical Review

Contrary to expectations the unstructured OTC market situation could offer some advantages over the structured exchange market in determining derivatives instrument prices correctly. Erasmus (2014) study showed that liquidity, regulation and commodity pricing were the determining factors in the OTC bond option market instruments deterioration in South Africa. While liquidity and commodity prices could work against the unstructured OTC market, regulation is a plus for development of more accurate instruments. However, it remains unclear how the weight of little or \no regulation will do against the other factors. Maher (2010) stressed the importance of issuers to understand the OTC option prices and liquidity situation as more information, than either the commodity price or implied volatility, are required to capture the contract conditions and value.

Alexander (2008) examined five representative commodities Commodity Options on the U.S. exchanges where options on energy futures, metals futures, and agricultural futures are traded and compared the historical volatilities of the commodities. He ascertained that the historical characteristics of commodity prices are specific to the commodity type over implied market volatility

Inani (2017) also examined the price discovery process and relative efficiency of ten most liquid agricultural commodities' futures contracts, traded on the largest agricultural commodity exchange of India (National Commodity and Derivative Exchange Limited). Using three different common factor methodologies—component share method, information share method), and modified information share method to determine the extent of price discovery contribution by spot and futures markets. Results showed that the futures market leads the spot market in case of six commodities, and the spot lead for four commodities. Thus he concluded that futures market is more efficient in price discovery of agricultural commodities. This proves that the position also holds for developing markets

However, price discovery is a function of the efficiency of the market and the model that best apply. Soaresy (2016) attempted to clarify the links between spot and futures prices for agricultural commodities, by building a model that incorporates the recent evolutions of these markets using a fast and sequential trading framework. His results proved that an increase of the orders' fragmentation allows a decreasing volatility and increasing information integration. Hence, concluding that the operational criterion of the market determines how efficient models will work.

The operational criterion that organized markets are assumed efficient has been largely criticized. Woodard and Sproul (2016) investigated the causal impact of hedging pressure on risk premiums in major commodity futures-options markets, relying on the U.S. Federal Crop Insurance Program for identification which assumes efficient markets and detected substantial pricing errors in the program due to futures-options market inefficiencies results in insurance premium misstatements. The results showed far-reaching implications owing to assumptions of market being efficient.

These assumptions of efficient market stem from the models applied therein. The BSOPM assumption that market volatility is has a normal distribution has been argued as the major source of error in markets that don't obey a normal distribution and Gordon (2014) in studying the distribution of changes in commodity future prices parametric and non parametric test of normality and resolved that agricultural futures markets, logarithmic price changes do not follow the normal distribution. He then recommended that in using econometric forecast and forecast accuracy models there is need to consider seasonality of variance.

Also, Onour and Sergi (2011) in capturing the volatility in the global food commodity prices employed two competing models; the thin tailed the normal distribution, and the fat-tailed Student *t*-distribution models. Results show the *t*-distribution model outperforms the normal distribution model, suggesting that the normality assumption of residuals which are often taken for granted may lead to unreliable results of the conditional volatility estimates.

In addition, Ladislav and Miloslav (2013) analysed the market efficiency of 25 commodity futures across various groups of agricultural commodities utilizing the Efficiency Index of an organized exchange and found that commodities of similar characteristic share similar market efficiency. Energy dependent commodities being the most efficient and livestock related being least efficient groups. They concluded that for agricultural commodities seasonal factors contribute most to predictability and commodities of shorter seasonal durations are more predictable.

Back, Prokopczuk and Rudolf (2010) also tested the effects of seasonal volatility on models' option pricing performance and confirmed that appropriate seasonality adjustment significantly reduces pricing errors and yields more

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improvement in valuation accuracy than increasing the number of stochastic factors.

Where seasonality factor has been established as prime for agricultural commodities, many authors have non conventional approaches to its implied volatility with significant results. Triantafyllou, Dotsis and Sarris (2013) examined volatility forecasting in agricultural commodity Markets using information content of model-free option implied moments in 3 commodities derivative markets. They found that option-implied risk-neutral variance outperforms historical variance as a predictor of future realized variance and also that the risk-neutral option implied skewness significantly improves variance forecasting when added in the information variable set. Hence they concluded that Variance risk premia added significant predictive power when included in predicting future commodity returns.

Furthermore, Lordkipanidze and Tomek (2014) in studying the pricing of options with stochastic volatilities in application to agricultural commodity contracts, supported the existence of seasonality, time-to-maturity, and long-memory effects in the volatility of prices, but not in the returns themselves, in futures markets. Here they used Orenstein-Ulenbeck process driven by fractional Brownian motion and their inclusion of long-memory stochastic volatility had a significant impact upon the term structure of implied volatilities. Thus they resolved that fractional stochastic volatility model offers improvement over the standard BSOPM and should provide better estimates for options' prices.

Yet, in all the arguments, BSOPM remains the most widely accepted model by most authors and the next step in the opinion trend is testing the model's performance on specific agricultural commodities futures in the specific market which it is traded. This evidenced by the aim and approach of recent tests. Goodwin, Ardian, Harri, Rejesus, Coble and Knight (2017) compared the predictive results of the Black-scholes model to several other models and empirical test show that Black-scholes prices still compared better than alternative implied volatility forecast approaches for agricultural commodities, although marginally. They recommended that Price and yield (profit margin) correlations should be reviewed to measured implied volatility.

Gupta **(**2014) in testing the effectiveness of the *BSOPM* in *pricing the* S&P CNX Nifty options traded at India's NSE *by* correlating between the historical volatility and the BSOPM implied volatility, established a significant and positive correlation between the historical volatility and the implied volatilities. Further tests carried out led to his concluding that BSOPM predicts more efficiently than historic volatility for stock options.

3. METHODOLOGY

This study is an ex-post facto research, involving a comparative analysis for the hypotheses #1 and a predictive correlation for hypotheses #2. The design required correlating, the historical price volatility as an independent variable and the BSOPM's implied cost volatility as a dependent variable. A Short Forward contract position was used for analysis.

Model Specification and Validity

Akintunde (2012), and Tijani & Mathias (2013) both discussed the use of the BSOPM and its application in creating a pricing framework for the development of the derivatives market in Nigeria. Their argument is based on that an efficient price mechanism is essential for the institutional exchange to absorbing trading from the physical market.

Black-Scholes (1973) presented their formula simply as:

$$C_0 = S_0 N(d_1) - Xe^{-rfT} N(d_2)$$

Where

$$d_1 = [In(S_0/X) + rfT]/\sigma(T^{\frac{1}{2}}) + 0.5\sigma(T^{\frac{1}{2}})$$ and

$$d_2 = d_1 - \sigma(T^{\frac{1}{2}})$$

where C_0: Contract Price
S_0: Underlying Security Price
X: Exercise Price.
rf: Risk free interest Rate.
σ: Standard deviation of underlying security.
T: Time unit expiration.

For hypotheses 1 the model used for comparative analysis is as described by Sofos (2013)

$$\frac{Cot}{HC_t} \quad › \quad 0 \qquad (1)$$

Where C_{0t} represents the contract price implied by the BSOPM at time t and HC_t represents the holding cost for the duration of the contract.

For hypotheses 2, the model for the predictive correlation is as adopted by Gupta (2014). The correlation of the historical volatility against the implied volatility of the commodity is expressed as

$$P_{mt} = \beta_0 + \beta_1 C_{0t} + \varepsilon_t \qquad (2)$$

Where: P_{mt} represents the periodic unit profit/loss margin for Palm-oil commodity trading in the physical market at time *t*. β_0 is a constant coefficient while β_1 defines the coefficient of the regression model 2 while ε_t is residual term.

Method of data analyses

The Product –Moment Coefficient of Correlation was used to determine the correlation between the generated BSOPM contract prices in trading with a palm-oil derivative contract and the profit / loss margins in trading without a palm –oil derivative contract. The correlation coefficient represented by (r) is given as

$$r = (n\sum xy - \sum x \sum y)/(\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]})$$

where, n : number of periods, x : variable represents BSOPM Contract prices, y : variable represents calculated profit/ loss in trading without contract.

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Presentation and Interpretation of Results

The seasonal dip and peak period for unit price of palm-oil for duration 2007 to 2016 were extracted and computed as follows:

Table 4.1 Prices of 25 litres of palm oil in peak and dip periods of September and March respectively, from 2007-2016.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dip period	N2,500	N3,200	N3,800	N4,000	N4,000	N3,800	N4,500	N6,000	N6,000	N6,500
Peak Period	N5,200	N6,000	N6,500	N8,000	N4,600	N8,500	N8,000	N11,000	N12,500	N18,000

Source: Nkwo-Nnewi market Anambra State, Nigeria – Palm oil line

The BSOPM contract prices were then generated for each period using exercise price as 100% increase of the security price at the dip periods since we analysed for a short forward position. Inputting the parameters on a Windows Excel formula sheet the following results were obtained.

Table 4.2 Black- Scholes contract prices for palm-oil futures exercised at double security price at dip periods, from 2007-2016 (Per Unit 25 liters Can).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Security Price	N2,500	N3,200	N3,800	N4,000	N4,000	N3,800	N4,500	N6,000	N6,000	N6,500
Exercise Price	N5,000	N6,400	N7,600	N8,000	N8,000	N7,600	N9,000	N12,000	N12,000	N13,000
Black-Scholes's price	N239	N306	N363	N382	N382	N363	N430	N573	N573	N621

Source: Computed by authors on excel 2007

The profit/loss margins for the actual trading with without a derivative contract for the study duration were then calculated as follows:

Table 4.3 Assessed Profit of Palm-Oil Purchased during dip period and sold during peak periods from 2007- 2016. (Per Unit 25 litres).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Actual Peak Period Price	N5,200	N6,000	N6,500	N8,000	N4,600	N8,500	N8,000	N11,000	N12,500	N18,000
Less Cost of Security	N2,500	N3,200	N3,800	N4,000	N4,000	N3,800	N4,500	N6,000	N6,000	N6,500
Less Cost of funds	N500	N640	N760	N800	N800	N760	N900	N1,200	N1,200	N1,300
Profit	N2,200	N2160	N1940	N3200	-N200	N3940	N2,600	N3,800	N5,300	N10,200

Source: Computed by the authors

The BSOPM contract prices generate was then computed against the actual profit/ loss margin in the corresponding periods, as follows:

Table 4.4 Black-Scholes contract unit price against unit profit of Palm-Oil traded between 2007-2016 expressed in a thousand naira (N'000) Per Unit 25 liters Can.

Source: Computed by the authors

BSOPM unit prices(x)	N0.239	N0.306	N0.363	N0.382	N0.382	N0.363	N0.430	N0.573	N0.573	N0.621

Unit Margin (y)	N2.2	N2.16	N1.94	N3.2	-N0.20	N3.94	N2.6	N3.8	N5.3	N10.2

Source: Computed by the authors

The value of the Product –Moment Coefficient of Correlation was then calculated and computations were done as follows.

N	X	Y	xy	x^2	y^2
1	0.239	2.2	0.5258	0.057121	4.84
2	0.306	2.16	0.66096	0.093636	4.6656
3	0.366	1.94	0.71004	0.133956	3.7636
4	0.382	3.2	1.2224	0.145924	10.24
5	0.382	-0.2	-0.0764	0.145924	0.04
6	0.363	3.94	1.43022	0.131769	15.5236
7	0.43	2.6	1.118	0.1849	6.76
8	0.573	3.8	2.1774	0.328329	14.44
9	0.573	5.3	3.0369	0.328329	28.09
10	0.621	10.2	6.3342	0.385641	104.04
$\sum_{i=1}^{10} for\ all\ variables$	4.235	35.14	17.13952	1.935529	192.4028

Substituting for (r)
r = 0.72167

Difference in average X-Y =	-3.0905
Variance in Set X =	0.142007
Variance in Set Y	68.92084
1/(n_x+$n_x$ny-2) =	0.055556

(1/nx + 1/ny) =	0.2
student's t =	-3.52799

Above the .05 level of significance 2.101, therefore this is not a sample error, and the hypothesis Ho2 is rejected

Table 4.5 Estimated fair value of handling costs, along BSOPM contract prices at dip periods 2007-2016.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Security Price	N2,500	N3,200	N3,800	N4,000	N4,000	N3,800	N4,500	N6,000	N6,000	N6,500
Fair Value of contract	N231.6	N296.5	N352.1	N370.6	N370.6	N352.1	N418.5	N561.6	N561.6	N608.4
Black-Scholes's price	N239	N306	N363	N382	N382	N363	N430	N573	N573	N621

Source: Computed by the authors

The BSOPM prices is higher than that of the estimated fair values of the contract for all the periods, therefore the hypothesis Ho1 is rejected.

Interpretation of results

i. The result shows that for the years 2007 -2016 the periodic seasonal BSOPM unit contract prices for palm-oil futures, with 100% increase in commodity spot price as strike price, exceeds the estimated holding cost of the commodity for all the periods.

Therefore, the null hypothesis H_0 1 is rejected and the alternative accepted.

ii. Also, the results indicates that there is a good positive relationship of 72.2 % between the BSOPM unit contract prices for the Future contracts and the profit/loss trend of trading in Palm-Oil without Future contracts for the period of study . Thus, the null hypothesis H_0 2 is rejected and the alternative accepted.

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4. Discussion of Findings

- Mole (2004) model of fair value of handling was more suitable as reflects more the situation in the physical market.
- It is like that if the research duration of period was applied for a longer number of years the efficiency of the model prices is likely to improve and cumulative profit /losses is likely to reduce.
- The parameters model parameters were not easy to obtain but any recognised body that represents an efficient exchange should be able to provide especially the SD and current government lending rates for markets participants to use. Asimple software on the model can be employed to give readily available contract prices at the exchange offices. The trader only has to provide his/her desired exercise price.
- The model can definitely be applied for Call and Put options for all possible derivatives of Palm-oil as presently traded in Nigeria.

5. Summary of Findings, Conclusion and Recommendations

Summary of findings

1. The implied contract prices of the BSOPM on palm-oil Futures at seasonal intervals were consistently greater that estimated holding costs of the physical commodity for the duration of the peak and dip seasons between 2007 and 2016. This is as traded in an underdeveloped Nigerian physical market where transactions are done OTC.
2. There is a fairly strong positive and significant correlation between the unit contract price implied by the BSOPM and the historically assessed unit profit/loss margin of trading in palm-oil between peak and dip seasons over the ten year period. This was also established in a Nigerian OTC physical market conditions.

Conclusion

Since the BSOPM contract prices compared higher than the estimated holding costs of the physical commodity, then, going by Sofos (2013) this makes the BSOPM at least usable as pricing tool in Nigeria's physical market. In absolute terms, BSOPM suggests that for example in 2007 a trader wishing the sell a unit of palm oil bought for N2,500 at N5,000 should pay N239 per unit as hedging costs. This cost is considered reasonable as it in excess of the estimated unit storage cost for the period of the contract.

Using the BSOPM, in determining the contract price for Palm Oil Futures in Nigeria, has a fairly good efficiency of 72% when compared with margins from seasonal trading over a ten year period. This is considered as satisfactory based on the t-tests as a base from which more efficient models can be developed.

The constant volatility, efficient market and perfect liquidity assumptions of the BSOPM impact negatively on its efficiency when predicting volatility in seasonal agricultural commodities of developing markets.

Recommendations

1. BSOPM as a pricing tool is efficient enough as a start up model for pricing derivatives contracts of Nigerian local securities. However extensive work still needs to be done to improve the model's efficiency by creating modifications aimed at substituting the constant volatility with stochastic-process generated estimates for agricultural commodities derivatives.

2. Nigeria should consider a bottom up approach rather than a top to bottom approach currently being practiced in trying to develop the derivative market in Nigeria. This means that rather than commissioning an Exchange and inviting traders to trade in derivatives, they should consider going to traders already trading in derivatives and tailor make their exchange or institutionalise the OTC Structure with the help pricing tools like the BSOPM.

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