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# The Relevance of Commodity Derivatives: A Literature Review

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**Abstract: Commodity derivatives have been devised to achieve price risk management on basing the value of a security of an underlying commodity. Commodity derivatives or futures markets hold a key in insulating the producers and the trade functionaries from the seasonal and cyclical oscillations in the prices of commodities, which are aggravated by the high income and low price elasticities of demand and the shifts in such elasticities overtime. In this paper, various researchers have put forth their findings in commodity derivatives with respect to different aspects. Few of them have calibrated the model using regression approach. The stochastic behavior of the commodity prices has also been considered by few researchers. Cross commodity option and locational spread option have also been explored by some investigators. The relevance of the commodity derivatives have been discussed and analyzed by various researchers and organizations.**

**Keywords: Future market, regression approach, stochastic behavior, cross commodity, locational spread.**

## Introduction

Commodity derivatives are investment tools that allow investors to profit from certain items without possessing them. This type of investing dates back to 1848 when the Chicago Board of Trade was established. Initially, the idea behind commodity derivatives was to provide a means of risk protection for farmers. They could promise to sell crops in the future for a pre-arranged price. Modern commodity derivatives trading are most popular with people outside of the commodities industry. The majority of people who use this investment tool tend to be price speculators. These people usually focus on supply and demand and try to predict whether prices will go up or down. When the prices of a certain commodity move in their favor, they make money. If price moves in the opposite direction, then they lose money. Commodity derivatives trading allow a person to use a small sum of money for the potential to earn substantial profits. This sort of investment, however, is considered high risk. When prices are not in an investor's favor, he can suffer substantial losses. Commodities that are open to this type of investing include cotton, soybean, and rice. In some countries, although these commodities are available, this type of trading is illegal. The findings obtained from different economists, researchers, investigators on commodity derivatives have been presented in the following section.

## Relevance of Commodity Derivatives over the Globe

Richard [1] has theoretically analyzed the equilibrium of forward and future prices by using a rational expectations model in continuous time. By using this methodology he has found the formulas for equilibrium forward, futures, discount bond, commodity bond and commodity option prices and shown a futures price is actually a forward price for the delivery of a random number of units of a good and also interpreted the conditions under which normal backwardation is found in forward or futures prices. Rauch et al. [2] have established a novel method for pricing commodity index derivatives by using regression approach for model calibration and they performed the pricing of call and barrier options by replicating the index with a portfolio of correlated single commodities. Li and Arriaga [3] have described Ornstein–Uhlenbeck processes time changed with additive subordinators as time- inhomogeneous Markov semi martingales and from which a new class of commodity derivative models is developed that can be used in many processes. Paschke and prokopczuk [4] have extended commodity derivatives valuations with autoregressive and moving average components in price dynamics by analyzing the convenience yield's time series dynamics. Empirically they have estimated parsimonious version of the general model for the crude oil futures market and demonstrated the model's superior performance in pricing of long-horizon contracts. Zolotko and Okhrin [5] have planned a novel framework for the joint modeling of commodity forward curves by introducing a family of dynamic conditional correlation models based on hierarchical Archimedean copulae (HAC-DCC) and also applied these models in the context of commodity forward curves as part of the framework. By analyzing they have shown that the preciseness of their out-of-sample distribution forecasts of the returns of various commodities and, can be a useful and convenient risk management tool.

Daskalaki et al. [6] have studied whether there are common factors in the cross-section of individual commodity futures returns by testing various asset pricing models and these models also allowed to test whether the commodities and equities market are integrated. By using these models they have implied that commodity markets are segmented from the equities market and considerably heterogeneous per se. Mirantes et al. [7] have added to the commodity pricing literature by consistently modeling the convenience yield by showing model for the stochastic behavior of commodity prices with empirically observed characteristics such as the mean reversion and stochastic seasonality. They also found out that commodity price seasonality is better estimated through convenience yields than through futures prices. Lee and Oren [8] have extended an equilibrium pricing model for weather derivatives in a multi-commodity setting by constructing a stylized economy in which agents optimize their hedging portfolios and also include derivatives that are issued in a fixed quantity and are combined in an equilibrium pricing model.

They have analyzed the gains due to the inclusion of derivatives in hedging portfolios. Stepanek et al. [9] have estimated numerous indicators of the supply risk by using the convenience yield of commodity futures as a supply risk indicator. Therefore they have compared the convenience yields to find that it has generally predictive power for the static stock lifetime (i.e., inventory volume/turnover) and future spot prices and an applicable indicator of a commodity's supply risk. Suenaga [10] has inspected bias in a term-structure model of commodity prices by comparing simultaneous and sequential method. In the former method he has compared all model parameters simultaneously with a panel of futures prices and in later a subset of model parameters is first estimated on the first difference of observed futures prices and the remaining model parameters are estimated on the futures price equations, while holding the parameters estimated. After comparing the methods he has indicated that the model estimated by the sequential method yields a considerably more accurate price forecast than the model estimated by the simultaneous method.

Symeonidis et al. [11] have empirically analyzed the behavior of commodity prices and their volatility as predicted by the theory of storage by analyzing the relationship between inventory and the shape of the forward curve and also show that price volatility is a decreasing function of inventory for the majority of commodities. They have analyzed that their findings are robust with respect to alternative inventory measures and over the recent commodity price boom. Back et al. [12] have observed volatility in many commodity markets exhibits a seasonal pattern by integrating this seasonal volatility pattern in option pricing models. They have studied four different commodity markets (soybean, corn, heating oil and natural gas) and find out that the inclusion of an appropriate seasonality adjustment significantly reduces pricing errors and yields more improvement in valuation accuracy. Tsitakis et al. [13] have offered a method for the valuation of cross-commodity electricity options i.e.

European spark spread options and locational spread options by assuming only absence of arbitrage they have provided a closed-form analytic formula for the price of the derivatives where the spot prices of the underlying process follow an exponential Ornstein–Uhlenbeck process. Valle et al. [14] have purposed to obtain the risk-neutral drift of the state variables directly from the market data in a multifactor commodity futures model and to derive some exact results which relate the risk-neutral drifts to the slope of the commodity futures price. They have estimated some of the coefficients of the pricing partial differential equation directly from the futures data available in the markets. They have reduced the computational cost as well as the misspecification error and to investigate the finite sample properties of this approach they have carried out some numerical experiments. Chen et al. [15] have suggested and develop a methodological framework for applying individual and ensembles of polynomial projection models to hedge against oil commodity price risk and also comparatively evaluates the hedging performances of these projection models. In this empirical analysis transaction costs and risk aversion are considered. They have indicated promising hedging capability by projection models and ensemble models perform better than individual models.

Loader [16] has observed derivatives and commodities of markets by trade exchange of different product in the market. He has found out that derivatives bring stability to all types of markets, reducing the need to sell assets and commodities in falling markets by preventing losses when such a fall occurs. Derivatives markets exist in all the major financial centers and are diverse in nature with some specializing in particular products and others being multi-product based. Zhang et al. [17] have studied efficiency properties of a numerical pricing of commodity options with early exercise based on Fourier-cosine expansions. They have focused on variants of Schwartz' model based on a mean reverting Ornstein–Uhlenbeck process, but it does not possess favorable properties for the option pricing method of interest. So they have proposed that the Fast Fourier Transform can be applied for highest efficiency. Yang [18] has recognized a "slope" factor in the cross section of commodity futures returns which is combined with a level factor explains most of the average excess returns of commodity.

He has investigated a competitive dynamic equilibrium model of commodity production to indigenize this correlation and he has found that this factor is significantly correlated with investment shocks. Daskalaki [19] has considered whether an investor is made better off by including commodities in a portfolio that consists of traditional asset classes by employing mean–variance and non-mean–variance spanning tests. Then they have formed optimal portfolios by returns distribution and evaluate their out-of- sample performance. They have found out that commodities are beneficial only to non- mean–variance investors' in-sample setting but these benefits are not preserved out-of-sample. Their findings have challenged the alleged diversification benefits of commodities. Buyuksahin and Robe [20] have used a unique, non-public dataset of trader positions in 17 U.S. commodity futures markets and showing that the correlation between the rates of return on investible commodity and equity indices rises and find no such relationship for commodity swap dealers, including index traders (CITs) and also the predictive power of hedge fund positions is weaker in periods of generalized financial market stress. Their results have supported the notion that WHO trades helps predict the joint distribution of commodity and equity returns.

Byers [21] has projected a valuation methodology for commodity storage facilities by utilizing traded instruments to replicate the fundamental derivative components of this method. He has found out that this methodology is robust to different commodities, physical characteristics, and markets for valuing these types of assets. Vivian and Wohar [22] have investigated whether there are structural breaks in commodity spot return volatility using an iterative cumulative sum of squares procedure and then uses GARCH (1,1) to model volatility during each regime. They have empirically found out that relatively few commodities have structural breaks in volatility during the recent financial crisis and the most structural breaks are idiosyncratic rather than common across sectors or the market. Finally they have concluded that commodity volatility remains highly persistent even after adjusting for structural breaks. Bowden and Posch [23] have stochastically explained 'convenience yield' variations and reversals in the spot –forward premium in commodity market by subjecting the market to disequilibrium phases characterized by rationing or clearing impediments that interfere with arbitrage which are likely to arise when market inventory is in short supply. So they have found out that disequilibrium switches can be based on the inventory/sales ratio. Wang et al. [24] have modeled joint dynamics between oil and agriculture prices using a structure VAR. Their findings have indicated that the effects of an oil shock on agriculture prices depend on its driving forces, it totally explain 20%–40% of variations in agricultural commodity prices and the effects of oil shocks become stronger after recent food crisis. Ji and Fan [25] have considered the volatility spillover effects between crude oil market and various non-energy markets using a bi-variant EGARCH model with time-varying correlation construction. They have revealed that the correlation between the crude oil market and non-energy markets strengthens after the financial crisis and crude oil market is proved to occupy the core position in the whole commodity markets.

Joseph et al. [26] have studied the causality between futures and spot prices of Indian commodity markets using frequency domain approach of Breitung and Candelon (2006) that offers an effective alternative tool by examining the causality in frequency domain by focusing focus on the eight metal and agricultural commodities in the Indian market. From the study they have suggested that there is a strong uni-directional relationship from futures to spot in almost all the selected commodities and futures market has a powerful price discovery function in all the selected commodities in short, medium, and long run. Creti et al. [27] have analyzed the links between commodity and stock markets relying on the dynamic conditional correlation (DCC) GARCH methodology. They have shown that the correlations between both markets evolve through time and are highly volatile and the 2007–2008 crises has accentuated the financialization of commodity markets and also a speculation phenomenon is highlighted for oil, coffee and cocoa, while the safe-haven role of gold is evidenced. Pilar et al. [28] have investigated heterogeneity of the photooxidation processes in plaques stabilized with hindered amine stabilizer (HAS) by using Electron Spin Resonance Imaging (ESRI) and three independent microscopic-scale methods: scanning electron microscopy (SEM), infrared microscopy (IR) and microhardness (MH). Depending upon the duration of accelerated photooxidation ESRI is determined the concentration profiles of nitroxides mapping photooxidation process inside polymer plaques along the direction perpendicular to their surface.

After analyzing and comparing the data they have confirmed that crystallinity and microhardness measured inside the aged plaques and stabilized with Chimassorb® 944 together with SEM micrographs of the irradiated surface layers are found to confirm efficacy of the stabilizer used. Ruadrew et al. [29] have studied mycological profile and aflatoxins content are examined in 12 dried food commodities imported from Asia. They have found out that aflatoxigenic Aspergillus spp. is present in five commodities with low or undetectable levels of aflatoxin and two food commodities have showed no aflatoxigenic moulds but contain aflatoxins exceeding the EU maximum limits. So they have concluded a result that there is no link between presence of aflatoxigenic moulds and occurrence of aflatoxins. Kim et al. [30] have analyzed the dependence structure of the commodity and stock markets using the random matrix theory technique and network analysis. Their results have shown that the stock and commodity markets must be handled as separated asset classes and the exception is selected for the multi-spread convergence trading strategy using a machine learning technique called the AdaBoost algorithm.

Sadorsky [31] has purposed to investigate asset return and volatility spillovers between an important group of commodity producing countries (Canada, Australia, Brazil, and South Africa), commodity prices and the developed stock markets of Japan, the United Kingdom, and the United States empirically using VAR techniques to calculate spillover tables and spillover plots. After analyzing spillover indices for returns and volatility between emerging and developed economy equity assets he has found out that the lower return and volatility spillovers between equities and commodities suggest that commodities may be useful for portfolio diversification and hedging strategies. Chkili et al. [32] have provided a comprehensive study of commodity volatility forecasting using linear and nonlinear GARCH-type models for this relevancy whether it is conducted over both in-sample and out-of-sample periods for accommodating the long memory and asymmetry features. They have found out that the FIAPARCH model is the best suited for estimating the VAR forecasts also gives the lowest number of violations under the Basel II Accord rule. Implications for market risk, policy regulations and hedging strategies are also discussed. Sanidas [33] has investigated various types of harmonic cycles affect commodity currencies (e.g. A$, CA$, NZ$, Norway's Krone) using theoretical and empirical aspects. He has found out that these four harmonics explain about 85% of the currency's fluctuations which is cross-checked in several ways, e.g. forecasts. Santiago et al. [34] have approached to use an optimal control approach to analyze the trade-off between the multiple uses of energy resource using a dynamic model which establishes relationships between economic growths, the fossil fuel, and water and biomass sectors. They have established that the price of commodities for non-energy uses should be twice the price of the energy assets indicating non-commodities sources like solar energy, wind energy, and geothermal energy should be used to generate electricity. Liz and Rost [35] have studied the global behavior of the price dynamics in a commodity market using a discrete model by providing these data to get new sufficient conditions for the global convergence of the solutions to the positive equilibrium in the continuous case. They have provided some bounds for the amplitude of the oscillations when the delay is large for unstable equilibrium.

Silvennoinen and Thorp [36] have estimated sudden and gradual changes in correlation between stocks, bonds and commodity futures returns using double smooth transition conditional correlation (DSTCC–GARCH) models. They have shown that smooth transition models detect both sudden and gradual changes in correlation states and financial state variables (VIX and financial trader open interest) drive changes in volatility and correlation. Feng et al. [37] have investigated a purchasing contract with options under capital constraint and credit support from a financial institution characterizing the buyer’s optimal ordering strategy with limited capital that is, the buyer will only purchase a fixed order when the capital is less than the value with more capital, the buyer will reduce the fixed order quantity and increase the option orders until the capital is used up. From this they have implied that the option is a risk-hedging tool only for easy finance companies and when the buyer obtains funding from a financial institution their profit will be increased with it.

Aboura and Chevallier [38] have studied the Interactions between financial and commodity markets using the asymmetric DCC with one exogenous variable (ADCCX) framework develop an econometric model in which returns and volatility allow to influence pairs of assets. They have found evidence that return and volatility spillovers do exist between commodity and financial markets. Arezki et al. [39] have provided recent work on commodity prices focusing on ‘financialization’ of commodity markets, trends and forecasts of commodity prices and fracking. They have drawn a changing nature of commodity markets due to price fluctuation. Fusai et al. [40] have allowed deriving a closed-form formula for the fair value of discretely monitored Asian-style options by computing an analytical expression of the joint random vector consisting of a spot price and its average for a large class of square-root price dynamics combined with the Fourier transform pricing method. Their analysis have encompassed the case of commodity price dynamics displaying mean reversion and the seasonal structure of spot price volatility and their results have shown show a remarkable improvement over the main alternative techniques developed for pricing Asian-style options within the market standard framework of geometric Brownian motion.

Acharya et al. [41] have studied an equilibrium model of commodity markets in which speculators are capital constrained and commodity producers have hedging demands for commodity futures where equilibrium hedging and supply decision inducing a link between a financial friction in the futures market and the commodity spot prices. By measuring producers' propensity to hedge forecasts futures returns and spot prices they found that the component of the commodity futures risk premium associated with producer hedging demand rises when speculative activity reduces and finally concluded that limits to financial arbitrage generate limits to hedging by producers, and affect equilibrium commodity supply and prices. Cortazara and Eterovic [42] analyzed estimate long term copper and silver future prices using prices of long term oil futures contracts. By analyzing the performance of multi-commodity model (used to estimates two commodities one with much longer maturity futures contracts than the other and they implement the procedure using highly correlated commodities like WTI and Brent) then applied to oil-copper and oil-silver having much lower correlation than the WTI–Brent contracts.

They have shown that for these commodities with lower correlation the multi-commodity model seems not to be effective so they have proposed another modified multi-commodity model with a simple structure to estimate and that uses the non-stationary long term process of oil to help estimate long term copper and silver futures prices. Behrens et al. [43] have investigated the impacts of tax harmonization and changes in tax principle on equilibrium tax rates, industry location, and welfare by offering convenient framework to find out the differences in market size and deepening international integration affect equilibrium outcomes under competing tax principles is shown to exacerbate tax competition and to erode tax revenues. So they have suggested that federations which care about spatial inequality face a non-trivial choice for their tax principle. Frankel [44] has presented a model “carry trade” to estimate the effects of speculative factor and interest rate of oil and other storable commodities by focusing the trade-off between interest rates on the one side and market participants' expectations of future price changes on the other side. He has found out a negative effect of interest rates on the demand for commodity prices and positive effects of expected future price gains on today's commodity prices. Filimonov et al. [45] have proposed a “reflexivity” index (the average ratio of the number of price moves to the total number of all price changes) that quantifies the relative importance of short-term endogeneity for several commodity futures markets and of structural regime shifts in commodity markets by calibrating the Hawkes self excited conditional Poisson model on time series of price changes accounts simultaneously for the co-existence and interplay between the exogenous impact of news and the endogenous mechanism by which past price changes may influence future price changes. They have found out that an overall increase of the reflexivity index since the mid-2000s to October 2012 so they have discovered striking coincidence between its dynamics and that of the price hikes.

Bullock and Hayes [46] have extended the Antonovitz-Roe framework to the construction of a money metric measuring and investor's private value for having access to a derivative security market by examine the case of commodity options. They have shown that when the investor's expected marginal speculative return to the option is equal to the hedge-adjusted marginal expected speculative return to the underlying futures contract then the value measure can never be negative and is equal to zero and their simulation analysis indicates that mean of the underlying price distribution is more significant than the variance in affecting the access value of the option. Janabi [47] has analyzed the performance of liquidity adjusted risk modeling in obtaining efficient and coherent investable commodity and proposed a practical technique for large portfolios that consist of multiple commodity assets where the holding periods are adjusted according to the specific needs of each trading portfolio and a robust technique to commodity optimal portfolio selection, in a liquidity-adjusted value-at-risk (L-VAR) framework that consist of merely pure long trading positions. Moreover he has developed a portfolio selection model and an optimization-algorithm which allocates commodity assets by minimizing the L-VAR subject to applying credible operational and financial constraints.

He has found out that this alternate L-VAR technique can be regarded as a robust portfolio management tool and applied in real-world asset management practices for fund managers with large commodity portfolios. Blancard and Coulibaly [48] have analyzed the causality between prices and index-based trading activity for agricultural commodity futures markets using panel Granger causality estimations based on SUR systems and Wald tests with market-specific bootstrap critical values. Their results have confirmed that there is no causality between index-based positions and commodity futures prices. Liu and Tang [49] have studied the dynamics of the commodity convenience yield which is heteroskedastic for industrial commodities. To explore the economic and statistical significance of the improved specification of the convenience yield process, they have proposed an affine model having three state variables (log spot price, interest rate, and the convenience yield) that captures important features of commodity futures like the heteroskedasticity of the convenience yield, the positive relationship between spot-price volatility and the convenience yield and the dependence of futures risk premium on the convenience yield.

## Discussion

In the literatures cited above, it has been observed that commodity derivatives have been analyzed all over the world to render a benefit to the customer end. A strong, healthy, vibrant and well developed commodity exchanges can play a pivotal role in the globalization of international trade by imparting a competitive pricing efficiency to exports. Commodity derivative market and the security market are expected to function independently of one another. By taking a position in the derivatives market, a producer can potentially offset losses in the spot market. The participation of intermediaries like securities brokers in the commodity futures market is expected to increase the number of quality players, introduce healthy competition, and boost trading volumes. These in turn would provide more liquidity and give greater impetus to the overall growth of the commodity market. Similar benefits are expected to accrue to the securities market if the commodity derivative brokers are allowed to participate in it.

## Conclusions

Derivatives markets hold an immense potential for the economy as they stabilize the amplitude of price variations, facilitate lengthy, complex production decisions, bringing a balance between demand and supply act as a price barometer to the farmers and the traders besides encouraging competition. These markets while enabling price discovery and better price risk management engender inter-temporal price equilibrium and horizontal and vertical price integration. A strong, healthy, vibrant and well developed commodity exchanges can play a pivotal role in the globalization of international trade by imparting a competitive pricing efficiency to exports.

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