ADDIS ABABA UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

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ESTIMATION OF OPTIMAL HEDGE RATIO FOR OIL FUTURES: AN APPLICATION TO THE ETHIOPIAN PETROLEUM SUPPLY ENTERPRISE

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A Thesis submitted to the MBA Program, AAU, in partial fulfillment of the requirement of the Degree of Master of Business Administration in Finance

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Statement of Declaration

I hereby declare that the thesis entitled: Estimation of optimal hedge ratio for oil futures: an application to the Ethiopian petroleum supply enterprise, is the result of my own effort and work and has not previously been presented in any form to the University or to any other institution whether for the purpose of assessment, publication or for any other purpose. I have undertaken it by myself under the supervision of my advisor Abebe Yitayew (PhD). I stated and acknowledged the different resources and materials that I used.

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Declaration

This is to certify that the thesis prepared by **Tesfaye Belete**, entitled *"***Estimation of optimal hedge ratio for oil futures: an application to the Ethiopian petroleum supply enterprise***"* and submitted in partial fulfillment of the requirements for the degree of Master of Business Administration in Finance complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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Advisor: Abebe Yitayew (PhD)

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Table of Contents

List of Tables and Figures

ABBREVIATIONS AND ACRONYMS

ADF	Augmented Dickey-Fuller
CFA	Certified Financial Analyst
CLRM	Classical Linear Regression Model
ECM	Error Correction Model
EPSE	Ethiopian Petroleum Supply Enterprise
FY	Fiscal Year
G.C	Gregorian Calendar
H. E	Hedging Effectiveness
I(d)	Order of Integration
ICE	Intercontinental Exchange
MV	Minimum Variance
MVHR	Minimum Variance Hedge Ratio
OHR	Optimal Hedge Ratio
OLS	Ordinary Least Square
OPEC	Organization of the Petroleum Exporting Countries
S&P	Standard and Poor
WTI	West Texas Intermediate

Abstract

Ethiopian Petroleum Supply Enterprise, the sole importer of different oil products in Ethiopia is exposed to price fluctuation risk. Hedging oil with futures contract can offset this risk. So, the most important issue is to what extent or percentage the risk exposure should be hedged with futures contract. The aim of this thesis is to estimate an optimal hedge ratio that will provide the highest price risk reduction using monthly spot and futures price from October, 1990 to March ,2019. Hedge ratios and hedging effectiveness are determined by employing three models namely: Naïve, OLS (Ordinary Least Square) and ECM (Error Correction Model). Hedging effectiveness is evaluated and compared for the three models. The empirical results show that the ECM model provide highest variance(risk) reduction as compared to other models indicating that this model fits better in designing hedging strategy for EPSE. The empirical finding suggests that the EPSE can use oil futures contract as an effective instrument to minimize price fluctuation risk.

Key Words: *Hedging, Optimal Hedge Ratio, Hedging Effectiveness, OLS, ECM.*

CHAPTER ONE: INTRODUCTION

1.1 Introduction

The energy sector is an essential part of the existence of any modern society. The sector includes fossil fuels (oil, gas and coal), integrated power utilities and renewable energy. Among these oil is the largest energy source in the world. Oil accounts 33% of the world primary energy consumption in 2015,whereas Coal and Natural Gas covers 30% and 24% respectively and the remaining are Hydro which accounts for 7%,Nuclear 4% and others 2% Primary energy (PE) is an energy form found in nature that has not been subjected to any human engineered conversion process. It is energy contained in raw fuels, and other forms of energy received as input to a system. Primary energy can be non-renewable or renewable (Wikipedia, 2018).

All countries consume crude oil or oil products. Both producers and consumers are highly concerned about crude oil prices. The crude oil prices are being directly affected by several economic, political, geopolitical, technological factors, and also oil reserves, available stocks and weather conditions, among others.

Every country in the world are dependent on oil either as a consumer (net importer) or exporter. Due to this they are exposed to price fluctuations. Surging oil prices will be painful for countries that consumes different oil products for their energy needs. On the other hand, countries that export oil products would gain from an increase in the market price of oil. The price changes can be expressed as volatility and higher volatility results in higher risk. Hedging the commodity contracts with futures can offset this risk.

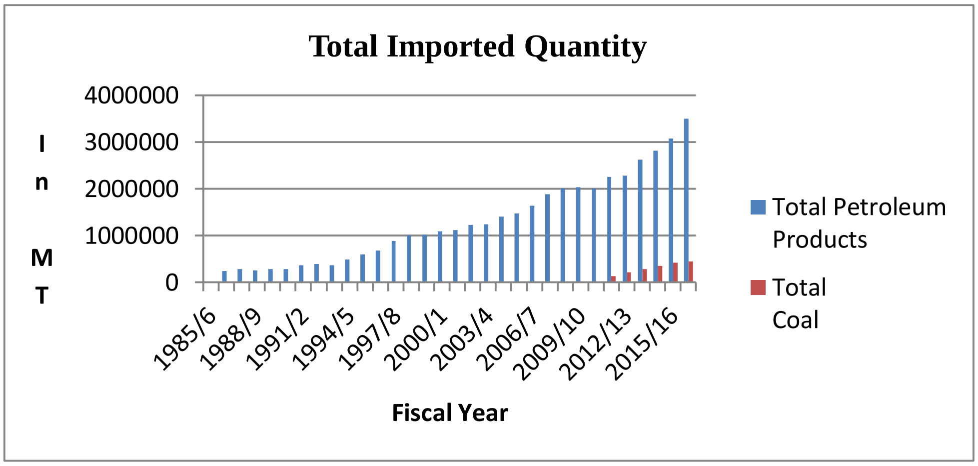
Hedging is an investment made to mitigate the price risk (unfavorable fluctuation) of the underlying assets at maturity. A futures contract is a dominant instrument used in hedging, mainly because of its transparency and liquidity advantages over the others. The hedging is primarily implemented by using a hedge ratio, which determines the portions of the spot that need to be hedged in order to achieve a minimum level of unfavorable price fluctuation (Edington, 1979; Johnson, 1960; Myers and Thompson, 1989).

According to data obtained from EPSE, Ethiopia consumed 3,770,588 (In Metric Ton) of different oil products in 2017/18 Fiscal Year. Import of oils accounts to 1.98 billion USD in 2017/18 FY which is the single highest foreign currency utilizer. According to new business Ethiopia website

Ethiopia export revenue in the 2017/18 FY was $2.84 billion. This shows that close to 70% foreign currency earned from export goes for the purchase of oil products.

Since domestic supply was not available, demand has had to be satisfied by imports: Demand for oil is increasing steadily. For Ethiopia, oil importer, a high oil price is unfavorable as this result in increasing cost for the consumer, and the Ethiopian government.

Figure 1.1: Total Imported Quantity of Petroleum products in Ethiopia from 1985/6-2015/16 G.C



Source: EPSE

The demand for oil products has been increasing steadily since 1993/4 (Epse, 2018). All of the demand for oil product in Ethiopia is met through import by the Ethiopian Petroleum Supply Enterprise(EPSE).

EPSE is a nationally registered public enterprise with a major mission of supplying refined petroleum products to the country. The enterprise had been established in 1967 G.C. Since, Ethiopia lacks oil refinery it only imports refined petroleum products. The enterprise has been the sole importer of refined petroleum products since its establishment. It is also responsible for the administration of strategic petroleum reserve and establishment of petroleum reserve depots.

EPSE imports the following oil products.

Refined Petroleum Products

- Gasoil (ADO: Automotive Gas Oil is used for cars)
- Gasoline (MGO: Marine Gasoil is used as fuel in ships engines.)
- Jet A-1/kerosene (Aviation fuel)

- Light Fuel Oil (LFO)
- Heavy Fuel Oil (HFO)

Steam Coal

- Standard Steam Coal
- Size Steam Coal

Most of the refined products are mainly purchased through open international tenders and are imported via Djibouti. However, 40% of Gasoil or benzene is imported directly from Sudan Petroleum Corporation based on the bilateral agreement between Sudan and Ethiopia. 50% of Aviation fuel and 50% of Diesel fuel (LFO &HFO) is purchased from Kuwait Petroleum Corporation based on the bilateral agreement between Kuwait and Ethiopia. In both cases, periodic negotiation is conducted on premiums based on the bilateral agreements Ethiopia has made with the two countries.

Petroleum Products imported via Djibouti are distributed to oil marketing companies working in Ethiopia at Horizon Terminal, Djibouti while the gasoline imported from Sudan is distributed to the companies at Khartoum through Nile Petroleum Company's Al Shagara terminal (Epse 2017).

Since the enterprise depends on international tenders and bilateral negotiations to purchase different oil products it is prone to oil price fluctuation. Until this day the enterprise is not using any hedging techniques to withstand the oil price fluctuation.

1.2 Background of the Study

The primary function of futures market is hedging. Futures contract is defined as a legal agreement usually between two parties to buy or sell a particular commodity or financial instrument at a predetermined price at a specified time in future. These contracts are standardized to facilitate trading on a futures exchange and are settled daily. Some futures contracts particularly on financial assets (stock or equity indices) are settled in cash, while futures contracts particularly on commodities (e.g., oil, palm oil, soybean etc.) are settled in physical delivery. Almost all exchanges throughout the world, futures contracts are available on different types of assets. Futures contract are used for different purposes depending on the goals of the trader (loss minimizing or gaining profit). However, futures contract has become the most common derivatives instruments of the investors for hedging the risk exposures that may arise from adverse price movements. The effectiveness of futures contracts in managing risks is critical to the development of futures market. To design a better strategy with futures contracts for hedging the risk exposures, it is important that the hedgers understand the optimal hedge ratio in order to be able to find the right number of futures contract for minimizing the risk (Islam, 2017).

Usually it is not possible to eliminate or offset the risk exposure completely. Instead, the investors attempt to neutralize the risk exposure by constructing the hedge in such a way so that it performs as close to perfect as possible. The most important and beneficial aspect of the use of a futures contract is that it removes the uncertainty of future price movements of the hedged item by locking in a price today. This also facilitates the hedging companies or corporations to eliminate the ambiguity relating to their expenses and profits in the futures. Since perfect hedge is almost impossible, it is important to choose a value for the hedge ratio defined as the ratio of the size of the position taken in futures contract to the size of the total exposure (Hull, 2015). Since the risk is most commonly measured as the volatility of portfolio returns, it is plausible to choose a hedge ratio that minimizes the variance of the portfolio returns known as the minimum variance hedge ratio or optimal hedge ratio. Once hedge is in place, its effectiveness can be evaluated. A hedge is considered to be effective if the changes in the price of the hedging derivative instrument and the changes in the price of the hedged item roughly offset each other.

Hedging does not completely eliminate price risk when spot and futures prices change by an unequal magnitude. Therefore, reduction in overall risk is an important criterion in evaluating the hedging performance of futures contracts (Malhotra ,2015).

1.3 Statement of the Problem

All companies that are dependent on commodities (like Oil) are affected by the price changes in the commodities. The price changes can be expressed as volatility and higher volatility results in higher risk. Hedging the commodity contracts with futures can offset this risk. To be able to explain how hedging is actually performed we need to introduce a statistical term called variance, which is basically the difference between a set of data points around their mean value. The futures contract is purchased with the objective to minimize the variance between the future and spot price. When the future is minimizing the variance at the most, one is said to have an optimal hedge ratio (Siegel & Siegel, 1990).

Because the price of oil depends on many factors it's market price changes promptly and this fluctuation is attributed to supply and demand. But there are multiple factors at play that can affect those fundamentals. Many of them are interconnected. These include weather events, supply interruptions (such as worker strikes or spills), broader demand trends such as the emergence of renewable energy, OPEC decisions, or other events that can have an immediate effect on supplies.

There are also meta factors, such as the "fear" that a future event may happen that could in turn affect supply and demand. This is where geopolitical risks get priced in, such as potential escalation of conflict in the Middle East or future election results of oil exporting nations. In order to mitigate this price fluctuations, we need to use hedging techniques.

Since there are no or very few previous studies have been conducted in this area in our country Ethiopia it would be interesting to study the hedging techniques using futures contract and to estimate the optimal hedge ratio which minimizes the variance. Based on the finding and results proper suggestion and recommendation will be given to EPSE that is facing oil price fluctuation risk.

1.4 Research Questions

- Do EPSE really need to start using hedging techniques to mitigate oil price fluctuations?
- Is hedging with future contracts more effective for EPSE than international tenders and bilateral agreements to reduce risk of oil price variation?
- How could EPSE gain from using hedging techniques?
- What is the optimal hedge ratio?

1.5 Objective of the Study

1.5.1 General Objective

The objective of this study is to estimate the optimal hedge ratio and hedging effectiveness of oil futures for application in Ethiopia. This will help the EPSE the sole importer of oil in Ethiopia to start using hedging techniques to minimize the price fluctuation and the policy makers in formulating and implementing better strategies to reduce the price volatility in oil.

1.5.2 Specific Objective

The study has the following specific objectives

- To provide an introduction to hedging
- To study hedging strategies in detail
- To estimate the optimal hedge ratio
- To analyze hedging effectiveness in mitigating oil price fluctuation

1.6 Hypothesis

Based on the defined objectives the following research hypotheses were proposed:

H1: Using optimal hedge ratio significantly reduce exposure to oil price fluctuation and thus reduce cost.

1.7 Significance of the Study

Since our country financial system is not developed, academic studies of hedging techniques in commodities market in Ethiopia are limited. To the best of my knowledge, this is the one of the first study to explore the hedging strategies, hedging effectiveness and the optimal hedge ratio for oil futures. In addition, the study would also contribute to the existing body of knowledge regarding hedging techniques and strategies.

1.8 Scope of the Study

The scope of this study is centered on impacts of hedging techniques to reduce oil price fluctuations and to estimate the optimal hedge ratio. The study employs 28 years of Europe Brent spot and futures price (Dollars per Barrel) from October, 1990 to March, 2019.

Brent Crude is a major trading classification of sweet light crude oil that serves as a benchmark price for purchases of oil worldwide. Whereas WTI (Western Texas Intermediate) is the benchmark for oil prices in the US, while the rest of the world and nearly two-thirds of all oil contracts traded are on Brent.

1.9 Limitation of the study

The study considered only the portion of oil EPSE purchased through international tender. The study couldn't take in to account oil purchased through bilateral agreements. Furthermore, Because of the high sensitivity and confidentiality of EPSE data, it was hard to get some critical information from EPSE.

1.10 Organization of the study

This study is organized in five chapters. The first chapter covers introduction, background of the study, statement of the problem, research questions and objectives, significance of the study, scope and limitation of the study. The theoretical framework on the issues relating to futures markets, hedge ratio and the existing literature is discussed in the second chapter. The third chapter enumerates the research design. Empirical findings are stated in the fourth chapter, followed by conclusion and recommendation in the fifth chapter.

CHAPTER TWO: LITRATURE REVIEW

2.1 Introduction: Risk and Uncertainty

Whenever you make a financing or investment decision, there is some uncertainty about the outcome. Uncertainty means not knowing exactly what will happen in the future. There is uncertainty in most everything we do as financial managers, because no one knows precisely what changes will occur in such things as tax laws, consumer demand, the economy, or interest rates. Though the terms "risk" and "uncertainty" are often used to mean the same thing, there is a distinction between them. Uncertainty is not knowing what's going to happen. Risk is how we characterize how much uncertainty exists: The greater the uncertainty, the greater the risk. Risk is the degree of uncertainty (Fabozzi & Peterson 2003, p. 257).

Risk is defined in Webster's as "a hazard; a peril; exposure to loss or injury." Thus, risk refers to the chance that some unfavorable event will occur. If you go skydiving, you are taking a chance with your life—skydiving is risky. If you bet on horse races, you are risking your money. If you invest in speculative stocks (or, really, any stock), then you are taking a risk in the hope of earning an appreciable return. An asset's risk can be analyzed in two ways: (1) on a stand-alone basis, where the asset is considered in isolation, and (2) on a portfolio basis, where the asset is held as one of a number of assets in a portfolio. Thus, an asset's stand-alone risk is the risk an investor would face if she held only this one asset. Obviously, most assets are held in portfolios (Ehrhardt & Brigham 2011, p. 220).

In a portfolio context, a risk can be divided into two components: (a) *diversifiable risk*, which can be diversified away and is thus of little concern to diversified investors, and (b) *market risk*, which reflects the risk of a general market decline and cannot be eliminated by diversification (hence, does concern investors). Only market risk is relevant to rational investors because diversifiable risk can and will be eliminated (Brigham & Houston 2015, p.259).

2.1.1 Diversifiable Risk (Nonsystematic Risk)

Nonsystematic risk is the risk that pertains to a single company or industry and is also known as company-specific, industry-specific, diversifiable, or idiosyncratic risk. Nonsystematic risk is risk that is local or limited to a particular asset or industry that need not affect assets outside of that asset class. Examples of nonsystematic risk could include the failure of a drug trial, major oil discoveries, or an airliner crash. All these events will directly affect their respective companies and possibly industries, but have no effect on assets that are far removed from these industries. Investors are capable of avoiding nonsystematic risk through diversification by forming a portfolio of assets that are not highly correlated with one another (McMillan et al. 2011, p.257).

In order to manage risk in the sense of a complex market perspective, the concept of modern portfolio was applied. Here, the risk in the financial system could be divided into two components. One part of financial risk is called unique risk, also called unsystematic, diversified, residual or idiosyncratic risk (Beja, 1972). The concept of financial risk is applied when financial sources are placed in the financial market no matter whether in the form of investment or speculation. In theory, but in practical application as well, it is common to work with the multiple assets concept. A reduction of residual risk is feasible by applying an appropriate algorithm for assets allocation (diversification). Apparently, a complete elimination of this risk could be achieved (Elton & Gruber, 1997).

2.1.2 Market Risk (Systematic Risk)

In contrast, Systematic risk, also known as non-diversifiable or market risk, is the risk that affects the entire market or economy. Systematic risk is risk that cannot be avoided and is inherent in the overall market. It is non-diversifiable because it includes risk factors that are innate within the market and affect the market as a whole. Examples of factors that constitute systematic risk include interest rates, inflation, economic cycles, political uncertainty, and widespread natural disasters. These events affect the entire market, and there is no way to avoid their effect. Systematic risk can be magnified through selection or by using leverage, or diminished by including securities that have a low correlation with the portfolio, assuming they are not already part of the portfolio (McMillan et al. 2011, p. 257).

All actors in the financial market face systematic risk, because every asset is exposed to market risk. (Frenkel et al. 2005). Its existence can only be accepted and not removed. What applies to financial markets can be applied without reservations to the commodities market as well. As noted by (Garner, 2010): "Producers and users of commodities are constantly faced with price and production risk due to an unlimited number of unpredictable factors including weather, currency exchange rates, and economic cycles." The embodiment of risk is actually uncertainty arising due to the nature of the markets. It is inherent in the entire financial market. However, that does not mean that active trading subjects on the market could not influence the impact of systematic risk. Hedging is a financial operation that aims to reduce the impact of non-diversifiable risk (Collins & Fabozzi, 1999). It is actually a closure of positions hold in assets. Growth or decline in the price of one asset is offset by the opposite movement of hedging assets price.

2.2 Financial Market Contract

A contract is an agreement among traders to do something in the future. Contracts provide for some physical or cash settlement in the future. If the underlying asset is a physical product, the contract is a physical; otherwise, the contract is a financial. Examples of assets classified as physical include contracts for the delivery of petroleum, lumber, and gold. Examples of assets classified as financial include forward and future contracts, option contract and contracts on interest rates, stock indices, currencies (McMillan et al. 2011, p. 16).

Financial markets are classified in terms of spot/cash market and derivative markets.

2.2.1 Spot /Cash Market

The cash market, also referred to as the spot market, is the market for the immediate purchase and sale of a financial instrument (Fabozzi & Peterson 2009, p. 126). A spot market is where a commodity or financial asset is bought or sold for immediate delivery (Chisholm 2010, p.1). Immediate delivery generally is three days or less, but depends on each market (McMillan et al. 2011, p.16).

2.2.2 Derivative Market

In contrast, some financial instruments are contracts that specify that the contract holder has either the obligation or the choice to buy or sell another something at or by some future date. The "something" that is the subject of the contract is called the underlying. The underlying is a stock, a bond, a financial index, an interest rate, a currency, or a commodity. Because the price of such contracts derives their value from the value of the underlying, these contracts are called derivative instruments and the market where they are traded is called the derivatives market. Derivatives instruments, or simply derivatives, include futures, forwards, options and swaps. Derivative instruments play an important role in financial markets as well as commodity markets by allowing market participants to control their exposure to different types of risk (Fabozzi & Peterson 2009, p.126).

A derivative can be defined as a financial instrument whose value depends on (or derives from) the values of other, more basic, underlying variables. Very often the variables underlying derivatives are the prices of traded assets (Hull 2015, p. 1).

A derivative security or a derivative is a financial contract that derives its value from an underlying asset's price, such as a stock or a commodity, or even from an underlying financial index like an interest rate. A derivative can both reduce risk, by providing insurance (which, in financial parlance, is referred to as hedging), and magnify risk, by speculating on future events. Derivatives provide unique and different ways of investing and managing wealth that ordinary securities do not (Jarrow & Chatterjea 2013, p.3).

All derivatives contracts specify four key terms: the (1) underlying: Derivatives are constructed based on an underlying, which is specified in the contract. Originally, all derivatives were based only on tangible assets, but now some contracts are based on outcomes. Some example of underlying's includes the following: Agricultural products, Currencies, Interest rates, Individual shares and equity indices, Bond indices, Economic factors (such as the inflation rate), Natural resources (such as crude oil, natural gas, gold, silver, and timber). A derivative's underlying must be clearly defined because quality can vary. (2) size and price: The contract must also specify size and price. The size is the amount of the underlying to be exchanged. The price is what the underlying will be purchased or sold for under the terms of the contract. Note that the price specified in the contract is not the current or spot price for the underlying but a price that is good for future delivery. (3) expiration date: All derivatives have a finite life; each contract specifies a date on which the contract ends, called the expiration date. (4) settlement: Settlement describes how a contract is satisfied at expiration. Some contracts require settlement by physical delivery of the underlying and other contracts allow for or even require cash settlement. If physical delivery to settle is possible, the contract will specify delivery location(s). In practice, most derivatives contracts are settled in cash (Singal 2017, p.347-348).

2.3 Types of Derivative Contracts

There are four main types of derivatives contracts: forward contracts (forwards), futures contracts (futures), option contracts (options), and swap contracts (swaps).

2.3.1 Forward Contracts

A forward contract is made directly between two parties. In a physically delivered forward contract one party agrees to buy an underlying commodity or financial asset on a future date at an agreed fixed price. The other party agrees to deliver that item at the stipulated price. Both sides are obliged to go through with the contract, which is a legal and binding commitment, irrespective of the value of the underlying at the point of delivery. Some forward contracts are cash-settled rather than through the physical delivery of the underlying. This means that the difference between the fixed price stipulated in the contract and the actual market value of the underlying commodity or financial asset at the expiry of the contract is paid in cash by one party to the other. Since forwards are privately negotiated, the terms and conditions can be customized. However, there is a risk that one side might default on its contractual obligation unless some kind of guarantee can be put in place (Chisholm 2010, P. 2).

A forward contract locks in a price today for a future transaction contract now, transact later is the mantra. More formally, a forward contract or a forward is a binding agreement between a buyer and a seller to trade some commodity at a fixed price at a later date. This fixed price is called the forward price (or the delivery price), and the later date is the delivery date (or the maturity date). Forward contracts are derivatives as their values are derived from the spot price of some underlying commodity. By market convention, no money changes hands when these contracts are created. Some market jargon is useful in understanding derivative transactions. If you agree to buy at a future date, then you take a long position or you are going long. If you agree to sell at a future date, then you are taking a short position or you are going short (Jarrow & Chatterjea 2013, p.84-85).

Forward contracts transact in the over-the-counter market-that is, the agreement is made directly between two parties, a buyer and a seller-although a dealer may help arrange the agreement. The risk that the other party to the contract will not fulfil its contractual obligations is called counterparty risk. To reduce counterparty risk, the parties to a forward contract evaluate the default risk of the other party before entering into a contract. If the risk of default is significant, the parties may not agree to a forward contract. Or one or both parties may require a performance bond. A performance bond is a guarantee, usually provided by a third party, such as an insurance company, to ensure payment in case a party fails to fulfil its contractual obligations (defaults). As an alternative to a performance bond, collateral may be requested. Collateral refers to pledged assets.

That is, if one party cannot fulfil its contractual obligations, the other party can keep the collateral as compensation (Singal 2017, p.349).

2.3.2 Future Contracts

A futures contract is essentially the same as a forward, except that the deal is made through an organized and regulated exchange rather than being negotiated directly between two parties. In a physically delivered contract one side agrees to deliver a commodity or asset on a future date (or within a range of dates) at a fixed price, and the other party agrees to take delivery. In a cash-settled future contract the difference between the fixed price and the actual market value of the underlying at expiry is settled in cash. Traditionally there are three key differences between forwards and futures. Firstly, a futures contract is guaranteed against default. Secondly, futures are standardized, in order to promote active trading. Thirdly, profits and losses on futures are realized on a daily basis to prevent them from accumulating (Chisholm 2010, p.2).

A futures contract is a highly standardized forward contract executed at an exchange. A party agrees to either buy or sell an underlying commodity or security at a specified price on a specified date in the future. The specified price in a futures contract is the delivery price. But unlike the over-the-counter (OTC) forward contract, a futures contract is traded on an exchange, a meeting place for buyers and sellers. As a result, a future differs from a forward contract in three important ways:

Anonymous counterparties: Unlike parties to a forward, the buyer and seller of a futures contract typically don't know each other. The exchange generally takes care of matching up buyers and sellers, helping to provide an important market quality known as liquidity.

Standard contracts: Exchanges also provide liquidity by strictly defining the terms of every contract executed. The type, quantity, and grade of underlier; its delivery price and date; and even the delivery locations are spelled out in great detail. A prospective buyer or seller must choose from one of these predefined contracts. Parties to a forward, by contrast, are free to define the terms of their contract however they mutually agree to.

Daily settlement: This is the biggie. Whereas parties to a forward realize their payoff on delivery (or on some earlier date if they agree to cancel or unwind a contract), parties to a futures contract realize a payoff at the end of every trading day. This substantially reduces the risk of a party failing to meet its obligations-an inherent risk of an OTC (Over-The-Counter) contract like a forward. It also affects the value of a futures relative to an otherwise identical forward (more on this in just a bit). The bottom line is that futures are generally more liquid than forwards and carry a smaller degree of default risk (Durbin 2011, p. 23-24).

Futures have a number of useful applications. First, they can be used to hedge risk in the spot or cash market. By taking a position opposite to that position held in the spot market, it is possible to reduce or even eliminate risk. Second, because futures are essentially costless, they can be used to speculate on the future price of a commodity. Third, because the futures contract is based on delivery of some asset or commodity in the spot market, there should be a relationship between the two prices. If these prices get out of line, an opportunity to arbitrage the difference be- tween the two prices will exist. And finally, futures can be used to adjust the risk of a portfolio (Moy, 2000; Hull, 2003).

2.3.3 Option Contracts

The word option has many meanings in daily life. Exchange-traded options are well-defined contracts with specific features. Options come in two basic types: calls and puts. A call option gives the buyer the right, but not the obligation to buy a specified quantity of a financial or real asset from the seller on or before a fixed future expiration date by paying an exercise price agreed on today. The buyer is also called the holder or the owner. The seller is known as the grantor, the issuer, or the writer. The known future expiration date is also called the maturity date, and the fixed price is known as the exercise price or strike price. The holder exercises the call when she exercises her right and buys the underlying asset by paying the exercise price; otherwise, she lets the call expire worthless.

By contrast, a put option gives the right to sell. Specifically, a put option gives the owner the right to sell the asset to the writer at the strike price until the expiration date. A buyer exercises the put when he sells the underlying asset and receives the strike price from the put writer; otherwise, he can let the put expire worthless. Options do not come free-the option buyer must pay the writer a fee (option’s price or premium) for selling those rights. The terms call and put come from what the buyer can do with these options. A call gives the option to buy, that is, to call the asset away from the writer. Conversely, a put gives the option to sell or to put the asset to the writer. In each case, the writer stands ready to take the other side of the buyer’s decision.

Notice that calls and puts have a lot in common with insurance policies and may be viewed as insurance contracts for hedging or risk reduction. If someone hits a car, the insurance company pays the owner enough money (subject to some deductibles) to restore the car to its original value. Likewise, a put pays the holder in case of a meltdown in the asset's value. A call buyer benefits from an asset price rise but does not suffer from its decline. The call buyer pays for insurance to avoid losses if the stock falls. The call writer provides this insurance. For these reasons, an option price is called a premium. A premium is what you pay for the insurance (Jarrow & Chatterjea 2013, p.110-111).

The purchaser of an option has to pay an initial fee called a premium to the seller or writer of the contract. This is because the option provides flexibility for the purchaser-it need never be exercised (Chisholm 2010, p.2-3). Options are traded both on exchanges and in the over-the-counter market (Hull 2015, p.8).

2.3.4 Swap Contracts

Swaps are typically derivatives in which two parties exchange (swap) cash flows or other financial instruments over multiple periods (months or years) for mutual benefit, usually to manage risk. Swaps of this type involve obligations in the future on the part of both parties to the contract. These swaps, like forwards and futures, are forward commitments or bilateral contracts because both parties have a commitment in the future. Swaps in which two parties exchange cash flows include interest rate and currency swaps. An interest rate swap, the most common type, allows companies to swap their interest rate obligations (usually a fixed rate for a floating rate) to manage interest rate risk, to better match their streams of cash inflows and outflows, or to lower their borrowing costs. A currency swap enables borrowers to exchange debt service obligations denominated in one currency for equivalent debt service obligations denominated in another currency. By swapping future cash flow obligations, the two parties can manage currency risk (Singal 2017, p. 359).

A swap is an over-the-counter agreement between two companies to exchange cash flows in the future. The agreement defines the dates when the cash flows are to be paid and the way in which they are to be calculated. Usually the calculation of the cash flows involves the future value of an interest rate, an exchange rate, or other market variable. The birth of the over-the-counter swap market can be traced to a currency swap negotiated between IBM and the World Bank in 1981.

The World Bank had borrowings denominated in US dollars while IBM had borrowings denominated in German deutsche marks and Swiss francs. The World Bank agreed to make interest payments on IBM's borrowings while IBM in return agreed to make interest payments on the World Bank's borrowings (Hull 2015, p.152).

2.4 Crude Oil Futures Pricing and Contracts

The value of a futures contract is determined by the underlying commodity and the principle of arbitrage. Arbitrage occurs when it is possible for investors to earn a guaranteed profit without using any of their own money. This opportunity arises when the relationship between cash and futures prices gets out of line. In principle, the value of a futures contract should be equal to the current cash market price plus any cost of carrying the commodity. These costs include interest, storage, and insurance costs. When the prices of the two markets get out of line, arbitrageurs will drive the prices back to their equilibrium state by purchasing in the market where the price is too low and simultaneously selling in the market where the price is too high (Moy, 2000; Hull, 2003).

An oil futures contract is an agreement to buy or sell a certain number of barrels set amount of oil at a predetermined price, on a predetermined date. When futures are purchased, a contract is signed between buyer and seller, and secured with a margin payment that covers a percentage of the total value of the contract. End users of oil purchase on the futures market to lock in a price; investors buy futures to essentially gamble on what the price will actually be down the road, and profit by guessing correctly. Typically, they will liquidate or roll over their futures holdings before they would have to take delivery.

There are two major oil contracts in which oil market participants are most interested. In North America, the benchmark for oil futures is West Texas Intermediate (WTI) crude, which trades on the New York Mercantile Exchange (NYMEX). In Europe, Africa and the Middle East, the benchmark is North Sea Brent crude, which trades on the Intercontinental Exchange (ICE). While the two contracts move somewhat in unison, WTI is more sensitive to American economic developments, and Brent responds more to those overseas (Investopedia, 2018).

2.5 WTI VS BRENT: What are the differences?

There are five main differences between WTI and Brent:

Extraction Location:

WTI is extracted from oil fields in the United States. It is primarily extracted in Texas, Louisiana and North Dakota and is then transported via pipeline to Cushing, Oklahoma for delivery.

Brent crude is extracted from oil fields in the North Sea. ‘Brent Crude’ refers to a blend of four crude oils - Brent, Forties, Osberg, and Ekofisk which together are known as BFOE.

Geopolitical: WTI is Not as sensitive to geopolitics whereas Brent is Sensitive to geopolitics

Content and composition: Brent and WTI have very different sulfur content and API (American Petroleum Institute) gravity, which can directly affect the price of the oils. While WTI has a sulfur content of 0.24%, Brent has a sulfur content of 0.37%. The lower the sulfur content of the oils the ‘sweeter’ the oil and the easier it is to refine. Both WTI and Brent are considered sweet crude.

Where Brent and WTI are traded

WTI futures contracts are traded on the New York Mercantile Exchange (NYMEX), which is owned by the Chicago Mercantile Group (CME). Brent futures contracts are traded on the Intercontinental Exchange (ICE) in London.

Table 2.1: WTI Vs BRENT Summary

	WTI	**Brent**
Contract Size	1,000 barrels	1,000 barrels
Priced in	U.S. Dollars and Cents	U.S. Dollars and Cents
Deliverable	YES	YES
Ticker Symbol	CL	BZ

Source: Dailyfx

Prices and benchmark

In the past, WTI traded at a premium to Brent. However due to the Shale Revolution in the early 2000s (in which WTI production increased) and more imports to the US from Canada, the price of WTI declined. It now usually trades at a discount to Brent (Dailyfx, 2018).

2.6 Basis Risk

Basis is an important concept in understanding the pricing and risk of using futures contracts. Basis is the current spot market price of the commodity minus the price of the futures contract on that commodity. The basis can be either positive or negative. When the basis is positive, prices in the cash market are higher than the futures prices, also called backwardation. When the basis is negative, prices in the cash market are lower than the futures prices, also called contango (Siegel & Siegel, 1990).

During the life of a futures contract, the basis will change. As the contract gets closer to expiration, the basis becomes smaller. At expiration, the basis of a contract will be zero because the futures price at expiration must equal the spot market price. Although the basis of a contract will equal zero at expiration, it can fluctuate during the life of the contract. The basis of a contract can widen or narrow. This type of risk is referred to as basis risk, which basically relates to the imperfect relationship between the future price and spot price at expiration. However, this is mostly an issue when cross hedging is used. Cross hedging is a term to describe a hedge situation where an asset is hedged with the closest security that exists. For example, a share will be hedged with futures on the index that the underlying share is part of. Fortunately, there are futures contracts that exactly match most commodities today, which mean that the commodity that is supposed to be hedged has high correlation with the futures contract and practically no basis risk needs to be accounted for (Moy, 2000; Hull, 2003; Siegel & Siegel 1990).

2.7 Speculation

Whereas hedgers want to avoid exposure to adverse movements in the price of an asset, speculators wish to take a position in the market. Either they are betting that the price of the asset will go up or they are betting that it will go down (Hull 2015, p.14).

Derivatives are very well suited to speculating on the prices of commodities and financial assets and on market variables such as interest rates, stock market indices and currency exchange rates.

Generally speaking, it is much less expensive to create a speculative position using derivatives than by trading the underlying commodity or financial asset. As a result, the potential returns are that much greater. A classic case is the trader who believes that increasing demand or reduced supply is likely to boost the market price of oil. Since it would be too expensive to buy and store the physical commodity, the trader buys exchange-traded futures contracts agreeing to take delivery of oil on a future delivery date at a fixed price. If the oil price rises in the spot market, the value of the futures contracts will also rise and they can be sold back into the market at a profit. In fact, if the trader buys and then sells the futures contracts before they reach the delivery point the trader never has to take delivery of any actual oil. The profit from the trades is realized in cash (Chisholm 2010, p. 4).

2.8 Hedging

The word hedge refers to a fence or barrier formed by bushes set close together. To hedge, accordingly, means to surround, guard or hem in with or as with obstructions or barriers. In financial lingo "hedging" is the act, exercised by exchange-market participants, of taking an offsetting position in a related commodity (or a security) in order to reduce or eliminate the risk of adverse price changes. Hedging is a transaction initiated to offset the risk of an adverse price change emanating from a position held in the physical market by establishing an equal and opposite position in the futures market. Every hedge is a risk-reduction or risk-eliminating strategy (Jovanovic 2014, p.105-112).

Derivatives are an excellent tool for a particular type of risk management known as hedging. Indeed, it's why they were invented in the first place. Generally speaking, hedging involves recognizing and measuring the financial risk of an existing position and then taking on some new position with opposite exposure characteristics such that the gains and losses of the positions cancel each other out. In essence, you no longer care if the original position loses money, because the hedge position will make money to compensate. And if the hedge position loses money, no worries, the original position makes money to compensate-provided it's a good hedge, of course (Durbin 2011, p. 71).

Corporations, investors, banks and governments all use derivative products to hedge or reduce their exposure to market variables such as interest rates, share prices, bond prices, currency exchange rates and commodity prices. The classic example is the farmer who sells a futures contract to lock into a price for delivering a crop on a future date. The buyer might be a food processing company that wishes to fix a price for taking delivery of the crop in the future, or a speculator. Another typical case is that of a company due to receive a payment in a foreign currency on a future date. It enters into a forward contract to sell the foreign currency to a bank and receive a predetermined quantity of domestic currency. Or it purchases an option which gives it the right but not the obligation to sell the foreign currency at a set rate (Chisholm 2010, p. 3-4).

The most common hedge does not make or take delivery, which mean that the futures will not be executed. Instead, the seller (buyer) of the futures contract cancels his delivery commitment by buying (selling) a contract of the same futures prior to delivery (Ederington, 1979).

2.8.1 Long hedge position (Buying hedge)

Hedges that involve taking a long position in a futures contract are known as long hedges. A long hedge is appropriate when a company knows it will have to purchase a certain asset in the future and wants to lock in a price now. The hedge has the same basic effect if delivery is allowed to happen. However, making or taking delivery can be costly and inconvenient. For this reason, delivery is not usually made even when the hedger keeps the futures contract until the delivery month. Hedgers with long positions usually avoid any possibility of having to take delivery by closing out their positions before the delivery period. A company that knows that it is due to buy an asset in the future can hedge by taking a long futures position, known as a long hedge. If the price of the asset rises, the futures position will profit and offset the company's loss due to higher supply costs (Hull 2015, p.50-51).

Every hedge begins either as a purchase or a sale of a specific quantity of futures depending on a position held in a physical market. A position initiated by buying futures, benefits if the underlying market price increases. Is designed to protect against possible price rise. It appreciates in value with the price rise: "buy low, sell dear" (Jovanovic 2014, p.105-112).

2.8.2 Short hedge position (Selling hedge)

A short hedge is a hedge, that involves a short position in futures contracts. A short hedge is appropriate when the hedger already owns an asset and expects to sell it at some time in the future. A short hedge can also be used when an asset is not owned right now but will be owned at some time in the future. If the price of the asset goes down, the company makes a loss on the sale of the asset but makes a gain on the short futures position. If the price of the asset goes up, the company gains from the sale of the asset but takes a loss on the futures position (Hull 2015, p. 50-51).

Short hedgers sell futures to protect a long position in the underlying commodity against a possible price fall. Hedge Selling (Short Hedge) is designed to protect against a possible price fall. It appreciates in value with the price fall: "sell high, buy low" (Jovanovic 2014, p. 105-112).

2.9 Hedging Theories

Hedging, as a function of futures market, has evolved through different connotations as an outcome of various hedging theories, such as the conventional, Working's and portfolio hedging theories. Conventional hedging suggested the naïve-hedging strategy of taking position in both the markets in the ratio 1:1, that is, holding one unit of futures contract for hedging a unit of spot position. However, spot and futures price changes are not perfectly synchronized due to which a hedge ratio of "1 does not maximize the returns of the hedged portfolio. (Working's 1953) hedging theory envisaged that hedgers do not seek to avoid risk, but have an objective to maximize profits out of favorable change in basis. The limitations of conventional and Working's hedging theory gave way to the works of (Johnson 1960) and (Stein 1961), who proposed the portfolio approach to hedging. They observed that hedgers are faced with the utility maximization frontier, and they chose the one that maximizes their utility for a given level of risk preference. Portfolio hedging theory allows the estimation of a wide range of hedge ratios, along with time-varying hedge ratios, which may be more efficient than the static hedge ratios estimated with ordinary least square (OLS) regression. This was followed by the development of a very popular portfolio hedging theory by (Ederington 1979). He gave a measure of hedging effectiveness as a percentage reduction in the variance of unhedged versus hedged portfolio. The minimum variance hedge ratio (MVHR), as per his approach, is the slope coefficient of the regression of spot returns on futures returns and R-square of the regression is a measure of hedging effectiveness.

2.10 Hedge Ratio

'Hedge ratio' is the ratio of the size of exposure in the physical market to the size of position taken in futures market or the hedge ratio is the ratio of the size of the position taken in futures contracts to the size of the exposure. Several types of hedge ratios can be produced depending on the type of risk that the hedger is concerned with. However, the following factors are usually important determinants of the hedge ratio:

1. Size of the spot or cash market position.
2. Size of the futures contract.
3. Sensitivity of spot price and futures price relative to some external factor.

The first two factors are quite obvious. The larger the size of the spot market positions relative to the size of the futures contracts, the greater the number of contracts necessary to hedge the risk. The third factor adjusts the number of contracts for the different sensitivities of spot prices and futures prices (Siegel & Siegel, 1990).

Usually it is not possible to eliminate or offset the risk exposure completely. Instead, the investors attempt to neutralize the risk exposure by constructing the hedge in such a way so that it performs as close to perfect as possible. The most important and beneficial aspect of the use of a futures contract is that it removes the uncertainty of future price movements of the hedged item by locking in a price today. This also facilitates the hedging companies or corporations to eliminate the ambiguity relating to their expenses and profits in the futures. Since perfect hedge is almost impossible, it is important to choose a value for the hedge ratio defined as the ratio of the size of the position taken in futures contract to the size of the total exposure (Hull, 2015).

2.11 Optimal Hedge Ratio: Empirical Review

There are many empirical studies which have analyzed the optimal hedge ratio and hedging efficiency.

A study by Islam (2017) on optimal hedge ratio indicate that to design a better strategy with futures contracts for hedging the risk exposures, it is important that the hedgers understand the optimal hedge ratio in order to be able to find the right number of futures contract for minimizing the risk. Since risk is most commonly measured as the volatility of portfolio returns, it is plausible to choose a hedge ratio that minimizes the variance of the portfolio returns known as the minimum variance hedge ratio or optimal hedge ratio. Optimal hedge ratio is determined as the ratio of the covariance between spot and futures return to the variance of futures return.

Johnson (1960) was the first who introduced minimum variance hedge ratio (MVHR) or optimum hedge ratio (OHR) which is the ratio of covariance between spot and futures return to the variance of futures return.

According to Hatemi-j & Roca (2006) a crucial input in the hedging of risk is the optimal hedge ratio defined by the relationship between the price of the spot instrument and that of the hedging instrument. Thus, the calculation of the optimal hedge ratio plays a critical role in the hedging process. Basically, the optimal hedge ratio is based on the coefficient of the regression between the change in spot prices and the change in prices of the hedging instrument. In other words, optimal hedge ratio may be defined as the quantities of the spot instrument and the hedging instrument that ensure that the total value of the hedged portfolio does not change.

Another study by Hatemi-J & El-Khatib (2012) on optimal hedge ratio indicate that finding an Optimal Hedge Ratio (OHR) is one of the vital issues pertinent to the investors' risk management analysis. The OHR is of fundamental importance in order to neutralize price risk. A hedge ratio that minimizes the variance of the hedger's position is the OHR. The minimum variance hedge ratio is widely used by investors to immunize against the price risk.

Chen & Ford (2010) reveal that one of the most widely-used hedging strategies in determination of the optimal hedge ratio (OHR) is to employ a minimum- variance (MV) framework, which is based on minimization of the variance of the hedged portfolio. For several reasons, the minimum-variance framework has become the benchmark in the hedging literature. First, its hedge ratio is optimal for exceptionally risk averse traders (Ederington, 1979; Kahl, 1983). Second, as has been verified in several empirical studies (Baillie & Myers, 1991; Martin & Garcia, 1981) the MV hedge ratio is still optimal when futures markets are unbiased.

A research conducted by Ripple & Moosa (2007) shows the optimal hedge ratio is measured as the slope coefficient in a regression of the rate of return on the unhedged (spot) position on the rate of return on the hedging instrument.

Benninga et al. (1984) defines MVHR as the slope coefficient in the OLS regression of changes in spot prices on changes in futures price. In other words, MVHR is the regression coefficient which gives maximum hedging effectiveness.

According to Malhotra (2015) citing Johnson (1960) and Ederington (1979), MVHR is calculated using simple OLS regression. In OLS regression, a linear regression of changes in spot prices is run on changes in futures prices.

A study by Hamldar & Mehrara (2014) shows that changes in spot price is regressed on the changes in futures price. The Minimum Variance Hedge Ratio is suggested as slope coefficient of the OLS regression. It is the ratio of covariance of (spot prices, futures prices) and variance of (futures prices).

Referring to Johnson (1960), Stein (1961) and Ederington (1979) as cited by Ji & Fan (2011) The core concept of a hedge is to identify optimal hedge ratios, for which numerous approaches are available. They demonstrated that the risk-minimizing hedge ratio was equal to the slope of the ordinary least squares (OLS) estimation. This classical method is still in use. A study by Islam (2017) help me to develop the methodologies used in this research.

2.12 Hedging Effectiveness

Once hedge is in place, its effectiveness can be evaluated. A hedge is considered to be effective if the changes in the price of the hedging derivative instrument and the changes in the price of the hedged item roughly offset each other (Islam, 2017).

According to Ji & Fan (2011) the estimation of hedge effectiveness is defined as the ratio of the variance of the unhedged position minus variance of the hedged position to variance of the unhedged position. The quotient of variance of the hedge (the difference between variance of unhedged portfolio and variance of the hedged portfolio) to the variance of unhedged portfolio.

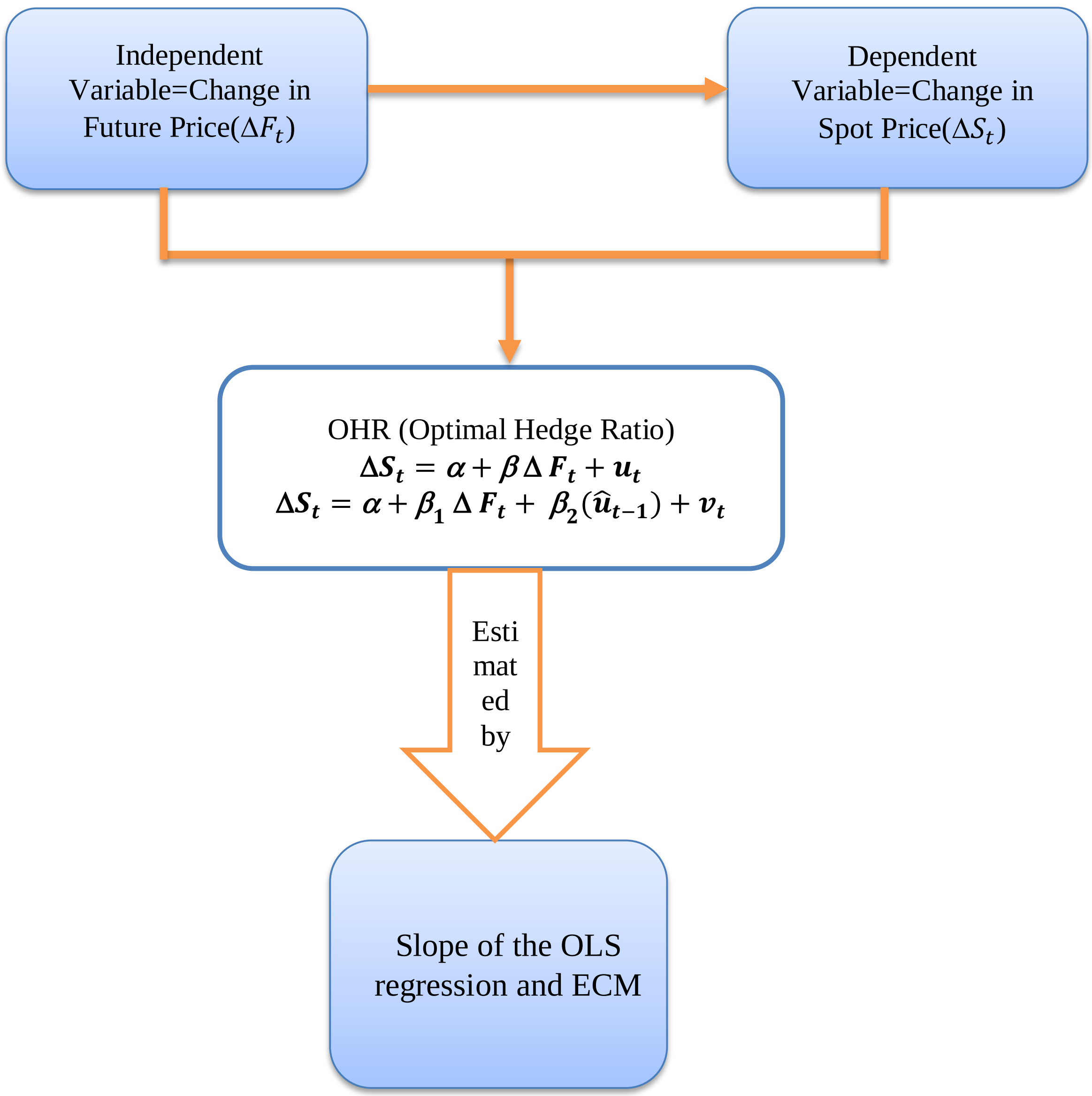
A study by to Malhotra (2015) citing Johnson (1960) and Ederington (1979) hedging effectiveness is given by the R^2 estimate of the OLS regression. A higher R^2 is indicative of better hedging effectiveness.

Another study by Hamldar & Mehrara (2014) shows the slope of the regression equation (changes in spot price is regressed on the changes in futures price) gives the hedge ratio and R^2, the hedging effectiveness

2.13 Conceptual Framework

This conceptual framework defines the relationship between the dependent variable (change in the spot price) and the independent variable (change in future price).

Figure 2.1: Conceptual Framework



(Source: Compilation by Researcher)

2.14 Conclusions and Knowledge Gap

The literature review discussed in this research shows that hedging is an instrument used to mitigate the risk associated with adverse price changes. Since hedging cannot offset the risk exposure completely, it is important to estimate the optimal hedge ratio that performs as close to perfect as possible.

The empirical study indicates that the optimal hedge ratio is calculated using simple OLS regression by regressing changes in spot prices to changes in futures prices. The optimal hedge ratio is measured as the slope coefficient in the regression. The hedging effectiveness is measured by the R^2 estimate of the OLS regression.

Oil is the largest import commodity in Ethiopia and it affects most economic activities. The volatility of oil price changes has an impact on both macro and micro level. A research work is needed to mitigate the volatility of price change. A large number of research is conducted on the optimal hedge ratio and hedging effectiveness on oil futures and different assets outside Ethiopia. Lack of research study on optimal hedge ratio and hedging effectiveness in the context of EPSE initiates this study. To the best of my knowledge, this is the one of the first study to estimate the optimal hedge ratio and hedging effectiveness for oil future and its application to the EPSE. Therefore, this research aims to take the first steps in estimating the OHR that can be applicable to EPSE.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

The research design is the general plan of how you will go about answering your research question(s). It will contain clear objectives derived from your research question(s), specify the sources from which you intend to collect data, how you propose to collect and analyze these, and discuss ethical issues and the constraints you will inevitably encounter (e.g. access to data, time, location and money). Crucially, it should demonstrate that you have thought through the elements of your particular research design (Saunders et al. 2016, p. 163-166).

According to EPSE, since it imports only refined petroleum products it uses the Platts market data for oil to settle payments with oil suppliers.

S&P Global Platts is a provider of energy and commodities information and a source of benchmark price assessments in the physical energy markets. S&P Global Platts is a division of S&P Global, Inc., a provider of ratings, benchmarks and analytics to the global capital and commodity markets (Wikipedia Global Platts ,2018).

The Platts market data for oil is available daily except on holidays. The Platts Price (refined oil price) can be estimated by the below equation:

Platts Price = Crude Oil Price + Refinery Cost +Shipping Cost + Premium (3.1)

Crude Oil Price: Brent crude oil spot price

Refinery Cost: A cost associated with transforming and refining crude oil in to more useful products like gasoil, diesel, jet fuel and so on.

Shipping Cost: A cost associated with transporting the refined oil product to its destination.

Premium: The amount the oil supplier adds to the cost of the oil it intends to sell to its customers.

Let us assume that the refinery cost, shipping cost and premium remain stable (exhibits small fluctuation) so that the daily change in the Platts price index is attributed to crude oil price change. If we use futures contract for Brent crude oil we can hedge or offset the risk of an adverse price change emanating from a position held in the physical market (Platts price). Therefore, Brent crude oil spot price and Brent crude futures price is used to study the relationship and to estimate the hedge ratio.

The first methodological choice is whether to follow a quantitative, qualitative or mixed methods research design. Each of these options is likely to call for a different mix of elements to achieve coherence in the research design. Quantitative research examines relationships between variables, which are measured numerically and analyzed using a range of statistical and graphical techniques (Saunders et al.2016, p.163-166).

For this study, quantitative research approach is employed to see the relationship between the return of the natural logarithm of the spot price of oil and the return on the natural logarithm of the futures price of oil. This study uses econometrics techniques to analyze the relationship between spot and future price of oil.

If a study is concerned with learning why-that is, how one variable produces changes in another-it is causal-explanatory. A causal-explanatory study tries to explain relationships among variables (Cooper & Schindler 2014, p. 127).

Because the research aims to study and relate the effect of return of the spot price on return on future price it is explanatory type of research.

3.2 Data Type and Source

In order to be consistent with EPSE which uses monthly average price to settle payments to suppliers, the data set in this study consist of historical monthly spot and futures prices for Brent crude oil. Thus, this study uses time series data obtained from secondary sources. Monthly spot and futures prices are calculated by adding the daily spot and future price in the month and dividing the sum by the number of trading days in the month. When there is a holiday both spot and futures prices are not considered for the same date.

The data are transformed into natural logarithmic form and then expressed into logarithmic return. Spot and futures return series are expressed as $\Delta R_t = \ln P_t - \ln P_{t-1}$, where R_t represents spot/futures returns and P_t and P_{t-1} are the prices at time t and $t - 1$, respectively. The futures contract is primarily used as a hedging instrument, and not for delivery of an actual commodity.

Table 3.1: Data Types and Source Summary

		Data Types	Source	Unit	Range	Frequency
Crude Oil	Spot	Time series Brent Crude Oil Spot Price FOB(Free On Board)	U.S. Energy Information Administration https://www.eia.gov/dnav/pet/hist/rbrteD.htm	USD per Barrel	October ,1990 – March ,2019.	Monthly
	Future	Time series Brent Crude Oil Futures	Investing.com https://www.investing.com/commodities/brent-oil-historical-data	USD per Barrel	October ,1990 – March ,2019.	Monthly

(Source: Compilation by Researcher)

3.3 Population and Sampling Method

Population of the study: The Population of this study consist of daily spot and futures prices since future contract for crude oil became available in 1983 (wisestockbuyer, 2018).

Sampling Method: The sampling method that this study employed is purposive sampling. In purposive sampling, you need to use your judgement to select cases that will best enable you to answer your research question(s) and to meet your objectives (Saunders et al.2016, P. 301).

Purposive or judgmental sampling is a nonprobability sample that conforms to certain criteria (Cooper & Schindler 2014, p. 359). This study used purposive sampling in which the availability of data is set as criteria. The sample period ranges from October,1990 to March, 2019 G.C.

3.4 Method of Data Analysis and Tools

For a number of statistical reasons, it is preferable not to work directly with the price series, so that raw price series are usually converted into series of returns. Additionally, returns have the added benefit that they are unit-free. The academic finance literature generally employs the log-return formulation (also known as log-price relatives since they are the log of the ratio of this period's price to the previous period's price). The two key reasons for this are:

1.Log-returns have the nice property that they can be interpreted as continuously compounded returns so that the frequency of compounding of the return does not matter and thus returns across assets can more easily be compared.

2.Continuously compounded returns are time-additive. For example, suppose that a weekly returns series is required and daily log returns have been calculated for five days, numbered 1 to 5, representing the returns on Monday through Friday. It is valid to simply add up the five daily returns to obtain the return for the whole week (Brooks 2014, p. 7-8)

Therefore, the researcher used natural logarithm difference in spot and future prices than the original raw price. After the natural logarithm difference in spot and future prices was calculated, descriptive statistical calculations including mean, maximum, minimum and standard deviation of each variable were carried out.

Standard inference procedures do not apply to regressions which contain an integrated dependent variable or integrated regressors. Therefore, it is important to check whether a series is stationary or not before using it in a regression. The formal method to test the stationarity of a series is the unit root test (Eviews help 2019). Stationarity Test /Unit root test is conducted to test whether the spot and futures prices (raw price) and their first difference (return) are stationary or not. Cointergration test also employed to check the long-run relationship of spot and future price. The assumptions of the Classical Linear Regression Model (CLRM) are tested to check whether or not they are violated. Goodness of fit statistic is tested by using adjusted R^2.

Then regression analysis is conducted to study the relationship between the dependent variable (the return of the natural logarithm of the spot price of oil) and the independent variable (the return on the natural logarithm of the futures price of oil). According to Brooks (2014) regression is concerned with describing and evaluating the relationship between a given variable and one or more other variables. More specifically, regression is an attempt to explain movements in a variable by reference to movements in one or more other variables. Eviews 9 software is used to conduct all the data analysis.

3.5 Variable Description, Measurement and Hypotheses of the Study

H1: Using optimal hedge ratio significantly reduce exposure to oil price fluctuation and thus reduce cost.

This study has aimed in analyzing the relationship between the dependent and independent variable through testing hypothesis regrading to using optimal hedge ratio significantly reduce exposure to oil price fluctuation and thus reduce cost. Therefore, the most important task is to select the appropriate explanatory variables. Based on the literature review the following variables are selected and the description and operational definitions of the selected variables are described below.

3.5.1 Dependent Variable

The dependent variable used in this study is log return on the spot price(ΔS_t) .

It is calculated by taking the natural logarithm (ln) of the current period spot price divided by the natural logarithm of the previous period spot price.

$$\Delta S_t = \frac{lnS_t}{lnS_{t-1}} \qquad \textbf{(3.2)}$$

By applying the quotient rule of logarithm: $ln\frac{X}{Y} = ln(X) - ln(Y)$

$$\frac{lnS_t}{lnS_{t-1}} = lnS_t - ln\,S_{t-1}$$

Therefore, $\Delta S_t = lnS_t - lnS_{t-1}$ **(3.3)**

Ripple & Moosa (2007) in their study ‘Hedging effectiveness and futures contract maturity: the case of NYMEX crude oil futures’ calculated log return on the spot price by taking the natural logarithm of the current period spot price minus the natural logarithm of the previous period spot price.

3.5.2 Independent Variables

The independent variable used in this study is log return on the future price(ΔF_t) .

It is calculated by taking the natural logarithm (ln) of the current period future price divided by the natural logarithm of the previous period future price.

$$\Delta F_t = \frac{lnF_t}{lnF_{t-1}} \qquad (3.4)$$

By applying the quotient rule of logarithm: $ln\frac{X}{Y} = ln(X) - ln(Y)$

$$\frac{lnF_t}{lnF_{t-1}} = lnF_t - ln\,F_{t-1}$$

$$\textbf{Therefore, } \Delta F_t = lnF_t - lnF_{t-1} \qquad (3.5)$$

A study by Islam (2017) calculated log return on the future price by taking the natural logarithm of the current period future price minus the natural logarithm of the previous period future price.

3.6 Model Specification

In order to study the relationship between change in spot price and change in future price a biavariate econometrics model was developed.

$$y_t = \alpha + \beta x_t + u_t \qquad (3.6)$$

The subscript t representing the time-series dimension. The left-hand side of the equation represents the dependent variable(ΔS_t) and the right-hand side represents the independent variable(ΔF_t). α is the intercept, β is the coefficient which represents the slope of the explanatory variable and u_t denotes the error term.

There are various models to estimate hedge ratio. In this study, I decided to employ Conventional Hedging (Naïve Portfolio), Ordinary Least Square (OLS) Model and Error Correction Model(ECM).

3.6.1 Model 1: Conventional Hedging (Naïve Portfolio)

Conventionally, hedging against the price fluctuation is done using hedge ratio of “-1”, that is, taking a position in the futures contract which is equal in magnitude, but opposite in sign to that of the physical market. If a trader has to buy the commodity in a future date, then he/she sells the same amount of futures contracts at present date (Johnson, 1960).

Conventional hedging suggested the naïve-hedging (a fully hedged position 100%) strategy of taking position in both the markets in the ratio 1:1, that is, holding one unit of futures contract for hedging a unit of spot position (Malhotra, 2015).

Naive hedge ratio implies: Quantity (unit) of spot = Quantity (unit) of futures

$$\boldsymbol{Q_s = Q_F} \qquad \textbf{(3.7)}$$

$$\textbf{or} \quad \frac{\boldsymbol{Q_s}}{\boldsymbol{Q_F}} = \mathbf{1}$$

Therefore, the hedge ratio is $\boldsymbol{h^* = 1}$

Where Qs: Quantity (unit) of spot and Q_F: Quantity (unit) of futures.

Hedging Effectiveness (H.E) is defined as the ratio of the variance of the unhedged portfolio over the variance of the unhedged portfolio

$$\text{H.E} = \frac{\boldsymbol{Var(U) - Var\ (H)}}{\boldsymbol{Var(U)}} \qquad \textbf{(3.8)}$$

Where , Var (U)=$\boldsymbol{\sigma_s}^{\mathbf{2}}$ and

Var (H)= $\boldsymbol{\sigma_s}^{\mathbf{2}} + \boldsymbol{h^2 \sigma_f}^{\mathbf{2}}$ −2h $\boldsymbol{\sigma_{s,f}}$

σ_S & σ_f are standard deviation of the spot & futures returns, $\sigma_{S,f}$ is the covariance, h is the hedge ratio.

This strategy would work effectively if the spot price and futures price moves exactly the same way. In practice, there is no perfect correlation between the spot and futures prices nor have the same volatility. So there comes a need to use a better strategy (Johnson, 1960).

3.6.2 Model 2: Ordinary Least Square (OLS)

According to Islam (2017) the OLS method is a simple linear regression method which involves regression of change (log return on the spot price ΔS_t = rspot) in spot price against the change (log return on the future price $\Delta\, F_t$ = rfutures) in future price.

$$\boldsymbol{\Delta S_t = \alpha + \beta \Delta\, F_t + u_t}\,, \qquad \boldsymbol{u_t \sim \mathrm{N}\,(0, \sigma^2\,)} \qquad \textbf{(3.9)}$$

Where $\boldsymbol{\Delta S_t = lnS_t - lnS_{t-1}}$, and $\boldsymbol{\Delta F_t = ln\mathrm{F}_t - lnF_{t-1}}$. $\boldsymbol{u_t}$ is the error term.

The coefficient β (the slope of the OLS regression) is the optimal hedge ratio which can also be calculated as: the ratio of the covariance between spot and futures return to the variance of futures return.

$$\boldsymbol{h^*} = \rho\frac{\sigma_S}{\sigma_F} = \frac{\boldsymbol{COV(\Delta S, \Delta F)}}{\sigma_F^2} \qquad \textbf{(3.10)}$$

where σ_S and σ_F are the standard deviations of ΔS_t and ΔF_t respectively. ρ is the coefficient of correlation between the two. The OLS estimate hedge ratio (slope of the regression) is considered reasonable if the underlying assumptions u_t has zero mean, same variance, and are uncorrelated are fulfilled. The hedging effectiveness is indicated by the $R^2$of the regression

3.6.3 Model 3: Error Correction Model (ECM)

There are several reasons why the concept of non-stationarity is important and why it is essential that variables that are non-stationary be treated differently from those that are stationary. A stationary series – I(0) can be defined as one with a constant mean, constant variance and constant autocovariances for each given lag. An examination of whether a series can be viewed as stationary or not is essential for the following reasons:

- The stationarity or otherwise of a series can strongly influence its behavior and properties.
- The use of non-stationary data can lead to spurious regressions (a regression that 'looks' good under standard measures: significant coefficient estimates and a high R^2, but which is really valueless).
- If the variables employed in a regression model are not stationary, then it can be proved that the standard assumptions for asymptotic analysis will not be valid. In other words, the usual 't-ratios' will not follow a t-distribution, and the F-statistic will not follow an F-distribution, and so on (Brooks 2014, p. 353-55).

Cointegration a concept whereby time series have a fixed relationship in the long run. Cointegration is said to exist between two or more non-stationary time series if they possess the same order of integration and a linear combination (weighted average) of these series is stationary. If the level series of spot and futures price are non-stationary and integrated of order one I(1) and if the linear combination of the two series is stationary, cointegration exists between the two series.

Error correction model is applied when the underlying series are cointegrated. Sometimes two or more-time series have the common stochastic trend. With such trends, they can move together so closely over the long run which can refer to as the long run equilibrium relationship between the series. In the short run, however there may be disequilibrium which is treated as the error term. This error term can be used to correct the short run disequilibrium. According to Engle and Granger (1987) who popularized this error correction term stated that if two series are cointegrated, then the relationship between them can be expressed by ECM. (Islam, 2017). If we had found the two series to be cointegrated (there would be a linear combination of the spot and futures prices that would be stationary), an error correction model (ECM) can been estimated.

Then, the ECM can be applied to estimate hedge ratio. The ECM specification is expressed as follows:

$$\Delta \boldsymbol{S_t} = \boldsymbol{\alpha} + \boldsymbol{\beta_1} \Delta \boldsymbol{F_t} + \boldsymbol{\beta_2}(\boldsymbol{\hat{u}_{t-1}}) + \boldsymbol{v_t} \qquad \textbf{(3.11)}$$

Where, $\boldsymbol{\hat{u}_{t-1}} = \Delta \boldsymbol{S_{t-1}} - \boldsymbol{\gamma} \Delta \boldsymbol{F_{t-1}}$ is the error correction term

$\boldsymbol{\gamma}$: Defines the long-run relationship between spot and futures price.

$\boldsymbol{\beta_1}$: Describes the short-run relationship between ΔS_t and ΔF_t

$\boldsymbol{\beta_2}$: Describes the speed of adjustment back to equilibrium, and its strict definition is that it measures the proportion of last period's equilibrium error that is corrected for.

Provided that ΔS_t and ΔF_t are cointegrated with cointegrating coefficient γ, then ($\Delta \boldsymbol{S_{t-1}} - \boldsymbol{\gamma} \Delta \boldsymbol{F_{t-1}}$) will be I(0) even though the constituents are I(1). It is thus valid to use OLS and standard procedures for statistical inference on (3.11) (Brooks 2014, p. 375-376).

3.7 Summary

This Chapter discussed the research methodology that was adopted for the research. It also outlined the data type and sources, Population and sampling method, methods of data analysis and tools used in the research. It also discussed the different types of diagnostic tests employed to check the selected models are appropriate or not. Finally, it discussed the dependent and independent variables and the different models that used to study the relationship between them.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Descriptive Statistics Analysis

Since more than one series ($\Delta S_t =$ Rspot and $\Delta\, F_t =$ Rfutures) is employed the researcher studies a number of descriptive statistics together and measure the association between the series. This section presents the descriptive statistics of dependent and explanatory variable used in the study. The dependent variable used in this study was log return on the spot price (Rspot) while explanatory variable is log return on the future price (Rfutures).

The summary descriptive results for the variables used in the study includes mean, median, maximum, minimum, standard deviation, skewness, kurtosis and number of observations.

Table 4.1 Summary of descriptive statistics for variables

	RSPOT	RFUTURES	JAN15DUM	AUG15DUM
Mean	0.186926	0.163481	0.002924	0.002924
Median	1.099181	0.650538	0	0
Maximum	20.06707	33.69973	1	1
Minimum	-31.09554	-40.74024	0	0
Std. Dev.	8.663763	8.943144	0.054074	0.054074
Skewness	-0.707034	-0.54703	18.41203	18.41203
Kurtosis	4.054437	5.006413	340.0029	340.0029
Jarque-Bera	44.33784	74.42291	1637710	1637710
Probability	0	0	0	0
Sum	63.92869	55.91041	1	1
Sum Sq. Dev.	25595.73	27273.12	0.997076	0.997076
Observations	342	342	342	342

Source: Eviews outputs

4.1.1 Log return on the spot price (Rspot)

The mean value of the sample is the measure of center found by adding the values and dividing the total by the number of values. The mean describes the average values of log return on the spot price which is 0.187%. The median of the sample is the measure of center that is the middle value when the original data values are arranged in order of increasing (or decreasing) magnitude. The median value of the log return on the spot price is 1.09%. The maximum and minimum values of each variable show the maximum and minimum value of the sample respectively. The maximum and minimum value shows outliers for each variable which are data values that are far away from other data values and strongly affects the result of analysis. The value of rspot ranges from a minimum of -31.09 % to a maximum of 20.06%. The standard deviation in the fifth row tells us how spread out the data are about the mean which is 8.66% for rspot. Skewness is a measure of symmetry. It measures how far a distribution is from being symmetric. It is a measure of asymmetry of the distribution of the series around its mean. The measure is usually compared to the value for the standard normal distribution, which is zero. The skewness for rspot is -0.70 which indicates that it is moderately skewed to the left. Kurtosis is a measure of tallness or flatness of the tails of a distribution. The measure is usually compared to the value for the standard normal distribution, which is three. The kurtosis for the rspot is 4.05 which shows that its tails are longer and fatter compared to a standard normal distribution. Distributions with kurtosis greater than 3 are said to be leptokurtic.

4.1.2. Log return on the future price (Rfutures)

As we can see in the table the average value of the log return on the future price is 0.163% and the median value is 0.65%. The value of rfutures ranges from a minimum of -40.74 % to a maximum of 33.69 %. The standard deviation of rfutures from its mean value is 8.94%. The skewness for rfutures is -0.54 which indicates that it is slightly skewed to the left. The kurtosis for the rfutures is 5.0 which shows that its tails are longer and fatter compared to a standard normal distribution.

4.2 Correlation Analysis

The correlation between two variables measures the degree of linear association between them. Correlation is an evidence for a linear relationship between two variables, and the movements in the two variables are on average related to an extent given by their correlation coefficient. The correlation takes the covariance and standardizes or normalizes it so that it is unit free. The result of this standardization is that the correlation is bounded to lie on the (–1,1) interval. A correlation of 1 (–1) indicates a perfect positive (negative) association between the series. If the correlation coefficient is 0, the movement of variables is said to have no correlation (Brooks 2014, p. 69 &76)

Table 4.2: Correlation matrix of dependent and independent variable

	RSPOT	RFUTURES	JAN15DUM	AUG15DUM
RSPOT	1.0000	0.725768	-0.167937	-0.123497
RFUTURES	0.725768	1.0000	-0.048729	0.021133
JAN15DUM	-0.167937	-0.048729	1.0000	-0.002933
AUG15DUM	-0.123497	0.021133	-0.002933	1.0000

Source: Eviews outputs

The above correlation matrix indicates a strongly positive relationship between the dependent (rspot) and the independent variables (rfutures)

4.3 Data Stationarity Test /Unit root test

Time series data points are often non-stationary or have means, variances and covariances that change over time. Non-stationary means contains unit roots (integrated once, denoted by I(1)). Non-stationary behaviors can be trends, cycles, random walks or combinations of the three. Non-stationary data, as a rule, are unpredictable and cannot be modeled or forecasted. The results obtained by using non-stationary time series may be spurious in that they may indicate a relationship between two variables where one does not exist. In order to receive consistent, reliable results, the non-stationary data needs to be transformed into stationary data. Stationary means contains no unit roots (integrated of order zero, denoted by I(0)). In contrast to the non-stationary process that has a variable variance and a mean that does not remain near, or returns to a long-run mean over time, the stationary process reverts around a constant long-term mean and has a constant variance independent of time.

Using non-stationary time series data in financial models produces unreliable and spurious results and leads to poor understanding and forecasting. The solution to the problem is to transform the time series data so that it becomes stationary (Investopedia stationary, 2019).

The early and pioneering work on testing for a unit root in time series was done by Dickey and Fuller. The test is known as an Augmented Dickey–Fuller (ADF). Thus, the hypotheses of interest are H_0: series contains a unit root versus H_1: series is stationary. If H_0 is rejected, it would simply be concluded that the series does not contain a unit root. But if H_0 is not rejected, the series contains a unit root (Brooks 2014, p. 361-55).

I employed ADF test to test whether the spot and futures prices (raw price) and their first difference(return) are stationary or not.

Table 4.3 Augmented Dickey-Fuller (ADF) test statistic on spot and rspot

Null Hypothesis: SPOT has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on SIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.899153	0.3326
Test critical values:	1% level		-3.449332	
	5% level		-2.8698	
	10% level		-2.571239	
Null Hypothesis: RSPOT has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-14.61381	0.0000
Test critical values:	1% level		-3.449332	
	5% level		-2.8698	
	10% level		-2.571239	

Source: Eviews outputs

The ADF test statistic for spot is greater than the critical value, so the null hypothesis of a unit root in the spot price series cannot be rejected. Spot has a unit root. Therefore, the spot price is non -stationary (its statistical properties varies with time). The ADF test statistic for rspot is less than the critical value, so the null hypothesis of a unit root in the spot return (first difference) is rejected. The spot return is stationary.

Table 4.4 Augmented Dickey-Fuller (ADF) test statistic on futures and rfutures

Null Hypothesis: FUTURES has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on SIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.854837	0.3536
Test critical values:	1% level		-3.449332	
	5% level		-2.8698	
	10% level		-2.571239	
Null Hypothesis: RFUTURES has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-15.62081	0.0000
Test critical values:	1% level		-3.449332	
	5% level		-2.8698	

Source: Eviews outputs

The ADF test statistic for futures is greater than the critical value, so the null hypothesis of a unit root in the futures price series cannot be rejected. Futures has a unit root. Therefore, the futures price is non-stationary (its statistical properties varies with time). The ADF test statistic for rspot is less than the critical value, so the null hypothesis of a unit root in the futures return (first difference) is rejected. The futures return is stationary.

4.4 Testing Assumptions of Classical Linear Regression Model (CLRM) for Model 2

Assumptions were made relating to the classical linear regression model (CLRM). These were required to show that the estimation technique, ordinary least squares (OLS), had a number of desirable properties, and also so that hypothesis tests regarding the coefficient estimates could validly be conducted (Brooks 2014, p. 179).

4.4.1 Test for weather average value of the error term is Zero

The first assumption required is that the average value of the errors is zero. In fact, if a constant term is included in the regression equation, this assumption will never be violated (Brooks 2014, p. 181).

Since a constant term (i. e. α) is included in the regression equation this assumption is not violated.

4.4.2 Hetroscedasticity Test: White test

The second assumption states that the variance of the errors is constant this is known as the assumption of homoscedasticity. A popular test is White's general test for heteroscedasticity. The test is particularly useful because it makes few assumptions about the likely form of the heteroscedasticity. If the *p*-values are considerably in excess of 0.05, there is no evidence for the presence of heteroscedasticity (Brooks 2014, p. 181-183).

Table 4.5. Heteroskedasticity Test: White

Heteroskedasticity Test: White			
F-statistic	0.042303	Prob. F(1,340)	0.8372
Obs*R-squared	0.042546	Prob. Chi-Square(1)	0.8366
Scaled explained SS	0.058235	Prob. Chi-Square(1)	0.8093

Source: Eviews outputs

Both the F-and Chi-Square version of the test statistics give the same conclusion that there is no evidence for the presence of heteroscedasticity, since the p-values are considerably greater than 0.05. Therefore, the assumption of Homoscedasticity is not violated.

4.4.3 Test for Multicollinearity

The third assumption is that there is no multicollinearity among the regressors included in the regression model.

Table 4.6. Multicollinearity test

	RFUTURES	JAN15DUM	AUG15DUM
RFUTURES	1.0000	-0.048729	0.021133
JAN15DUM	-0.048729	1.0000	-0.002933
AUG15DUM	0.021133	-0.002933	1.0000

Source: Eviews outputs

Since, the correlation between the independent variable is very week the assumption of Multicollinearity is not violated.

4.4.4 Autocorrelation Test: Breusch-Godfrey Serial Correlation LM Test

Assumption 4 that is made of the CLRM's disturbance terms is that the covariance between the error terms over time is zero. In other words, it is assumed that the errors are uncorrelated with one another. The Breusch–Godfrey test is a more general test for autocorrelation up to the *r*th order. The conclusion from the test is that the null hypothesis of no autocorrelation should be rejected if the *p*-values are below 0.05 (Brooks 2014, p. 197 &198).

Table 4.7 Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	6.430365	Prob. F(10,330)	0.0000
Obs*R-squared	55.77389	Prob. Chi-Square(10)	0.0000

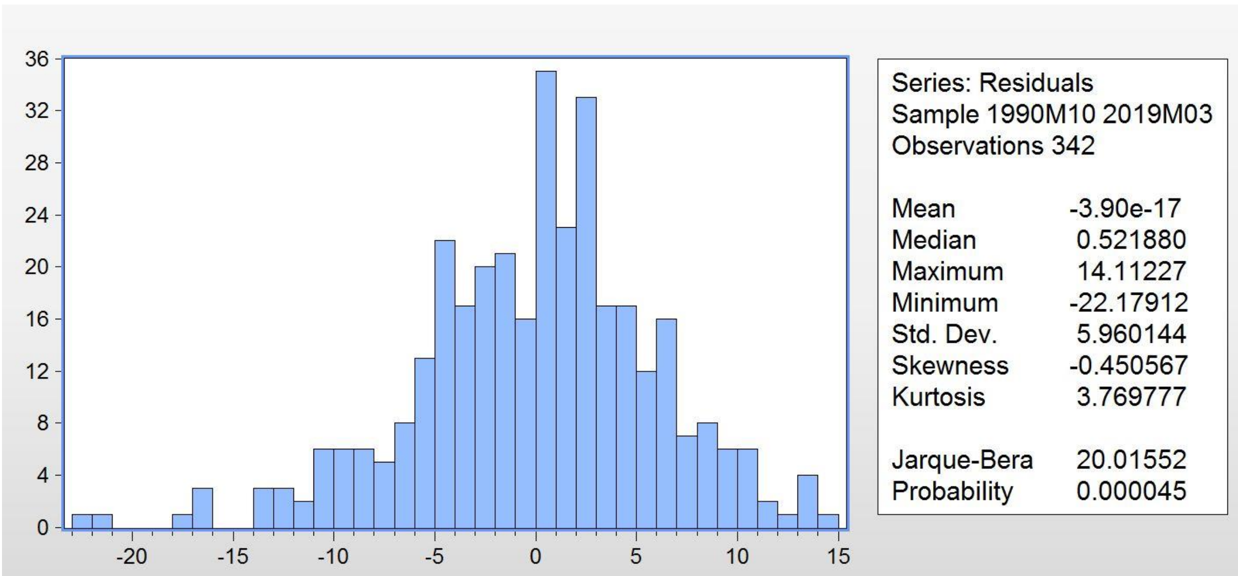
Source: Eviews outputs

The conclusion from the test in this case is that there is evidence of autocorrelation since the p - value is less than 0.05. Therefore, the assumption of no autocorrelation is violated.

4.4.5 Normality Test

The normality assumption ($u_t \sim N(0, \sigma^2)$) is required in order to conduct single or joint hypothesis tests about the model parameters. A normal distribution is not skewed (skewness=0) and is defined to have a coefficient of kurtosis of 3. One of the most commonly applied tests for normality is the Jarque - Bera (JB) test (Brooks 2014, p. 209).

Figure 4.1 Normality Test



Source: Eviews outputs

In this case the residuals are slightly skewed to the left (negatively). The Skewness is different from zero, the Kurtosis is 3.76 and the p - value is less than 0.05. All these are strong evidence that normality assumption is violated.

4.4.6 Test for Linearity: Ramsey RESET test

A further implicit assumption of the classical linear regression model is that the appropriate 'functional form' is linear. This means that the appropriate model is assumed to be linear in the parameters, and that in the bivariate case, the relationship between the dependent and the independent variable can be represented by a straight line. Whether the model should be linear can be formally tested using Ramsey's RESET test, which is a general test for misspecification of functional form. If the p value of the test statistic is greater than 0.05, don't reject the null hypothesis that the functional form was correct (Brooks 2014, p. 220).

Table 4.8: Ramsey RESET Test

Ramsey RESET Test				
Equation: EQ01				
Specification: RSPOT C RFUTURES				
Omitted Variables: Squares of fitted values				
	Value	df	Probability	
t-statistic	1.001004	339	0.3175	
F-statistic	1.002009	(1, 339)	0.3175	

Source: Eviews outputs

The p-values from the test statistics are in excess of 0.05. This indicate that the relationship between rspot and rfutures is linear.

4.5 Solutions for the violated assumptions and possible remedies

Violated assumption: Normality

Normality assumption is violated in the above regression because of outliers in the observation (on January 2015 and August 2015).

Suggested solution

The best solution to correct the violation of normality assumption is to use Dummy Variables to effectively remove the outlier observations (Brooks 2014).

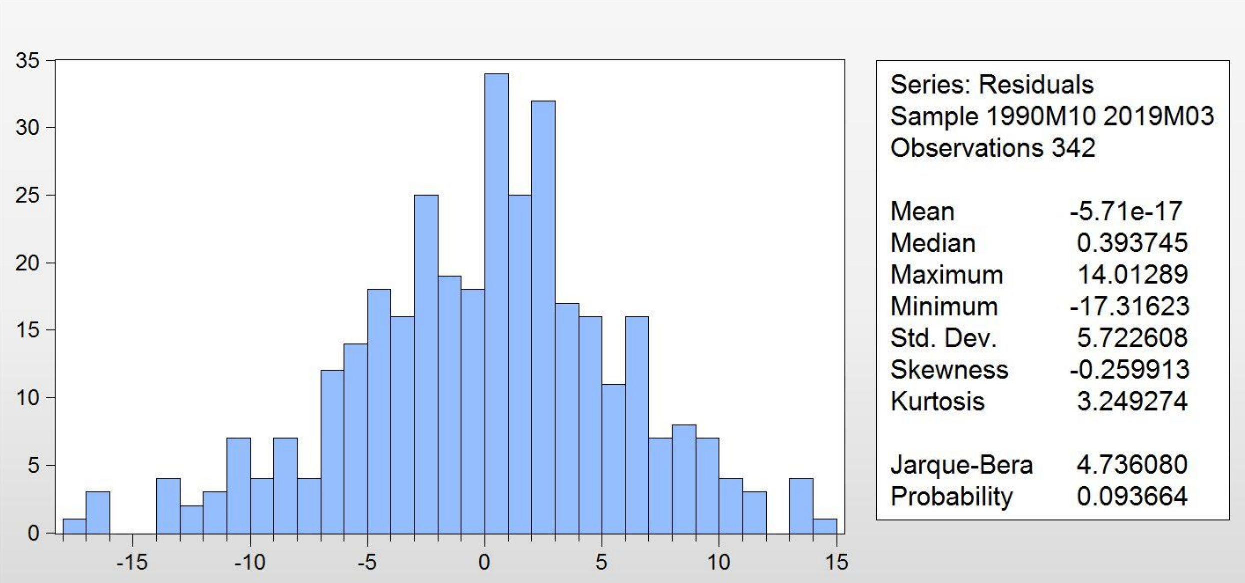
Corrected output

I generate new series called JAN15DUM and AUG15DUM which initially contains only zero. Then I open the spread sheet and turn on editing mode and input a single 1 in the cell that corresponds to the outlier observation and leave all other entries as zero.

I rerun the regression including the previous variable plus the two dummy variables.

The test for normality is conducted on the new regression which gives the below result.

Figure 4.2 Normality Test



Source: Eviews outputs

In this case the residuals are distributed almost symmetrically. The Skewness is close to zero and the Kurtosis is near to 3. The p-value of the JB stat is greater than 0.05. Therefore, Normality assumption is no more violated.

4.6 Regression Analysis and discussion of Model 2: OLS

In this section, the relationship between the dependent and independent variable will be discussed based on the regression result of the OLS model.

The regression model used to find the relationship between ΔS_t *and* ΔF_t was;

$\Delta S_t = \alpha + \beta \Delta F_t + u_t$, $u_t \sim N(0, \sigma^2)$

Accordingly, Table 4.9 below presents the result of the OLS model using Eviews 9 software that examines the effect of explanatory variables on rspot. Hence, rspot is explained variable whereas rfuture, jan15dum, and aug15dum are explanatory variables.

Table 4.9 Results of OLS regression output

Dependent Variable: RSPOT
Method: Least Squares
Date: 04/24/19 Time: 22:55
Sample (adjusted): 1990M10 2019M03
Included observations: 342 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.200114	0.311787	0.641829	0.5214
RFUTURES	0.699658	0.034854	20.07375	0.0000
JAN15DUM	-21.33383	5.763227	-3.701715	0.0002
AUG15DUM	-22.29471	5.757667	-3.872178	0.0001

R-squared	0.563710	Mean dependent var	0.186926
Adjusted R-squared	0.559838	S.D. dependent var	8.663763
S.E. of regression	5.747948	Akaike info criterion	6.347190
Sum squared resid	11167.15	Schwarz criterion	6.392042
Log likelihood	-1081.369	Hannan-Quinn criter.	6.365058
F-statistic	145.5716	Durbin-Watson stat	2.703974
Prob(F-statistic)	0.000000		

Source: Eviews outputs

Therefore, the second model applied on this study through Ordinary Least Square (OLS) was:

$$\Delta S_t = 0.200 + 0.699\,\Delta F_t - 21.33\text{Jan15dum} - 22.29\text{Aug15dum} + u_t$$

4.6.1 Interpretation of the regression result

a) Constant term (C)

Coefficient

The intercept (often labeled the constant) is the expected mean value of rspot when all the independent variables are zero.

On average, when rfutures, Jan15dum and Aug15dum are all zero, the value of rspot changes positively by 0.20 % but the relationship is statistically insignificant even at 10% significance level.

Standard Error

The value can vary by 0.31 % up and down.

t-Statistics

Per unit of 1 standard error 0.20 is far away from zero by 0.64.

b) Independent Variable (rfutures)

Coefficient

When on average rspot is increased by 1% the value of rfuture will increase by 0.699% and the relationship is statistically significant at 1% significance level. This result is consistent with financial theory which premises a positive relationship between the spot and future price.

The coefficient β (the slope of the OLS regression) is the optimal hedge ratio. It means that for every spot contract EPSE must purchase 0.699 future contract to hedge against oil price fluctuation. It is statistically highly significant and less than unity.

Standard Error

The value can vary by 0.034 % up and down.

t-Statistics

Per unit of 1 standard error 0.699 is far away from zero by 20.07.

Independent Variable (jan15dum)

On average, holding other variables constant, being in the month Jan 2015 (Jan15dum=1) decreases the return on spot by 21.33 % as compared to being in a different month and the relationship is statistically significant at 1% significance level.

Independent Variable (aug15dum)

On average, holding other variables constant, being in the month Aug 2015 (Aug15dum=1) decreases the return on spot by 22.29 % as compared to being in a different month and the relationship is statistically significant at 1% significance level.

c) R^2 and Adjusted R^2

The most common goodness of fit statistic is known as R^2. R^2 describes how well the regression model actually fits the data. It shows how much of the variability of the dependent variable from its mean value can be explained by the change in the independent variable. R^2must always lie between zero and one (provided that there is a constant term in the regression). A value of R^2close to 1 indicates that the model explains nearly all of the variability of the dependent variable about its mean value, while a value close to zero indicates that the model fits the data poorly. A higher

R^2 implying, everything else being equal, that the model fits the data better. Adjusted R^2 takes into account the loss of degrees of freedom associated with adding extra variables were inferred to see the explanatory powers of the model and it is an output in which we shall use for better interpretation. It can be interpreted as the fraction of the variance of the dependent variable explained by the independent variables (Brooks 2014, p. 151-155).

In this study 55.98 % of the variability in rspot (log return on the spot price ΔS_t) has been explained by rfutures (log return on the future price ΔF_t) and the dummy variables. However, 44.02 % remains unexplained. This shows that the model is strongly fit to explain the relationship between spot and future price.

The hedging effectiveness is indicated by the $R^2$of the regression. It means the hedge ratio obtained from OLS regression provides approximately 56.37 % reduction in the variance of the position. Therefore, this model is 56.37 % effective in hedging the oil price fluctuation.

d) Regression F-Stat

The regression F -statistic tests the null hypothesis that all of the coefficients except the intercept coefficient are zero. This test is sometimes called a test for 'junk regressions', since if this null hypothesis cannot be rejected, it would imply that none of the independent variables in the model was able to explain variations in the dependent variable. It is a test for model adequacy (Brooks 2014, p. 152).

rfutures, Jan15dum and Aug15dum have a joint significance effect on rspot at 1% significance level. Hence, prob (F-statistic) = 0.000000. Therefore, the model was fit for estimation.

e) DW Stat

Referring to the DW (342,1) table of 1% significance, d_L=1.664 and d_U=1.684. The DW stat of the regression output is 2.70, therefore 2.70 > 4 - d_L (2.336) implying that there is negative autocorrelation.

4.6.2. Test for Autocorrelation (after the dummy variables are included in the regression): Breusch-Godfrey Serial Correlation LM Test

Table 4.10 Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	6.649124	Prob. F(10,328)		0.00000
Obs*R-squared	57.64387	Prob. Chi-Square(10)		0.00000
Prob(F-statistic)	0.00000			

Source: Eviews outputs

There is evidence of autocorrelation since the p-value is less than 0.05. Assumption of no autocorrelation is again violated.

4.6.3 Consequences of ignoring autocorrelation if it is present

The consequences of ignoring autocorrelation when it is present are: the coefficient estimates derived using OLS are still unbiased, but they are inefficient, i.e. they are not BLUE (Best Linear Unbiased Estimators), even at large sample sizes, so that the standard error estimates could be wrong. There thus exists the possibility that the wrong inferences could be made about whether a variable is or is not an important determinant of variations in the dependent variable (Brooks 2014, p. 199).

4.7. Cointegration Test

It is implied that non-stationary variables can lead to spurious regressions unless at least one cointegration relationship is present means that some form of testing for cointegration is almost mandatory.

Financial theory should suggest where two or more variables would be expected to hold some long-run relationship with one another. There are many examples in finance of areas where cointegration might be expected to hold, including: Spot and futures prices for a given commodity or asset.

Spot and futures prices may be expected to be cointegrated since they are obviously prices for the same asset at different points in time, and hence will be affected in very similar ways by given pieces of information. The long-run relationship between spot and futures prices would be given by the cost of carry (Brooks 2014, p. 374).

If the two series are cointegrated, this means that the spot and futures prices have a long-term relationship, which prevents them from wandering apart without bound. To test for cointegration using the Engle–Granger approach, the residuals of a regression of the spot price on the futures price are examined. The residuals of this regression are found in the object called RESID. Generate a new series that will keep these residuals in an object for later use:

ECM = RESID

This is required since every time a regression is run, the RESID object is updated (overwritten) to contain the residuals of the most recently conducted regression. Perform the ADF Test on the residual series ECM.

The Engle–Granger approach is employed because it is easy to use and there can be at most one cointegrating relationship since there are only two variables (spot and futures) in the system (Brooks 2014, P. 401-403).

The residuals should be I (0) if the variables series are cointegrated, but the residual will still be non-stationary if they are not. The null hypothesis is: there is a unit root in the potentially cointegrating regression residuals, while the alternative hypothesis is: the residuals are stationary.

Table 4.11 Cointegration test using the Engle–Granger approach

Null Hypothesis: ECM has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on SIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-17.38908	0.0000
Test critical values:	1% level		-3.449389	
	5% level		-2.869825	
	10% level		-2.571253	

Source: Eviews outputs

Since the test statistic (−17.38) is less than the critical values, even at the 1% level, the null hypothesis of a unit root in the test regression residuals is rejected. We would thus conclude that the two series are cointegrated. This means that the most appropriate form of model to estimate would be an error correction model (ECM).

ECM is suitable because there would be a linear combination of the spot and futures prices that would be stationary. The ECM would be the appropriate model in this case because it would enable us to capture the long-run relationship between the series as well as the short-run one (Brooks 2014, p. 403).

4.8 Regression analysis and discussion of Model 3: ECM

Since we had found the two series to be cointegrated, an error correction model (ECM) is employed, as there would be a linear combination of the spot and futures prices that would be stationary (Brooks 2014, p. 403).

The regression model used to find the relationship between ΔS_t and ΔF_t was;

$$\boldsymbol{\Delta S_t = \alpha + \beta_1 \Delta F_t + \beta_2(\hat{u}_{t-1}) + v_t}$$

We could estimate an error correction model by running the regression

rspot c rfutures ecm (−1)

Since there were another outliers in the observation (on November 2008 and December 2008) two additional dummy variables (nov08dum and dec08dum) are included. This effectively remove the outlier observations so that normality assumption is not violated.

Accordingly, Table 4.11 below presents the result of the ECM model using Eviews 9.

Table 4.12 Result of ECM Regression Output

Dependent Variable: RSPOT
Method: Least Squares
Date: 04/30/19 Time: 22:55
Sample (adjusted): 1990M11 2019M03
Included observations: 341 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.303001	0.275082	1.101491	0.2715
RFUTURES	0.666676	0.031134	21.41337	0.0000
JAN15DUM	-25.83683	5.083674	-5.082313	0.0000
AUG15DUM	-20.04770	5.061100	-3.961135	0.0001
NOV08DUM	-18.91830	5.094533	-3.713451	0.0002
DEC08DUM	-23.87469	5.146632	-4.638896	0.0000
ECM(-1)	-0.409034	0.046763	-8.747026	0.0000

R-squared	0.667628	Mean dependent var	0.178211
Adjusted R-squared	0.661657	S.D. dependent var	8.674993
S.E. of regression	5.046002	Akaike info criterion	6.095384
Sum squared resid	8504.354	Schwarz criterion	6.174044
Log likelihood	-1032.263	Hannan-Quinn criter.	6.126723
F-statistic	111.8165	Durbin-Watson stat	2.075928
Prob(F-statistic)	0.000000		

Source: Eviews outputs

Therefore, the third model applied on this study through ECM was:

$$\Delta S_t = 0.30 + 0.667\,\Delta F_t - 25.84\ \text{Jan15dum} - 20.04\ \text{Aug15dum} - 18.92\ \text{Nov08dum} - 23.87\ \text{Dec08dum} - 0.409\ \text{Ecm}(-1) + v_t$$

4.8.1 Interpretation of the regression result

a) Constant term (C)

Coefficient

On average, when rfutures, Jan15dum, Aug15dum, Nov08dum, Dec08dum and lag of the error correction term (ECM (-1)) are all zero, the value of rspot changes positively by 0.30 % but the relationship is statistically insignificant even at 10% significance level.

Standard Error

The value can vary by 0.27 % up and down.

t-Statistics

Per unit of 1 standard error 0.30 is far away from zero by 1.10.

b) Independent Variable (rfutures)

Coefficient

When on average rspot is increased by 1% the value of rfuture will increase by 0.667% in the short run and the relationship is statistically significant at 1% significance level. This result is consistent with financial theory which premises a positive relationship between the spot and future price in the short run.

The coefficient β (the slope of the OLS regression) is the optimal hedge ratio. It means that for every spot contract EPSE must purchase 0.667 future contract to hedge against oil price fluctuation. It is statistically highly significant and less than unity. Since futures contract size are a positive integer multiple of 1,000 barrels EPSE should purchase 8,000 barrels of futures contract for every 12,000 barrels of oil that purchases for physically delivered to hedge against the oil price fluctuation.

Standard Error

The value can vary by 0.031 % up and down.

t-Statistics

Per unit of 1 standard error 0.667 is far away from zero by 21.4.

Independent Variable (jan15dum)

On average, holding other variables constant, being in the month Jan 2015 (Jan15dum=1) decreases the return on spot by 25.84 % as compared to being in a different month and the relationship is statistically significant at 1% significance level.

Independent Variable (aug15dum)

On average, holding other variables constant, being in the month Aug 2015 (Aug15dum=1) decreases the return on spot by 20.05 % as compared to being in a different month and the relationship is statistically significant at 1% significance level.

Independent Variable (nov08dum)

On average, holding other variables constant, being in the month Nov 2008 (nov08dum=1) decreases the return on spot by 18.92 % as compared to being in a different month and the relationship is statistically significant at 1% significance level.

Independent Variable (dec08dum)

On average, holding other variables constant, being in the month Dec 2008 (dec08dum=1) decreases the return on spot by 23.87 % as compared to being in a different month and the relationship is statistically significant at 1% significance level.

c) The error term (ecm (-1))

The coefficient on of ECM (-1) measures how much the spot price responds to equilibrium errors. The coefficient is negative and significantly different from zero.

on average 40.9% of the data will be adjusted back to the equilibrium this year and the remaining 59.1% will be adjusted next year. Or the proportion of last period's equilibrium error that is corrected is 40.9% and the relationship is statistically significant at 1% significance level.

This can be considered as moderate adjustment to equilibrium error.

d) R^2 and Adjusted R^2

66.17% of the variability in rspot (log return on the spot price ΔS_t) has been explained by rfutures (log return on the future price ΔF_t), the dummy variables and lag of ECM. However, 33.83 % remains unexplained. This shows that the model is strongly fit to explain the relationship between spot and future price.

The hedging effectiveness is indicated by the R^2 of the regression. Therefore, this model is 66.76 % effective in hedging the oil price fluctuation. It means the hedge ratio obtained from ECM model provides approximately 66.76 % in risk reduction.

e) Regression F-Stat

rfutures, jan15dum, aug15dum, nov08dum, dec08dum and ecm (-1), have a joint significance effect on rspot at 1% significance level. Hence, prob (F-statistic) = 0.000000. Therefore, the model was fit for estimation.

f) DW Stat

Referring to the DW (341,6) table of 1% significance, d_L =1.613 and d_U =1.735. When d_U < DW < (4- d_U) it implies no autocorrelation.

The DW stat of the regression output is 2.07 and 4- d_U = 2.265. Therefore, 1.735 < 2.07 < 2.265 implying that there is no autocorrelation.

4.9 Summary

This chapter discussed the results of the study regarding the estimation of optimal hedge ratio for oil futures. The chapter begins with the descriptive statistics which confirmed that data are in a good level of consistency and stability in distribution. Following the descriptive statistics, correlation analysis, data stationary test and test for the assumption of CLRM were conducted.

Finally, the optimal hedge ratio is estimated using OLS and ECM models. Both models show that hedging with future contracts significantly reduces oil price fluctuation risk.

Based on the findings of the regression results previously formulated alternative hypothesis is tested.

H1: Using optimal hedge ratio significantly reduce exposure to oil price fluctuation and thus reduce cost.

The hedging effectiveness obtained from the R^2 of both regression shows that both models significantly reduce exposure to oil price fluctuation risk. Thus, the hypothesis is valid.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

The previous chapter presented the analysis of the findings and discussions of the study. The purpose of this chapter is to discuss the conclusions, recommendations and give future research directions. Accordingly, the chapter starts by outlining the conclusions of the study in accordance with the study results. It also gives an insight on the policy recommendations as well as suggestions for future studies.

5.1 Conclusion

The main objective of this research was to estimate the optimal hedge ratio that significantly reduce exposure to oil price fluctuation and thus lower costs. Time series data from October 1990 to March 2019 have been used for analysis. The data was analyzed using descriptive statistics and regression models. The dependent variable rspot (Log return on the spot price) was regress with the independent variable rfutures (Log return on the futures price) and some other variables.

The finding of the study confirmed that using optimal hedge ratio significantly reduce exposure to oil price fluctuation and thus reduce cost. Summary of the hedge ratio and hedge effectiveness for the different model is described below.

Table 5.1 hedge ratio and hedging effectiveness of the different models

Model	Hedge ratio	Risk reduction (Hedging effectiveness)
Unhedged	0	0
Naive	1	
OLS	0.699	56.40%
ECM	0.667	66.76%

Source: Compilation by Researcher

As evident from Table 5.1, all models have produced significant variance reduction over the unhedged position. The OLS model reduce the risk exposure by 56.40%. Meanwhile, the largest reduction is by the ECM model which indicates a variance reduction of 67.76 %. Thus, hedging with futures contracts has significantly reduced the risk (variance, in this case) of unhedged spot for Brent crude oil.

ECM is more effective in reducing the volatility of oil price than the OLS indicating that ECM performs better than the OLS model. This result is consistent with Ji & Fan (2011), Hamldar & Mehrara (2014) and Islam (2017).

In conclusion, the results obtained from the OLS model make me cautious with the consequent inferences since the OLS model did not pass residual diagnostic test for no autocorrelation. Therefore, the ECM model fits better in designing hedging strategy for EPSE. The empirical finding suggests that the EPSE can use oil futures contract as an effective instrument to minimize price fluctuation risk.

5.2 Recommendations

On the basis of the above findings, the following possible recommendations are forwarded: The recommendations will help EPSE to mitigate oil price fluctuation.

- As indicated in this study hedging significantly reduced the risk exposure. Thus, EPSE should start using hedging techniques to reduce the risk arise due to volatility of oil price.
- EPSE need to reduce the amount of refined oil that purchases through international tender and bilateral agreement and gradually adapt and participate in the international market for oil like ICE.
- EPSE need to undertake intensive research in areas of hedging and optimal hedge ratio so that it can start using and benefit from the use of different financial instruments

5.3 Farther Research Consideration

The primary focus of this research was to estimate optimal hedge ratio for oil future and its application to EPSE.

This study uses OLS and ECM models to estimate constant optimal hedge ratio. However, there are also other methods or models to estimate optimal hedge ratio that are not included in this study. Thus, future researchers are recommended to undertake similar study to estimate time varying hedge ratios using MGARCH (Multivariate Generalized Autoregressive Conditional Heteroscedasticity) and other models. Furthermore, researches need to be undertaken to account transaction costs that will be incurred by engaging in to future contracts on commodity market like ICE.

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Appendixes

Appendix I: Raw Data

Date	Monthly Spot	Monthly Futures
Sep-1990	34.9	39.1
Oct-1990	36.02	34.41
Nov-1990	33.07	29.2
Dec-1990	28.27	28.27
Jan-1991	23.57	20.06
Feb-1991	19.54	18.68
Mar-1991	19.08	17.95
Apr-1991	19.18	19.42
May-1991	19.19	19.21
Jun-1991	18.17	18.72
Jul-1991	19.4	19.74
Aug-1991	19.77	20.7
Sep-1991	20.5	21.05
Oct-1991	22.21	22.1
Nov-1991	21.11	20.13
Dec-1991	18.41	17.61
Jan-1992	18.16	18.15
Feb-1992	18.05	17.55
Mar-1992	17.63	18.14
Apr-1992	18.92	19.66
May-1992	19.89	20.79
Jun-1992	21.16	20.41
Jul-1992	20.24	20.47
Aug-1992	19.74	19.87
Sep-1992	20.27	20.34
Oct-1992	20.26	19.45
Nov-1992	19.21	18.84
Dec-1992	18.14	18.29
Jan-1993	17.39	18.47
Feb-1993	18.47	18.92
Mar-1993	18.79	18.9
Apr-1993	18.67	19.15
May-1993	18.51	18.6
Jun-1993	17.65	17.51
Jul-1993	16.78	16.75
Aug-1993	16.7	17.08
Sep-1993	16.01	17.43
Oct-1993	16.61	15.8
Nov-1993	15.2	14.52
Dec-1993	13.73	13.2
Jan-1994	14.29	14.22
Feb-1994	13.8	13.35

Mar-1994	13.82	13.25
Apr-1994	15.23	15.69
May-1994	16.19	16.45
Jun-1994	16.76	17.52
Jul-1994	17.6	18.59
Aug-1994	16.89	16.24
Sep-1994	15.9	17.15
Oct-1994	16.49	16.92
Nov-1994	17.19	17.11
Dec-1994	15.93	16.5
Jan-1995	16.55	16.8
Feb-1995	17.11	16.87
Mar-1995	17.01	17.5
Apr-1995	18.65	19.06
May-1995	18.35	17.7
Jun-1995	17.31	16.38
Jul-1995	15.85	16.01
Aug-1995	16.1	16.25
Sep-1995	16.7	16.12
Oct-1995	16.11	16.33
Nov-1995	16.86	17.04
Dec-1995	17.93	18.33
Jan-1996	17.85	16.52
Feb-1996	18	17.76
Mar-1996	19.85	19.41
Apr-1996	20.9	19.02
May-1996	19.15	17.8
Jun-1996	18.46	18.91
Jul-1996	19.57	18.9
Aug-1996	20.51	20.78
Sep-1996	22.63	23.21
Oct-1996	24.16	22.67
Nov-1996	22.76	22.77
Dec-1996	23.78	23.81
Jan-1997	23.54	22.52
Feb-1997	20.85	18.85
Mar-1997	19.13	19.38
Apr-1997	17.56	18.52
May-1997	19.02	19.4
Jun-1997	17.58	18.51
Jul-1997	18.46	18.94
Aug-1997	18.6	18.51
Sep-1997	18.46	19.9
Oct-1997	19.87	20.02
Nov-1997	19.17	18.94
Dec-1997	17.18	16.52
Jan-1998	15.19	15.96
Feb-1998	14.07	14.17
Mar-1998	13.1	14.26

Apr-1998	13.53	14.46
May-1998	14.36	14.37
Jun-1998	12.21	13.38
Jul-1998	12.08	13.09
Aug-1998	11.91	12.56
Sep-1998	13.34	14.68
Oct-1998	12.7	13.22
Nov-1998	11.04	10.46
Dec-1998	9.82	10.53
Jan-1999	11.11	11.35
Feb-1999	10.27	10.88
Mar-1999	12.51	15.24
Apr-1999	15.29	16.57
May-1999	15.23	15.2
Jun-1999	15.86	17.51
Jul-1999	19.08	19.37
Aug-1999	20.22	21.33
Sep-1999	22.54	23.58
Oct-1999	22	21.69
Nov-1999	24.58	23.64
Dec-1999	25.47	25.08
Jan-2000	25.51	25.97
Feb-2000	27.78	28.09
Mar-2000	27.49	24.77
Apr-2000	22.76	23.89
May-2000	27.74	28.31
Jun-2000	29.8	30.57
Jul-2000	28.68	26.93
Aug-2000	30.2	31.72
Sep-2000	33.14	29.84
Oct-2000	30.96	30.76
Nov-2000	32.55	31.88
Dec-2000	25.66	23.87
Jan-2001	25.62	26.66
Feb-2001	27.5	25.57
Mar-2001	24.5	24.74
Apr-2001	25.66	27.89
May-2001	28.31	29.34
Jun-2001	27.85	26.08
Jul-2001	24.61	24.69
Aug-2001	25.68	26.41
Sep-2001	25.62	23.26
Oct-2001	20.54	20.37
Nov-2001	18.8	19.14
Dec-2001	18.71	19.9
Jan-2002	19.42	19.18
Feb-2002	20.28	21.33
Mar-2002	23.7	25.92
Apr-2002	25.73	26.47

May-2002	25.35	24.45
Jun-2002	24.08	25.58
Jul-2002	25.74	25.44
Aug-2002	26.65	27.47
Sep-2002	28.4	28.75
Oct-2002	27.54	25.72
Nov-2002	24.34	25.16
Dec-2002	28.33	28.66
Jan-2003	31.18	31.1
Feb-2003	32.77	32.79
Mar-2003	30.61	27.18
Apr-2003	25	23.68
May-2003	25.86	26.32
Jun-2003	27.65	28.33
Jul-2003	28.35	28.37
Aug-2003	29.89	29.49
Sep-2003	27.11	27.61
Oct-2003	29.61	27.7
Nov-2003	28.75	28.45
Dec-2003	29.81	30.17
Jan-2004	31.28	29.18
Feb-2004	30.86	32.23
Mar-2004	33.63	31.51
Apr-2004	33.59	34.48
May-2004	37.57	36.58
Jun-2004	35.18	34.5
Jul-2004	38.22	40.03
Aug-2004	42.74	39.61
Sep-2004	43.2	46.38
Oct-2004	49.78	48.98
Nov-2004	43.11	45.51
Dec-2004	39.6	40.46
Jan-2005	44.51	45.92
Feb-2005	45.48	50.06
Mar-2005	53.1	54.29
Apr-2005	51.88	51.09
May-2005	48.65	50.73
Jun-2005	54.35	55.58
Jul-2005	57.52	59.37
Aug-2005	63.98	67.02
Sep-2005	62.91	63.48
Oct-2005	58.54	58.1
Nov-2005	55.24	55.05
Dec-2005	56.86	58.98
Jan-2006	62.99	65.99
Feb-2006	60.21	61.76
Mar-2006	62.06	65.91
Apr-2006	70.26	72.02
May-2006	69.78	70.41

Jun-2006	68.56	73.51
Jul-2006	73.67	75.15
Aug-2006	73.23	70.25
Sep-2006	61.96	62.48
Oct-2006	57.81	59.03
Nov-2006	58.76	64.26
Dec-2006	62.47	60.86
Jan-2007	53.68	57.4
Feb-2007	57.56	61.89
Mar-2007	62.05	68.1
Apr-2007	67.49	67.65
May-2007	67.21	68.04
Jun-2007	71.05	71.41
Jul-2007	76.93	77.05
Aug-2007	70.76	72.69
Sep-2007	77.17	79.17
Oct-2007	82.34	90.63
Nov-2007	92.41	88.26
Dec-2007	90.93	93.85
Jan-2008	92.18	92.21
Feb-2008	94.99	100.1
Mar-2008	103.64	100.3
Apr-2008	109.07	111.36
May-2008	122.8	127.78
Jun-2008	132.32	139.83
Jul-2008	132.72	123.98
Aug-2008	113.24	114.05
Sep-2008	97.23	98.17
Oct-2008	71.58	65.32
Nov-2008	52.45	53.49
Dec-2008	39.95	45.59
Jan-2009	43.44	45.88
Feb-2009	43.32	46.35
Mar-2009	46.54	49.23
Apr-2009	50.18	50.8
May-2009	57.3	65.52
Jun-2009	68.61	69.3
Jul-2009	64.44	71.7
Aug-2009	72.51	69.65
Sep-2009	67.65	69.07
Oct-2009	72.77	75.2
Nov-2009	76.66	78.47
Dec-2009	74.46	77.93
Jan-2010	76.17	71.46
Feb-2010	73.75	77.59
Mar-2010	78.83	82.7
Apr-2010	84.82	87.44
May-2010	75.95	74.65
Jun-2010	74.76	75.01

Jul-2010	75.58	78.18
Aug-2010	77.04	74.64
Sep-2010	77.84	82.31
Oct-2010	82.67	83.15
Nov-2010	85.28	85.92
Dec-2010	91.45	94.75
Jan-2011	96.52	101.01
Feb-2011	103.72	111.8
Mar-2011	114.64	117.36
Apr-2011	123.26	125.89
May-2011	114.99	116.73
Jun-2011	113.83	112.48
Jul-2011	116.97	116.74
Aug-2011	110.22	114.85
Sep-2011	112.83	102.76
Oct-2011	109.55	109.56
Nov-2011	110.77	110.52
Dec-2011	107.87	107.38
Jan-2012	110.69	110.98
Feb-2012	119.33	122.66
Mar-2012	125.45	122.88
Apr-2012	119.75	119.47
May-2012	110.34	101.87
Jun-2012	95.16	97.8
Jul-2012	102.62	104.92
Aug-2012	113.36	114.57
Sep-2012	112.86	112.39
Oct-2012	111.71	108.7
Nov-2012	109.06	111.23
Dec-2012	109.49	111.11
Jan-2013	112.96	115.55
Feb-2013	116.05	111.38
Mar-2013	108.47	110.02
Apr-2013	102.25	102.37
May-2013	102.56	100.39
Jun-2013	102.92	102.16
Jul-2013	107.93	107.7
Aug-2013	111.28	114.01
Sep-2013	111.6	108.37
Oct-2013	109.08	108.84
Nov-2013	107.79	109.69
Dec-2013	110.76	110.8
Jan-2014	108.12	106.4
Feb-2014	108.9	109.07
Mar-2014	107.48	107.76
Apr-2014	107.76	108.07
May-2014	109.54	109.41
Jun-2014	111.8	112.36
Jul-2014	106.77	106.02

Aug-2014	101.61	103.19
Sep-2014	97.09	94.67
Oct-2014	87.43	85.86
Nov-2014	79.44	70.15
Dec-2014	62.34	57.33
Jan-2015	47.76	52.99
Feb-2015	58.1	62.58
Mar-2015	55.89	55.11
Apr-2015	59.52	66.78
May-2015	64.08	65.56
Jun-2015	61.48	63.59
Jul-2015	56.56	52.21
Aug-2015	46.52	54.15
Sep-2015	47.62	48.37
Oct-2015	48.43	49.56
Nov-2015	44.27	44.61
Dec-2015	38.01	37.28
Jan-2016	30.7	34.74
Feb-2016	32.18	35.97
Mar-2016	38.21	39.6
Apr-2016	41.58	48.13
May-2016	46.74	49.69
Jun-2016	48.25	49.68
Jul-2016	44.95	42.46
Aug-2016	45.84	47.04
Sep-2016	46.57	49.06
Oct-2016	49.52	48.3
Nov-2016	44.73	50.47
Dec-2016	53.31	56.82
Jan-2017	54.58	55.7
Feb-2017	54.87	55.59
Mar-2017	51.59	52.83
Apr-2017	52.31	51.73
May-2017	50.33	50.31
Jun-2017	46.37	47.92
Jul-2017	48.48	52.65
Aug-2017	51.7	52.38
Sep-2017	56.15	57.54
Oct-2017	57.51	61.37
Nov-2017	62.71	63.57
Dec-2017	64.37	66.87
Jan-2018	69.08	69.05
Feb-2018	65.32	65.78
Mar-2018	66.02	70.27
Apr-2018	72.11	75.17
May-2018	76.98	77.59
Jun-2018	74.41	79.44
Jul-2018	74.25	74.25
Aug-2018	72.53	77.42

Sep-2018	78.89	82.72
Oct-2018	81.03	75.47
Nov-2018	64.75	58.71
Dec-2018	57.36	53.8
Jan-2019	59.41	61.89
Feb-2019	63.96	66.03
Mar-2019	66.14	68.39

Appendix II: Augmented Dickey-Fuller (ADF) test statistic on spot and rspot

Null Hypothesis: SPOT has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.899153	0.3326
Test critical values:	1% level	-3.449332	
	5% level	-2.869800	
	10% level	-2.571239	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SPOT)
Method: Least Squares
Date: 05/06/19 Time: 12:33
Sample (adjusted): 1990M11 2019M03
Included observations: 341 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SPOT(-1)	-0.013619	0.007171	-1.899153	0.0584
D(SPOT(-1))	0.367978	0.050593	7.273321	0.0000
C	0.730184	0.426733	1.711103	0.0880

R-squared	0.139566	Mean dependent var	0.088328
Adjusted R-squared	0.134475	S.D. dependent var	4.723961
S.E. of regression	4.394872	Akaike info criterion	5.807513
Sum squared resid	6528.436	Schwarz criterion	5.841224
Log likelihood	-987.1809	Hannan-Quinn criter.	5.820944
F-statistic	27.41253	Durbin-Watson stat	1.997313
Prob(F-statistic)	0.000000		

Null Hypothesis: RSPOT has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.61381	0.0000
Test critical values:	1% level	-3.449332	
	5% level	-2.869800	
	10% level	-2.571239	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RSPOT)
Method: Least Squares
Date: 05/06/19 Time: 12:34
Sample (adjusted): 1990M11 2019M03
Included observations: 341 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RSPOT(-1)	-0.773015	0.052896	-14.61381	0.0000
C	0.137888	0.458286	0.300878	0.7637

R-squared	0.386496	Mean dependent var	0.000565
Adjusted R-squared	0.384686	S.D. dependent var	10.78635
S.E. of regression	8.461023	Akaike info criterion	7.114665
Sum squared resid	24268.64	Schwarz criterion	7.137139
Log likelihood	-1211.050	Hannan-Quinn criter.	7.123619
F-statistic	213.5635	Durbin-Watson stat	1.988472
Prob(F-statistic)	0.000000		

Appendix III: Augmented Dickey-Fuller (ADF) test statistic on futures and rfutures

Null Hypothesis: FUTURES has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.854837	0.3536
Test critical values:	1% level	-3.449332	
	5% level	-2.869800	
	10% level	-2.571239	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(FUTURES)
Method: Least Squares
Date: 05/06/19 Time: 12:38
Sample (adjusted): 1990M11 2019M03
Included observations: 341 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FUTURES(-1)	-0.014244	0.007679	-1.854837	0.0645
D(FUTURES(-1))	0.303243	0.051781	5.856276	0.0000
C	0.787767	0.461529	1.706865	0.0888

R-squared	0.096993	Mean dependent var	0.099648
Adjusted R-squared	0.091650	S.D. dependent var	4.972020
S.E. of regression	4.738704	Akaike info criterion	5.958163
Sum squared resid	7589.898	Schwarz criterion	5.991875
Log likelihood	-1012.867	Hannan-Quinn criter.	5.971595
F-statistic	18.15244	Durbin-Watson stat	2.005534
Prob(F-statistic)	0.000000		

Null Hypothesis: RFUTURES has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.62081	0.0000
Test critical values:	1% level	-3.449332	
	5% level	-2.869800	
	10% level	-2.571239	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RFUTURES)

Method: Least Squares
Date: 05/06/19 Time: 12:38
Sample (adjusted): 1990M11 2019M03
Included observations: 341 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RFUTURES(-1)	-0.834185	0.053402	-15.62081	0.0000
C	0.175951	0.477555	0.368442	0.7128

R-squared	0.418535	Mean dependent var	0.047769
Adjusted R-squared	0.416819	S.D. dependent var	11.54610
S.E. of regression	8.817321	Akaike info criterion	7.197161
Sum squared resid	26355.61	Schwarz criterion	7.219636
Log likelihood	-1225.116	Hannan-Quinn criter.	7.206115
F-statistic	244.0098	Durbin-Watson stat	2.002639
Prob(F-statistic)	0.000000		

Appendix IV: Heteroskedasticity Test: White

Heteroskedasticity Test: White

F-statistic	0.042303	Prob. F(1,340)	0.8372
Obs*R-squared	0.042546	Prob. Chi-Square(1)	0.8366
Scaled explained SS	0.058235	Prob. Chi-Square(1)	0.8093

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/06/19 Time: 12:41
Sample: 1990M10 2019M03
Included observations: 342

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	35.08926	3.577135	9.809321	0.0000
RFUTURES^2	0.004139	0.020124	0.205676	0.8372

R-squared	0.000124	Mean dependent var	35.41945
Adjusted R-squared	-0.002816	S.D. dependent var	59.03370
S.E. of regression	59.11677	Akaike info criterion	11.00274
Sum squared resid	1188230.	Schwarz criterion	11.02516
Log likelihood	-1879.468	Hannan-Quinn criter.	11.01167
F-statistic	0.042303	Durbin-Watson stat	1.641717
Prob(F-statistic)	0.837167		

Appendix V: Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	6.430365	Prob. F(10,330)	0.0000
Obs*R-squared	55.77389	Prob. Chi-Square(10)	0.0000

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/06/19 Time: 12:44
Sample: 1990M10 2019M03
Included observations: 342
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.005006	0.299798	0.016698	0.9867
RFUTURES	-0.007149	0.033872	-0.211056	0.8330
RESID(-1)	-0.399917	0.055062	-7.262979	0.0000
RESID(-2)	-0.118063	0.059186	-1.994774	0.0469
RESID(-3)	0.015549	0.059805	0.259993	0.7950
RESID(-4)	-0.034140	0.060187	-0.567227	0.5709
RESID(-5)	-0.065202	0.059658	-1.092933	0.2752
RESID(-6)	-0.134942	0.059845	-2.254863	0.0248
RESID(-7)	-0.008072	0.060444	-0.133545	0.8938
RESID(-8)	-0.038342	0.060389	-0.634914	0.5259
RESID(-9)	-0.063722	0.060110	-1.060082	0.2899
RESID(-10)	0.014661	0.056073	0.261458	0.7939

R-squared	0.163082	Mean dependent var	-3.90E-17
Adjusted R-squared	0.135184	S.D. dependent var	5.960144
S.E. of regression	5.542664	Akaike info criterion	6.297285
Sum squared resid	10137.97	Schwarz criterion	6.431840
Log likelihood	-1064.836	Hannan-Quinn criter.	6.350888
F-statistic	5.845787	Durbin-Watson stat	1.969767
Prob(F-statistic)	0.000000		

Appendix VI: Ramsey RESET Test

Ramsey RESET Test
Equation: EQ01
Specification: RSPOT C RFUTURES
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.001004	339	0.3175
F-statistic	1.002009	(1, 339)	0.3175
Likelihood ratio	1.009385	1	0.3151

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	35.69915	1	35.69915
Restricted SSR	12113.45	340	35.62779
Unrestricted SSR	12077.75	339	35.62758

LR test summary:

	Value	df
Restricted LogL	-1095.279	340
Unrestricted LogL	-1094.774	339

Unrestricted Test Equation:
Dependent Variable: RSPOT
Method: Least Squares
Date: 05/06/19 Time: 12:46
Sample: 1990M10 2019M03
Included observations: 342

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.241431	0.364505	0.662352	0.5082
RFUTURES	0.693935	0.037284	18.61235	0.0000
FITTED^2	-0.004257	0.004252	-1.001004	0.3175

R-squared	0.528134	Mean dependent var	0.186926
Adjusted R-squared	0.525350	S.D. dependent var	8.663763
S.E. of regression	5.968885	Akaike info criterion	6.419730
Sum squared resid	12077.75	Schwarz criterion	6.453369
Log likelihood	-1094.774	Hannan-Quinn criter.	6.433131
F-statistic	189.7122	Durbin-Watson stat	2.716067
Prob(F-statistic)	0.000000		

Appendix VII: Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	6.649124	Prob. F(10,328)	0.0000
Obs*R-squared	57.64387	Prob. Chi-Square(10)	0.0000

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/06/19 Time: 12:48
Sample: 1990M10 2019M03
Included observations: 342
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013892	0.288667	0.048123	0.9616
RFUTURES	-0.012430	0.032621	-0.381029	0.7034
JAN15DUM	-4.227020	5.372147	-0.786840	0.4319
AUG15DUM	3.012056	5.424480	0.555271	0.5791
RESID(-1)	-0.409907	0.055539	-7.380468	0.0000
RESID(-2)	-0.103864	0.059378	-1.749198	0.0812
RESID(-3)	0.015459	0.060041	0.257470	0.7970
RESID(-4)	-0.055354	0.060578	-0.913756	0.3615
RESID(-5)	-0.118772	0.059982	-1.980136	0.0485
RESID(-6)	-0.156443	0.060249	-2.596621	0.0098
RESID(-7)	-0.027278	0.060585	-0.450249	0.6528
RESID(-8)	-0.051156	0.060840	-0.840830	0.4011
RESID(-9)	-0.057691	0.060428	-0.954702	0.3404
RESID(-10)	0.021917	0.056234	0.389739	0.6970

R-squared	0.168549	Mean dependent var	-5.71E-17
Adjusted R-squared	0.135596	S.D. dependent var	5.722608
S.E. of regression	5.320501	Akaike info criterion	6.221086
Sum squared resid	9284.936	Schwarz criterion	6.378067
Log likelihood	-1049.806	Hannan-Quinn criter.	6.283623
F-statistic	5.114711	Durbin-Watson stat	1.958135
Prob(F-statistic)	0.000000		

Appendix VIII: Cointegration test using the Engle–Granger approach

Null Hypothesis: ECM has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.38908	0.0000
Test critical values:	1% level	-3.449389	
	5% level	-2.869825	
	10% level	-2.571253	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ECM)
Method: Least Squares
Date: 05/06/19 Time: 12:50
Sample (adjusted): 1990M12 2019M03
Included observations: 340 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECM(-1)	-1.540931	0.088615	-17.38908	0.0000
D(ECM(-1))	0.129018	0.053570	2.408383	0.0166
C	-0.061068	0.298190	-0.204795	0.8379

R-squared	0.688118	Mean dependent var	-0.006224
Adjusted R-squared	0.686267	S.D. dependent var	9.816101
S.E. of regression	5.498183	Akaike info criterion	6.255497
Sum squared resid	10187.51	Schwarz criterion	6.289282
Log likelihood	-1060.434	Hannan-Quinn criter.	6.268959
F-statistic	371.7682	Durbin-Watson stat	1.965168
Prob(F-statistic)	0.000000		