APPLICATION OF GARMAN KOHLHAGEN MODEL IN PRICING OF CURRENCY OPTIONS IN THE KENYAN FOREIGN EXCHANGE MARKET

BY

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DECLARATION

This Research Project is my original work and has not been submitted for the award of a degree at any other university.

Signed…… Date ……..

Simon Maina **D63/75351/2014**

This Research Project has been submitted for examination with my approval as a University Supervisor.

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DEDICATION

This project is dedicated to my family. Without their encouragement, understanding, support, and unconditional love, completion of this study could not have been possible.

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ABSTRACT

Currency options are derivative financial instruments that are used to hedge against foreign exchange rate exposure. All the international business transactions involve an exchange of one currency for another**.** Most manufacturers have to import some or all of their raw materials. The cost of production is directly dependent on the prevailing exchange rates**.** The depreciation of Kenyan shillings leads to increase in cost of materials. Thus firms have to absorb any losses incurred when exchange rates vary. The study therefore, sought to test the applicability of Garman Kohlhagen model in pricing foreign currency options in the Kenyan foreign exchange market. The study used descriptive research design and the Garman Kohlhagen model for pricing of foreign currency options. First, Descriptive statistics and graphical analysis (time series analysis and histograms) were used to determine the trend of the foreign exchange rates and test for normality of the data. The research sought to obtain volatility based on the United States Dollar and Kenya Shillings exchange rates in Kenya for a period of five years between 2010-2014. The study also sought to show how foreign currency options would be priced from the available data. The study used historical data to obtain volatility that together with other variables were plugged into the Garman Kohlhagen model to price the foreign currency options. The study gave findings that were consistent with global studies done in the area of pricing foreign currency options that affirms the suitability of the Garman Kohlhagen model in pricing foreign currency options. The study showed that foreign currency options can be priced in Kenya by use of a Garman Kohlhagen model, the study found out that for call options, when the spot exchange rate is below the strike price, the option has statistically zero value and when above strike price, the option has a positive value. On the other hand, the price of a put currency option is positive when the spot exchange rate is below the strike price and statistically zero when the spot exchange rates are above the strike prices and the further away from the strike price the spot exchange rate is, the higher the value of the option. The study recommended that, the Central Bank of Kenya and the Capital Markets Authority should spearhead faster introduction of an options market in Kenya where options and other derivatives and futures can be traded. The study also, provided suggestions on further research in the areas of pricing currency options under constant volatility.

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ABBREVIATIONS AND ACRONYMS

ATM	-	At the Money
ARCH	-	Autoregressive Conditional Heteroscedasticity
BSM	-	Black-Scholes Model
CBK	-	Central Bank of Kenya
CMA	-	Capital Markets Authority
FX	-	Foreign Exchange
GARCH	-	Generalized Autoregressive Conditional Heteroscedasticity
GBP	-	Great Britain Pound
GK	-	Garman Kohlhagen Model
ITM	-	In the Money
KES	-	Kenyan Shillings
NSE	-	Nairobi Securities Exchange
OTC	-	Over the Counter
OTM	-	Out of the Money
US	-	United States
USD	-	United States Dollar

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The Bretton Woods established fixed exchange rates between most currencies. Under this understanding, various countries agreed to keep their currencies within a narrow band of a parity value. In 1973 however, floating exchange rate system were adopted globally (Hall et al, 2009).The central bank of Kenya maintains a floating exchange rate system, thus the value of the Kenyan shilling is determined by the market forces of demand and supply. These tend to vary unpredictably and can range from mild to adverse market movements (Kipkemboi, 2015).

Under today's system of floating foreign exchange rates, currencies often move erratically over short periods. Empirical studies demonstrate that foreign exchange volatility can have significant impact on companies' profits (Armitage et al, 2002). In addition David, (1997) observes that under current system of floating exchange rates, investors have experienced significant real and paper volatility in earnings as a result of relative fluctuations in foreign exchange rates. Most researchers have measured the impact by studying how changes in foreign exchange rates affect market capitalization (Bodnar et al, 1998). Researchers consistently find that periods of significant foreign exchange movements produce substantial changes in stock market capitalization (Dahlquist, 1999).

Adverse market movements has led to market players such as importers and exporters being exposed to a volatile currency, given that the central bank does not directly intervene in the direct control of the value of the shilling, there are measures that can be put in place in an effort

to stabilise it. Thus the central bank has introduced monetary policies that help to cushion the shilling against major movements (Mohan and Kapur, 2014).

These policies do not shield the shilling entirely and in the end, it is the business community that has to absorb the losses incurred. Foreign exchange instruments exist and are used to hedge against market movements that could be potentially harmful to businesses (Hull, 1997).

1.1.1 Currency Options

Currency options are derivative financial instrument where there is an agreement between two parties that gives the purchaser the right, but not the obligation, to exchange a given amount of one currency for another, at a specified rate, on an agreed date in the future. Currency options insure the purchaser against adverse exchange rate movements (Hull, 1997). Currency options are a useful tool for a business to use in order to reduce costs and increase benefits from having increasing certainty in financial transactions that increase currency conversions (Chance, 2008).

According to Hull, (1997), a derivative is defined as a financial instrument that derives its value from an underlying asset which in foreign currency options is the exchange rate. There are two types of foreign currency options, a call currency option and a put currency option. A call option on a particular currency gives the holder the right but not an obligation to buy that currency at a predetermined exchange rate at a particular date and a foreign currency put option gives the holder the right to sell the currency at a predetermined exchange rate at a particular date. The seller or writer of the option, receives a payment, referred to as the option premium, that then obligates him to sell the exchange currency at the pre specified price known as the strike price, if the option purchaser chooses to exercise his right to buy or sell the currency. The

holder will only decide to exchange currencies if the strike price is a more favorable rate than can be obtained in the spot market at expiration (Hull, 1997).

Foreign currency options can either be European options that can only be exercised on the expiry date or American options that can be exercised at any day and up to the expiry date. Foreign currency options can either be traded in exchange markets which occur in developed financial markets that have an option market or be traded over the counter. Over the counter traded foreign currency options are better for they can be customized further to offer more flexibility. The majority of currency options traded over the counter (OTC) are European options. The date on which the foreign currency option contract ends is called the expiration date. Currency options can be at the money (ATM) where currency options have an exercise price equal to the spot rate of the underlying currency, in the money (ITM) where currency options may be profitable, excluding premium costs, if exercised immediately or the foreign currency options may be out of the money (OTM) options would not be profitable, excluding the premium costs, if exercised (Hull, 1997)

According to Kotz'e (2011), the holder of a call option on a currency will only exercise the option if the underlying currency is trading in the market at a higher price than the strike price of the option. The call option gives the right to buy, so in exercising it the holder buys currency at the strike price and can then sell it in the market at a higher price. Similarly, the holder of a put option on a currency will only exercise the option if the spot currency is trading in the market at a lower price than the strike price. The put option gives the right to sell, so in exercising it, the holder sells currency at the strike price and can then buy it in the market at a lower price. From the point of view of the option holder, the negative profit and loss represent the premium that is

paid for the option. Thus, the premium is the maximum loss that can result from purchasing an option.

1.1.2 Pricing of Currency Options

The pricing of currency options is normally done by modifying the Black-Scholes Model (BSM) and incorporating the interest rates of the foreign currency being evaluated. The BSM uses a constant volatility but for the pricing of the option prices in this paper, a varying volatility will be used. That is, volatility that changes with the passage of time. Volatility to be used in the BSM formulas will be derived from historic data and estimated using the Garch (1, 1) model. This is because the variance, which is taken to be the volatility, is mean reverting and the Garch (1, 1) model incorporates this (Bollerslev, 1986).

The currency derivatives designed in this paper will have their variables of interest derived from data collected from the market over time. The exchange rate data is from the Central Bank of Kenya. The foreign risk free rates are from the respective Central Banks.

1.1.3 The Garman Kohlhagen Model

Garman and Kohlhagen model is used in pricing of options. The original option pricing model was developed by Black and Scholes (1973). GK model is an extension of Black–Scholes model, the Black -Scholes Model(BSM) is one of the most important concepts in modern financial theory the model was developed in 1973 by Fisher Black, Robert Merton and Myron Scholes and is still widely used today, and regarded as one of the best ways of determining fair prices of options.

The BSM was extended to cope with the presence of two interest rates (one for each currency). Garman and Kohlhagen (1983) suggested that foreign exchange rates could be treated as non-dividend-paying stocks.

The GK model assumes that, the option can only be exercised on the expiry date (European style), there are no taxes, margins or transaction costs, the risk free interest rates (domestic and foreign) are constant, the price volatility of the underlying instrument is constant and the price movements of the underlying instrument follow a lognormal distribution (Garman and Kohlhagen, 1983).

Suppose that r_d is the risk-free interest rate to expiry of the domestic currency and r_f is the foreign currency risk-free interest rate (where domestic currency is the currency in which we obtain the value of the option; the formula also requires that FX rates – both strike and current spot be quoted in terms of "units of domestic currency per unit of foreign currency") (Garman and Kohlhagen, 1983).

1.1.4 Kenyan Foreign Exchange Market

The foreign exchange market has become the world's largest financial market with daily trading exceeding$5.3 trillion. This makes it the most volatile and the most liquid of all financial markets. Unlike the stock or bond markets, there is no geographic location where the transactions are bid and cleared. American and European options on foreign currencies are actively traded in both over the counter (OTC) markets, where trading takes place via the telephone or in the electronic network as well as in exchanges. The major currencies traded include United States Dollar, Australian Dollar, Sterling pound, Canadian dollar, Japanese yen and Euros (Bank for International Settlements, 2013).

The capital market in Kenya is regulated by the capital markets authority (CMA) which is an independent public agency that was established in 1989, the capital market in Kenya is composed of the primary and secondary market (Capital Markets Authority Kenya).The Kenya shilling is usually very volatile i.e for the last five years. Most of the trading in imports and exports involve the dealing with the USD and hence development of foreign currency options market will enable hedge against losses resulting from exchange rate fluctuations. Pricing of currency options will be important in development of an efficient currency options market in Kenya (Kambi, 2013).

According to Alaro (1998), the main conditions for an options market in Kenya to exist were a growing economy, supported by the Central Bank of Kenya, a fairly independent exchange rate mechanism, market liquidity and efficiency, a regulatory organization and a strong and developing banking system. The study pointed to the growing demand for options in the Kenyan market.

1.2 Research Problem

Every country has its own currency through which both national and international transactions are performed. All the international business transactions involve an exchange of one currency for another. Most manufacturers have to import some or all of their raw materials. The main concern is to minimise the cost of production by keeping the cost of raw materials at a minimum. Therefore, the cost of production is directly dependent on the prevailing exchange rates**.** The depreciation of Kenyan shillings leads to increase in cost of materials. Thus firms have to absorb any losses incurred when exchange rates vary (World Bank, 2011) and (Irungu, 2013).

Earlier studies by Nance and Smith (1993), Rawls and Smithson (1990), Beckman and Brandbury (1996) and Smithson (1995) suggested that foreign exchange risk management would benefit companies. In addition Chow and Lee (1997) argued that risk management could reduce the effect of foreign exchange risk volatility on companies. Hence, foreign exchange risk management gives positive effect to shareholders.

Various studies have been done in Kenya relating to currency options but most of the studies done so far have been exploratory in nature, Aloo (2011) explored currency options, how they are utilized and who they can benefit in the Kenyan market. The study found out that currency options do not exist in Kenya, but the existence of the currency options market would thrive in Kenya given certain conditions as all respondents agreed on the usefulness of this market. The study found that Manufacturers and oil importers are likely to be affected by both foreign currency fluctuations and commodity price changes. They thus would like to hedge themselves against these risks. Sectors such as horticulture and agriculture are involved in the import of farm in-puts and export of farm products whose prices are determined before delivery date. They are therefore also subject to currency fluctuations.

In Kenya, none of the studies have explored option pricing using the GK model. This study applies the GK model to price options in the Kenyan foreign exchange market. The Garman and Kohlhagen model has been acclaimed as the most frequently used model for pricing options by Scott and Tucker (1989), Ritchken (1996), Bharadia et al (1996) and Hull (1997). Shastri and Tandon (1986) studied the pricing mechanism of call and put options written to foreign currencies, and the test of the efficiency of the market in which they are traded. The test of the efficiency of the market for foreign currency options and pricing of the options was done with the help of modified Black- Scholes Model, which is the Garman Kohlhagen model.

Ochong (2002) examined treasury management in commercial organizations in Kenya. The study sought to understand how treasuries in Kenya are managed and what tools are employed in this management. The study involved a sample of quoted companies on the Nairobi stock exchange, to find out which tools were utilized in the management of their foreign exchange exposures. The findings of the research pointed to the increased uses of options in Kenya as a hedging tool to manage currency risk. The study also indicated that today, treasury departments have evolved to focus on much more than just working capital requirements of the organization but are expected to hedge transactions with the most appropriate tools in the market. The findings that options were in use in the Kenyan market by corporate companies supported the need for further studies in this area. This study therefore seeks to answer the research question which is; what is the applicability of GK model in pricing foreign currency options in the Kenyan foreign exchange market?

1.3 Research Objective

To test the applicability of Garman Kohlhagen Model in pricing foreign currency options in the Kenyan foreign exchange market.

1.4 Value of the Study

The pricing of foreign currency options is important to Importers/Exporters; Currency fluctuations can really take a bite out of a firm's profits. Importers have to pay for their imports in the foreign currency; Exporters on the other hand usually receive the payment for their exports in foreign currency equivalent of their Kenya shillings price. Exporters and importers use currency hedging to protect their companies from the risk of changing currency values.

The study is important to firms with overseas branches, or those that trade internationally, the firms are at the mercy of global currency fluctuations. As is the case with private investments, changes in conversion rates can wipe out profits or increase gains. Firms will be able to use the currency options to shield themselves against fluctuating exchange rates and reduce associated costs/losses.

Since plans are underway to introduce a derivatives market in the Nairobi Securities Exchange, this study intended to introduce an alternative investment for the Kenyan economy once trading in derivative securities is introduced. Foreign currency option trading has emerged as an alternative investment for many traders and investors. As an investment tool, foreign currency option trading provides both large and small investors with greater flexibility when determining the appropriate forex trading and hedging strategies to implement.

The study findings would contribute to policy formulation to govern the management of foreign exchange rate fluctuations in projects funded by foreign currency through governmental institutions, non-governmental institutions and private organizations. The study would be useful to academicians as it will provide information that can be used as a basis for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on discussing theoretical and empirical literature review on currency options, the application and relevance to the Kenyan market. The chapter shows how the pricing of foreign currency options has evolved by analyzing three theories of Black and Scholes (1973) model, Garman and Kohlhagen (1983) model and the Binomial option pricing model (1979). The chapter highlights the various determinants of option prices. Empirical studies will be analysed showing findings of various studies into the area of pricing of currency options.

2.2 Theoretical Review

The key theories on the pricing of currency options include; Black-Scholes Option Pricing Theory, Garman Kohlhagen Option Pricing Theory and Binomial Option Pricing Theory.

2.2.1 Black -Scholes Option Pricing Model

Black and Scholes (1973) Model is one of the most important concepts in modern financial theory. It was developed in 1973 by Fisher Black, Robert Merton and Myron Scholes and is still widely used today, and regarded as one of the best ways of determining fair prices of options. The BSM prices European put or call options, a basic assumption of the Black-Scholes model is that the stock price is log normally distributed. One of the attributes the lognormal distribution has is that stock price can never fall by more than 100 percent, but there is some small chance that it could rise by much more than 100 percent. Black and Scholes model assumes that foreign exchange spot rate denoted by $S_{\circ}$ follows a geometric Brownian motion process, call and put

option prices are a function of only one stochastic variable $S_\circ$, assumes that the interest rates r_d and r_f are constant, further assumes a risk neutral world. Such that the equation used to value the option does not involve any variable affected by the risk preferences of the investor hence concludes that the returns are at the prevailing risk free interest rates.

The forward rate of an option can be written as;

$$F_o = S_o e^{(r_d - r_f)T} \quad \text{(i)}$$

This can now be used to modify the Black Scholes option pricing formula.

European call option on a non-dividend paying stock and a European put option on a non-dividend paying stock are given in the following equations.

$$C = S_o N(d_1) - Ke^{-rt} N(d_2) \quad \text{(ii)}$$

$$P = Ke^{-rt} N(-d_2) - S_o N(-d_1) \quad \text{(iii)}$$

Where N (d_1) and N (d_2) are the cumulative normal distribution functions. d_1 and d_2 are found as follows;

$$d_1 = \frac{\ln\left(\frac{S_o}{k}\right) + \left(r + \frac{\sigma_n^2}{2}\right)T}{\sigma_n \sqrt{T}} \quad \text{(iv)}$$

$$d_2 = \frac{\ln\left(\frac{S_o}{k}\right) + (r - \sigma_n^2/2)T}{\sigma_n \sqrt{T}} \quad \text{(v)}$$

The variables *c* and *p* are the European call and European put price, *So* is the stock price at time zero, *K* is the strike price of the option, *r* is the continuously compounded risk-free rate, *σ* is the stock price standard deviation, and *T* is the time to maturity of the option. N (d_1) and N (d_2) are

the cumulative probability distribution functions for a standardized normal distribution, or the probability that a variable with a standard normal distribution, with zero mean and standard deviation is one, will be less than d_1 and d_2

2.2.2 The Garman Kohlhagen Option Pricing Model

In 1983, Garman and Kohlhagen extended the Black–Scholes model to cope with the presence of two interest rates (one for each currency). Suppose that r_d is the risk-free interest rate to expiry of the domestic currency and r_f is the foreign currency risk-free interest rate (where domestic currency is the currency in which we obtain the value of the option; the formula also requires that FX rates – both strike and current spot be quoted in terms of "units of domestic currency per unit of foreign currency").

The price of a European call option with strike price K and time of maturity T is given by the formula:

$$C = S_o e^{-r_f T} N(d_1) - K e^{-r_d t} N(d_2) \quad \text{(vi)}$$

And that for a put option is given by;

$$P = K e^{-r_d t} N(-d_2) - S_o e^{-r_f T} N(-d_1) \quad \text{(vii)}$$

And

$$d_1 = \frac{\ln\left(\frac{S_o}{k}\right) + (r_d - r_f + \sigma_n^2/2)T}{\sigma_n \sqrt{T}} \quad \text{(viii)}$$

$$d_2 = \frac{\ln(\frac{S_o}{K}) + (r_d - r_f - \sigma_n^2/2)T}{\sigma_n\sqrt{T}} \quad \text{.....(ix)}$$

Where;

S_o is the current spot rate

K is the strike price

N is the cumulative normal distribution function

r_d is domestic risk free rate

r_f is foreign risk free simple interest rate

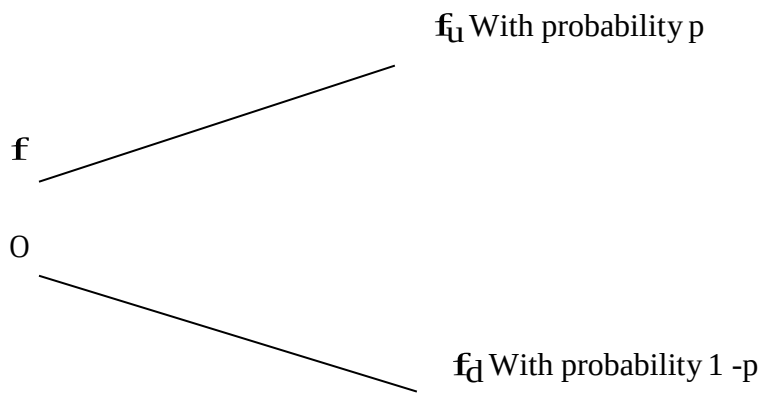
T is the time to maturity

σ_n is the volatility of the FX rate.

2.2.3 Binomial Option Pricing Model

Cox, Ross and Rubinstein (1979) developed the binomial option pricing model that is a discrete time model which contains the continuous time BSM as a special limiting case. Despite its simplicity, the model can be applied to European and American style options. Furthermore, it is applicable for the valuation of a variety of complex derivatives. In the binomial model as indicated by the name, the price of the underlying stock S is assumed to follow a multiplicative binomial process over discrete time periods. The stock price follows a random walk, because in each period, it may either move up by a certain percentage amount u-1 where u > 1 or down by a certain percentage amount 1 - d where d < 1. The (physical) probability of an upward move is denoted as *p* and the (physical) probability of a downward move as 1 - *p*.

Let f_o be the current value of a European style option, whereas f can be either a call c_o or a put p_o option. Then f_u (c_u or p_u) is the option's price if the stock price moves upward, and f_d (c_d or p_d) its price if the stock price moves downward:



If the call option is only away one period from expiration, Then f_u (c_u or p_u) and f_d (c_d or p_d) are given by

Cu=max (So u-k; 0) or Pu=max (k-So u; 0);

Cd=max (So d-k; 0) or Pd=max (k-So d; 0);

2.3 Determinants of Option Prices

The existing literature suggests that the main determinants of option prices (Underlying Price, Strike price, volatility, Time to maturity, Interest rates & dividends), (Black and Scholes, 1973) and (Hull,1997).

2.3.1 Underlying price

The most influential factor on an option premium is the current market price of the underlying asset. In general, as the price of the underlying increases, call prices increase and put prices decrease. Conversely, as the price of the underlying decreases, call prices decrease and put prices increase (Hull, 1997).

This is not surprising, since a call option grants the right to buy stock shares and a put option grants the right to sell stock shares at a fixed strike price. Consequently, a higher stock price at option expiration increases the payoff of a call option. Likewise, a lower stock price at option expiration increases the payoff of a put option (Hull, 1997).

2.3.2 Volatility

Volatility is the degree to which price moves, regardless of direction. It is a measure of the speed and magnitude of the underlying's price changes. Historical volatility refers to the actual price changes that have been observed over a specified time period. Option traders can evaluate historical volatility to determine possible volatility in the future. Implied volatility, on the other hand, is a forecast of future volatility and acts as an indicator of the current market sentiment. While implied volatility is often difficult to quantify, option premiums will generally be higher if the underlying asset exhibits higher volatility, because it will have higher expected price fluctuations (Venkata, 2007).

The owner of a call benefits from price increases but has limited downside risk in the event of price decreases since the most that he or she can lose is the price of the option. Similarly, the owner of put benefits from price decreases but has limited downside risk in the event of price

increases. The values of both calls and puts therefore increase as volatility increases (Hull, 1997).

2.3.3 Strike Price

The strike price determines if the option has any intrinsic value. Intrinsic value is the difference between the strike price of the option and the current price of the underlying. The premium typically increases as the option becomes further in-the-money (where the strike price becomes more favorable in relation to the current underlying price). The premium generally decreases as the option becomes more out-of-the-money (when the strike price is less favorable in relation to the underlying) (Venkata, 2007).

Call options become more valuable as stock prices increases and less valuable as strike price increases. For a put option, the pay off on exercise is the amount by which the strike price exceeds the stock price. Put options therefore behave in the opposite way of call options, they become less valuable as the stock prices increases and more valuable as the strike prices increases (Hull, 1997).

2.3.4 Time until expiration

The longer an option has until expiration, the greater the chance that it will end up in-the-money, or profitable, both call and put option prices normally increase. This is expected, since a longer time remaining until option expiration allows more time for the stock price to move away from a strike price and increase the option's payoff, thereby making the option more valuable (Venkata, 2007).

In general, an option loses one-third of its time value during the first half of its life and two-thirds of its value during the second half. The underlying's volatility is a factor in time value; if the underlying asset is highly volatile, one could reasonably expect a greater degree of price movement before expiration. The opposite holds true where the underlying typically exhibits low volatility; the time value will be lower if the underlying price is not expected to move much (Hull,1997).

2.3.5 Interest Rate and Dividends

Interest rates and dividends also have small, but measurable, effects on option prices. In general, as interest rates rise, call premiums will increase and put premiums will decrease. This is because of the costs associated with owning the underlying asset; the purchaser will incur either interest expense (if the money is borrowed) or lost interest income (if existing funds are used to purchase the shares). In either case, the buyer will have interest costs (Venkata, 2007).

Dividends can affect option prices because the underlying stock's price typically drops by the amount of any cash dividend on the ex-dividend date. As a result, if the underlying's dividend increases, call prices will decrease and put prices will increase. Conversely, if the underlying's dividend decreases, call prices will increase and put prices will decrease (Hull, 1997).

2.4 Empirical Review

When Black and Scholes (1973) developed the Black-Scholes model in the early 1970’s, it soon became a major breakthrough. Since then, many traders use the Black-Scholes model as their premier model for pricing and hedging options. An important property of the Black-Scholes model is that all variables in the equation are not influenced by the risk preferences of investors. In particular, the analysis is based on a risk-neutral pricing approach, which in return simplifies

the analysis of derivatives. In the classic Black-Scholes model, the volatility is assumed to be constant (Black and Scholes, 1973).

However, empirical research shows that the volatility of financial asset prices is following a stochastic process and varies through time. It means that while other properties of an option- such as exercise price, time to maturity, current price of underlying asset- can be observed directly from the market, the return volatility is the uncertainty factor in the Black-Scholes model (Sataputera, 2003).

As volatility increases, the probability that stock price will rise or fall increases, which in response will also increase the value of both call and put options. Return volatility thus plays a major role in option pricing. Therefore, accurate measures and good forecasts of volatility are critical for option pricing theories as well as trading strategies. At present, there have been many models developed to determine volatility, and some of them act as alternatives or improvement from earlier models. The family of GARCH models is an example, i.e. the GARCH (1, 1) model by Bollerslev (1986). Although there are many more complicated GARCH models, GARCH (1, 1) often performs as well as others.

Pricing foreign currency options was first done by Garman and Kohlhagen (1987) for European type currency options. Their argument was that the standard Black-Scholes option pricing model does not apply well to foreign exchange options since multiple interest rates are involved unlike in the Black-Scholes assumptions. They came up with modified valuation formulas for foreign currency options.

A study by Ziobrowski and Ziobrowski (1992), on hedging foreign investments in the U.S real estate market with currency options found that currency options behave very much like an

insurance policy. When used on a continuous basis, they insure foreign investors against sudden currency losses and spread out the cost of these extreme losses over time. Such studies have demonstrated the challenges associated with currency options and the advantages that an economy may obtain if a vibrant currency option market was developed.

Hull (1997) explains that currency options markets exhibit similar trends in growth to those of foreign exchange markets, with currency options growth exceeding the underlying asset because of the leveraged nature of the product. The underlying asset on a currency option is the forward foreign exchange rate, while other derivatives like futures have their underlying assets as forward interest rates. The same applies to all other derivatives that have their own underlying assets.

Alaro (1998) studied the conditions necessary for the existence of a currency options market in Kenya. The study analyzed the conditions necessary for the operation of currency options by reviewing of available literature and concluded that the main conditions for an options market to exist were a growing economy, supported by the Central Bank of Kenya, a fairly independent exchange rate mechanism, market liquidity and efficiency, a regulatory organization and a strong and developing banking system. The study pointed to the growing demand for options in the Kenyan market. This was propelled by the increased uncertainty that resulted from the liberalization of the Kenyan market to allow for a free-floating currency. Because of these developments, during the late 1990's, companies looked to benefit through hedging using options to reduce the uncertainty posed by the freely moving exchange rates in Kenya. The study recommended the strengthening of the regulatory framework to provide clear guidelines as to the operation of currency option markets.

Bodnar et al (1998) found that the most frequently cited motivation for using foreign exchange derivatives is for hedging short term observable exposures. However, many firms use foreign currency derivatives at least sometimes to hedge long term exposures. Few firms use foreign currency derivatives to hedge translation exposure.

According to Bodnar and Gebhardt (1998), German and US firms use derivatives primarily to manage foreign exchange (and interest rate) risk. They show that the main purpose of using derivatives in exchange risk management is to minimize the variability in cash flows. They also show that companies prefer to use simple foreign exchange instruments. Similar results are found by Bodnar et al, (1998): 83% of derivative using firms use foreign currency derivatives and 95% of US manufacturing firms‟ hedge foreign exchange risk with derivatives.

DeMark et al, (1999), stated that options are more difficult to understand because unlike trading in the underlying asset (in this case the actual currency) because options trading is not as simple as just buying or selling the contract. Rather, there are two types of options, call options and put options, and each has two sides. One can buy or sell a call option, and buy or sell a put option, or a combination of them. It is important to note that holding or selling either a call or put option is completely different. For every call buyer, there is a call seller; while for every put buyer, there is a put seller. It is important to note that option buyers have rights, while option sellers have obligations. For this reason, option buyers have a known level of risk while option sellers have unlimited risk in the contract.

The statistical distribution of daily exchange rate price changes: Dependent vs independent models by Johnston and Scott (1999) empirical distribution of changes in exchange rates was best described by either a normal or lognormal probability distribution. Indeed, some current

studies and most current tests “automatically” apply the logarithmic transformation to returns from spot, forward, and futures exchange rate changes. This transformation assumes, explicitly or implicitly, that the transformed data produces returns that are normally distributed.

Allayannis and Wetson (2001) found that from 1990 to 1995, there was an increase in the number of firms with foreign exchange sales that use currency derivatives. In contrast, the percentage of firms with no foreign sales that use foreign currency derivatives is small.

A study of comparing volatility models done by Hansen and Lunde (2001) using GARCH(1 ,1) as benchmark, had as result that the best models do not provide a significantly better forecast than the GARCH(1,1) model. For this reason, GARCH (1, 1) is preferred here above all family of GARCH models.

Ochong (2002) examined treasury management in commercial organizations in Kenya. The study sought to understand how treasuries in Kenya are managed and what tools are employed in this management. The study therefore took a sample of quoted companies on the Nairobi Securities Exchange, to find out which tools were utilized in the management of their foreign exchange exposures. The findings of the research pointed to the increased uses of options in Kenya as a hedging tool to manage currency risk. The study also indicated that today, treasury departments have evolved to focus on much more than just working capital requirements of the organization but are expected to hedge transactions with the most appropriate tools in the market.

Egan (2007) examined the fit of statistical distributions to the returns of the S&P 500 Index for option traders. The Black-Scholes option pricing model assumes lognormal asset price distributions. The lognormal distribution has been found to be a usefully accurate description of the distribution of prices for many financial assets.

Aloo (2011) explored currency options, how they are utilized and who they can benefit in the Kenyan market. The study found out that currency options do not exist in Kenya, but the existence of the currency options market would thrive in Kenya given certain conditions as all respondents agreed on the usefulness of this market. The study found that Manufacturers and oil importers are likely to be affected by both foreign currency fluctuations and commodity price changes. They thus would like to hedge themselves against these risks. Sectors such as horticulture and agriculture are involved in the import of farm in-puts and export of farm products whose prices are determined before delivery date. They are therefore also subject to currency fluctuations.

Kambi (2013) studied how foreign currency options can be valued in Kenya under stochastic volatility .The research gave findings that were consistent with research done in the area of valuation of foreign currency options globally. The study found out that foreign currency options can be valued in Kenya by use of a Garch (1, 1) framework which was a good fit for the actual data.

2.5 Summary of Literature Review

Many studies done on the effects of exchange rate exposure were focused on studying the effects of exchange rate fluctuation on the value of the firm and their management or the sensitivity of exchange rate exposure on the value of the firm. Although considerable advances have been made in the understanding of currency risk exposure, many puzzles remain. The puzzles include the question of how firms' hedging activities affect their sensitivity to currency fluctuations, or equivalently, which companies should and which companies should not hedge their foreign currency exposure in order to maximize firm value. Furthermore, the particular effect of

increased exchange rate volatility during periods of financial turmoil on shareholder wealth deserves to be empirically assessed.

From the literature volatility is the main variable involved where by most researchers now focus on developing ways of obtaining volatility based on either historical data or implied volatility and the applications of Garman Kohlhagen model in pricing of currency option, Garman and Kohlhagen (1983) is an extension of the Black and Scholes (1973).The Garman and Kohlhagen (1983) is used since multiple interest rates are involved unlike in the Black-Scholes assumptions.

While theoretical foundations of exchange rate exposure are evident, the empirical research is to a certain extent incomplete. Local studies on currency options in the Kenyan market by Alaro, (1998), Ochong, (2002), Aloo, (2011), Kambi (2013) support the need for use of currency options in hedging against exchange rate exposures. Both overseas and local studies do point to a growing need of use of currency options to minimise/hedge against foreign exchange rate exposure. Most of the local studies have focused on the existence and the importance of currency option in the Kenyan market. This study applies GK model to price currency options that can be used to hedge against foreign exchange rate exposure.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter documents the research methodology adopted in conducting the study. It explains the research design giving a definition of the study design and why this type of design was the most appropriate for this study. The chapter then identifies the population and sample size stating the sample design before proceeding to showing the data collection method and the data analysis blue print.

3.2 Research design

Research design refers to how data collection and analysis are structured in order to meet the research objectives through empirical evidence economically Schindler (2006).

The research used a descriptive research design. Descriptive survey research portrays an accurate profile of persons, events, or account of the characteristics, for example behaviour, opinions, abilities, beliefs, and knowledge of a particular individual, situation or group. The descriptive survey method was preferred because it ensured complete description of the situation, making sure that there is minimum bias in the collection of data.

The research looked at USD/KES exchange rate in the past and analysed it to come up with a pricing model for foreign currency options in Kenya.

3.3 Data Collection

The study made use of secondary data. The secondary data (daily USD/KES exchange rate for 5 years from January 2010 to December 2014) was obtained from Central bank of Kenya. Secondary data was collected from daily rates and statistics on foreign exchange rates, data that is available from the CBK website. Data collection for all the variables was done as listed in appendix 2.

3.4 Data Analysis

The method for analysing data involves the utilization of the right analytical tools to address the research questions of the study.

Data analysis was done using latest version of Statistical package for social sciences (SPSS) and Microsoft Office Excel, Secondary data was collected then volatility was derived from the historical data, and the volatility obtained was applied into the GK model and used to price foreign currency options.

3.7 Model

This study used historical data to obtain the volatility (i.e. standard deviation of historical returns) which will be plugged into the GK Model to price the options. The model is based on the original propositions of Black and Scholes model as adjusted by the GK Model. Under this model, the foreign currency call (C) and put (P) option is a function of the following six variables;

C/P= f (S, K, T, r_d, r_f, σ).

Where: (S) is the current currency spot rate, (K) the strike price, (T) the time to expiration,(r_d)the local risk free interest rate ,(r_f) the foreign risk free interest rate and(σ) is the volatility.

All the variables above were observable except volatility, which was estimated as below;

Where;

U_t , Is the continuously compounded return between the end of day t-1 and the end of day t.

s_{t-1}, The spot exchange rate at time t-1.

s_t , The spot exchange rate at time t

And $U_t = \ln \frac{S_t}{S_{t-1}}$

Once the returns of the spot exchange rates were obtained, standard deviation of the historical returns was calculated, the volatility was annualized i.e. multiplied by an annualization factor based on the period used (252 trading days in a year). Then the resultant volatility plugged into the Garman and Kohlhagen model stipulated below;

$C = S_o e^{-r_f T} N(d_1) - K e^{-r_d t} N(d_2)$……...……...……(vi)

And that for a put option is given by;

$P = K e^{-r_d t} N(-d_2) - S_o e^{-r_f T} N(-d_1)$…….....(vii)

And

$$d_1 = \frac{\ln\left(\frac{S_o}{k}\right)+(r_d - r_f + \frac{\sigma 2}{2})T}{\sigma\sqrt{T}} \quad \text{(viii)}$$

$$d_2 = d_1 - \sigma\sqrt{T} \quad \text{(ix)}$$

Where;

C is the theoretical price of the call option

P is the theoretical price of the put option

r_d is the domestic risk free rate of interest

r_f is the foreign risk free rate of interest.

T is the time to maturity of the option.

σ is the annual volatility

N (d_1): and N (d_2): the cumulative normal distribution function

All the above variables were observable except annual volatility which was obtained as outlined above and the foreign currency call and put options was priced at various strike prices.

3.9 Data Validity & Reliability

A reliable data is that which is free from error and therefore yield consistent results and applies to a measure when similar results obtained over time and across situations. The data validity and reliability was assured, for this study used secondary data from trusted sources of Central bank of Kenya.

Table 3.1: Operational Definition of Variable

Variables	Definition	Measurement
So	Underlying Price	Daily mean exchange rate available from the CBK website
σ	Annual Volatility	Was derived from historical data
r_d	Domestic Risk free interest rate	Domestic risk free rate that was used, was the 364 days Treasury bill rate for the domestic Kenya interest rate
r_f	Foreign Risk free interest rate	Foreign risk free rate that was used, was the 1 year treasury bill rate for US
K	Strike Price	Price based on simulated strike prices
T	Time until expiration	Time to maturity that was used in this study, was a foreign currency option of 6 months

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF FINDINGS

4.1 Introduction

This chapter presents analysis and findings of the study as set out in the research objective and research methodology. The objective of the study was to test the applicability of the Garman Kohlhagen Model in pricing foreign currency options in the Kenyan Foreign exchange market. The data was gathered exclusively from the secondary source which included records at Central Bank of Kenya.

4.2 Data Presentation

Tables and figures in this chapter were derived from the findings of the study. The exchange rate data as given in Appendix 3 was derived from CBK website. The variables used in the study were volatility, underlying price, strike price, risk free rates, time to maturity.

4.2.1 Descriptive Statistics

The study first found it necessary to determine the trend of the USD/KES exchange rates for the year 2010-2014. This was to determine the basic features of the data in the study as a result of foreign exchange trading over a range of time period. The descriptive statistics provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data. Foreign exchange rates under the study from 2010-2014 i.e. their mean, median, maximum, minimum, kurtosis, skewness and standard deviation were taken in to account.

The findings were as indicated below:

Table 4.1: Descriptive Statistics

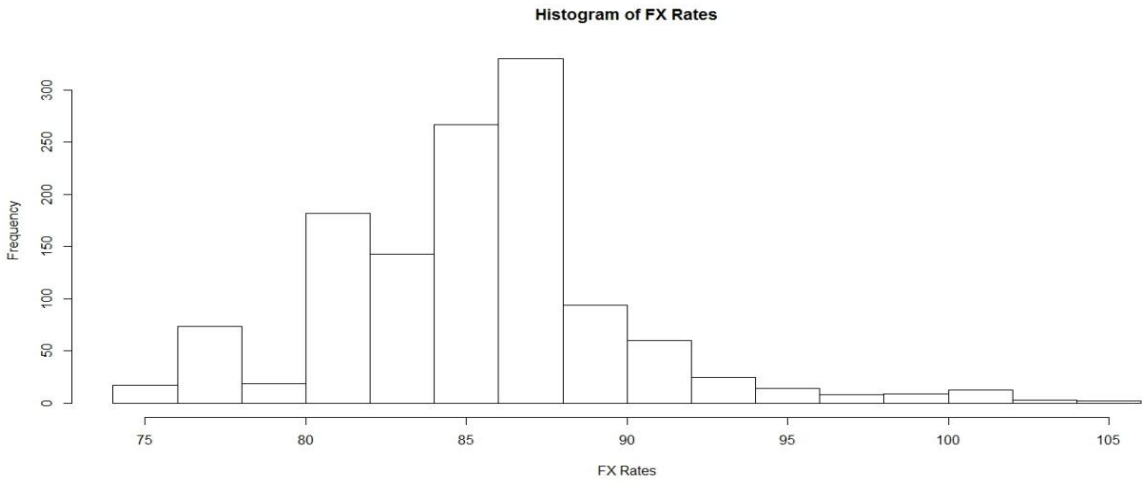
	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
USD/KES	1260	75.361	105.961	107.07	4.5665	2.1142	0.6711
Valid N (listwise)	1260						

Source; Research Findings

The table above represents the descriptive statistics of exchange rates for 5 years. The mean of exchange rate was 107.0670 and a standard deviation of 4.5665. The maximum value of the exchange rate was 105.961 with a minimum of 75.361, the skewness and kurtosis of the data was 2.1142 and 0.6711 respectively. The skewness is greater than 1.0, the skewness is substantial and the distribution is far from symmetrical, Kurtosis is greater than 0 indicating that the distribution is more peaked and has a positive kurtosis.

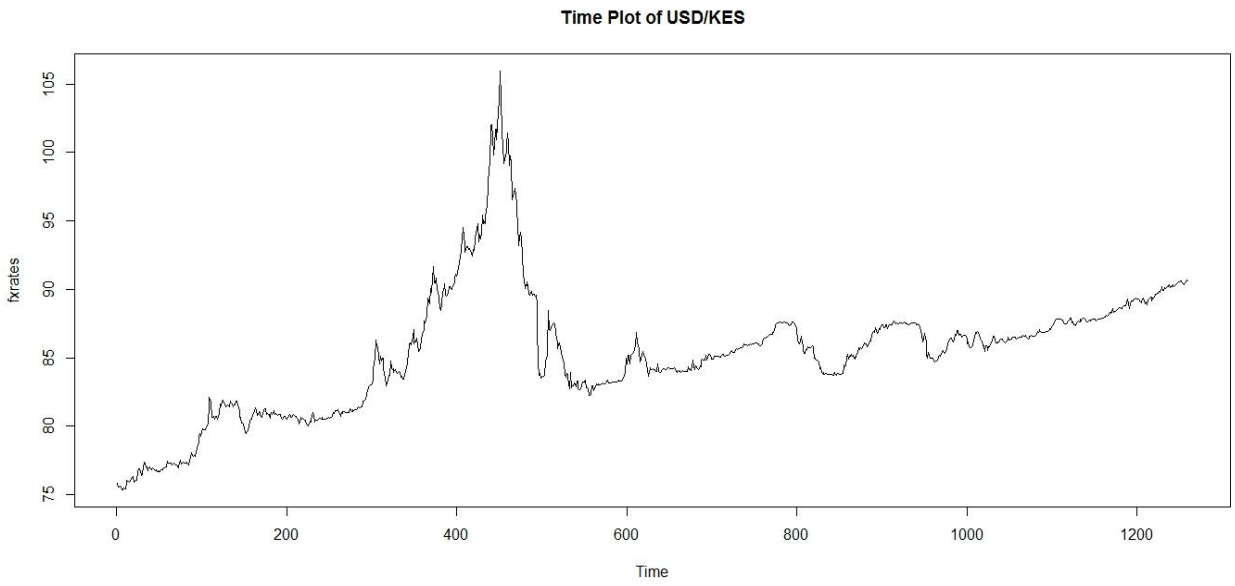
4.2.1 Graphical Presentation of Data

4.2.1.1 Histogram of Exchange Rates



Foreign exchange rates have been erratic throughout the 5 years period. The exchange rate for the USD against the Kenya Shilling range from a low of 75 to a high of around 105, the majority of the exchange rates lies between 80-90 against the USD. Finally, due to the atypical large value, the histogram is slightly skewed to the right, or positively skewed.

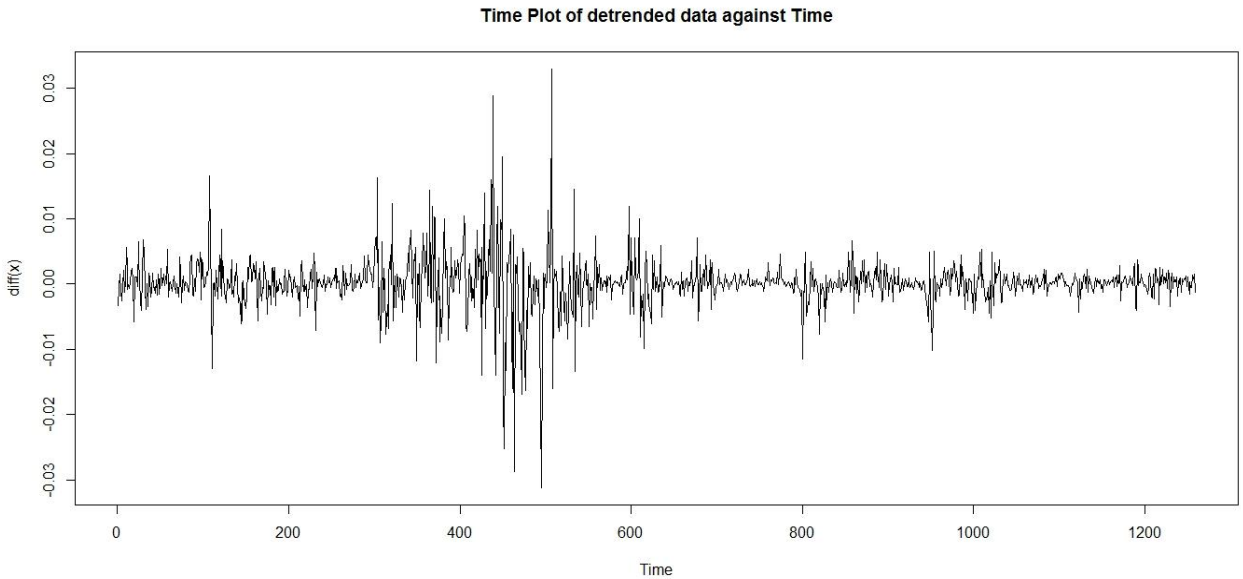
4.2.1.2 Time Plot of Raw Data



There is an upward trend. The presence of trend indicates that the time series is non-stationary.

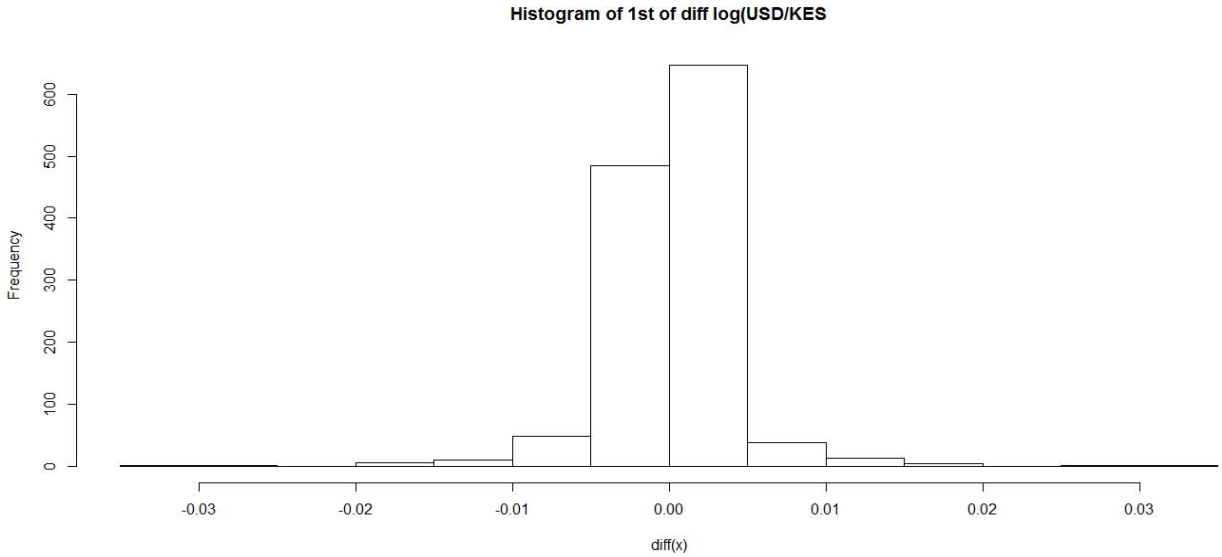
The standard deviation of the series is proportional to the level of the series, and then transforming to logarithms will produce a series with approximately constant variance over time. Also the level of the series is changing roughly exponentially; the log-transformed series exhibits a linear time trend. On applying the first difference filter on the natural logarithms of the data, the following results are observed:

4.2.1.3 First differences of the natural logarithms of the raw data



The transformed data series looks much more stationary when compared with the original time series, stationarized series is relatively easy to predict: one simply predicts that its statistical properties will be the same in the future as they have been in the past.

4.2.1.4 Histogram of transformed data



The transformed data resembles the normal distribution.

4.2.2 Risk Free Rate

Risk free interest rate is the theoretical rate of return of an investment with zero risk including the default risk. The risk free rate represents the interest that an investor would expect from an absolutely risk free investment over a given period of time. Risk free rate can be said to be the rate of interest with no risk. Therefore, any rational investor will reject all the investments yielding sub risk free returns. The risk free rate is usually obtained from government securities which offer a guaranteed return with no risk. The risk free rates used are the 364 days Treasury bill rate for the domestic Kenya interest rate which in January 2014 averaged 10.65% and the foreign risk free rate the 1 year Treasury bill for USA was used in the study and the foreign risk free rate is as shown in appendix 2.

4.2.3 Strike Price

The strike price is defined as the price at which the holder of currency options can buy in the case of a call option or sell in the case of a put option the underlying security when the option is exercised. Since there is no options market in Kenya the foreign currency options was priced based on simulated strike prices of 70,80,90 and 100.These four strike prices are adequate in this analysis as they help potray various pricing dynamics of foreign currency option pricing.

4.2.4 Time to Maturity

The time to maturity is the period that remaining before the option expires. This research assumes that the currency options are European currency options that can only be exercised on the maturity date on their expiry date. The time to maturity used in this study is a foreign currency option of 6 months and this translates to a 0.5 fraction of a year.

4.2.5 Volatility

Volatility is one of the major variable in this research and coming up with a good volatility estimate is very key in coming up with an adequate and accurate foreign currency pricing model. Volatility shows the variation in data in relation to the mean. If the data is close together, the standard deviation will be small. If the data is spread out, the standard deviation will be large. Volatility is estimated from a sample of recent continuously compounded returns .This research uses historical volatility estimates and assumes that volatility of the past will hold in the future and in this research standard deviation from past data of the exchange rates for the USD against the Kenya shilling is calculated. In this research, first price relatives are calculated from the exchange rates given, and then natural logs of the price relatives are now used as the variable by which standard deviation is estimated. The annualized standard deviation which represents the volatility is used in pricing of foreign currency options. The volatility used in this study is obtained as shown in appendix 2.

4.3 Application of the Garman Kohlhagen Model

After obtaining all the variables, the variables are plugged into the GK model to price the call and put options. Tables 4.2 - 4.5 indicates the various call and put prices obtained and the explanations on the variation in the prices, compares the option prices to the strike prices and spot exchange rates. The study uses the month of January 2014 as an example (the various dates daily mean exchange rates), so as to observe the various price dynamics.

Table 4.2: Strike Price at 70

K=70							
Date-January(2014)	**Exchange Rate(S)**	**σ%**	**364 day T-Bill-CBK(r_d)**	**r_f**	**T**	**Call Price**	**Put Price**
2	86.4167	2.22245536	10.65%	12%	0.5	15.01418	7.2651E-40
3	86.8722	2.22440576	10.65%	12%	0.5	15.44315	9.99E-42
6	86.8228	2.16951160	10.65%	11%	0.5	15.80648	1.792E-45
7	86.9583	2.17260704	10.65%	13%	0.5	15.11579	4.572E-42
8	86.9611	2.17246001	10.65%	13%	0.5	15.11841	4.39E-42
9	86.8639	2.17682923	10.65%	13%	0.5	15.02733	1.677E-41
10	86.6306	2.17735939	10.65%	11%	0.5	15.62457	2.706E-44
13	86.4372	2.16228371	10.65%	11%	0.5	15.44152	5.397E-44
14	86.2806	2.15263655	10.65%	11%	0.5	15.2933	1.192E-43
15	86.2344	2.14730416	10.65%	12%	0.5	14.84249	1.067E-41

First for the analysis of the model in practice, first we look at the foreign currency option having a strike price of 70.The strike price of 70 is below the spot exchange rates which are above 86 for the simulation period of January 2014 and hence its advantageous for the currency call holders to exercise the calls as they would gain while for put holders they would lose out hence no put holder would exercise their put currency options. For this reason based on the laws of demand and supply and practical options trading we have a higher demand for currency call options hence the higher price compared to the currency put options. The price of the currency call option ranges between 14.84-15.80 while the currency put option prices for this period of simulation are statistically Zero as shown in the above table.

Table 4.3: Strike Price at 80

K=80							
Date-January(2014)	**Exchange Rate(S)**	**σ%**	**364 day T-Bill-CBK(rd)**	**rf**	**T**	**Call Price**	**Put Price**
2	86.4167	2.22245536	10.65%	12%	0.5	5.532748	9.45E-07
3	86.8722	2.22440576	10.65%	11%	0.5	6.371811	3.313E-08
6	86.8228	2.16951160	10.65%	11%	0.5	6.325055	1.936E-08
7	86.9583	2.17260704	10.65%	13%	0.5	5.634358	3.71E-07
8	86.9611	2.17246001	10.65%	13%	0.5	5.636982	3.665E-07
9	86.8639	2.17682923	10.65%	13%	0.5	5.545899	5.536E-07
10	86.6306	2.17735939	10.65%	11%	0.5	6.143141	4.745E-08
13	86.4372	2.16228371	10.65%	11%	0.5	5.96009	8.533E-08
14	86.2806	2.15263655	10.65%	11%	0.5	5.811871	1.414E-07
15	86.2344	2.14730416	10.65%	12%	0.5	5.361065	5.3610646

Looking at the option prices at strike price of 80 where the strike price of 80 is below the spot exchange rates which are above 86 for the simulation period of January 2014 and hence they would lose out hence no put holder would exercise their put currency options. For this reason based on the laws of demand and supply and practical options trading, we have a higher demand for currency call options hence the higher price compared to the currency put options. The price of the currency call option ranges between 5.36-6.37 while the currency put option prices for this period of simulation are statistically Zero as shown in the above table. From above we can see that the call prices are lower that for the strike price of 70 and this is for the reason that the strike price of 80 is closer to the spot exchange rate than that of 70.

Table 4.4: Strike Price at 90

K=90							
Date-January(2014)	**Exchange Rate(S)**	**σ%**	**364 day T-Bill-CBK(r_d)**	**r_f**	**T**	**Call Price**	**Put Price**
2	86.4167	2.22245536	10.65%	12%	0.5	0.000475	3.9491569
3	86.8722	2.22440576	10.65%	11%	0.5	0.004039	3.1136577
6	86.8228	2.16951160	10.65%	11%	0.5	0.00294	3.1593147
7	86.9583	2.17260704	10.65%	13%	0.5	0.000485	3.8475564
8	86.9611	2.17246001	10.65%	13%	0.5	0.000488	3.8449358
9	86.8639	2.17682923	10.65%	13%	0.5	0.000385	3.9359162
10	86.6306	2.17735939	10.65%	11%	0.5	0.001934	3.340223
13	86.4372	2.16228371	10.65%	11%	0.5	0.001125	3.5224645
14	86.2806	2.15263655	10.65%	11%	0.5	0.000718	3.6702768
15	86.2344	2.14730416	10.65%	12%	0.5	0.000188	4.1205533

The option prices at strike price of 90 where the strike price of 90 is now above the spot exchange rates, which are above 86 for the simulation period of January 2014 and hence its advantageous for the currency put holders to exercise the puts as they would gain for they can buy the currency from the foreign currency market at a lower exchange rate of 86 and then sell it at 90 hence gaining from exercising their put options. while for call holders they would lose out by exercising the currency call options as they will be buying the currency at 90 and can only sell the currency to the market at only 86 hence no call holder would exercise their call currency options. For this reason based on the laws of demand and supply and practical options trading we have a higher demand for currency put options hence the higher price compared to the currency call options. The price of the currency put option ranges between 3.11-4.12 while the currency call option prices for this period of simulation are statistically Zero as shown in the above table.

Table 4.5: Strike Price at 100

K=100							
Date-January(2014)	**Exchange Rate(S)**	**σ%**	**364 day T-Bill-CBK(r_d)**	**r_f**	**T**	**Call Price**	**Put Price**
2	86.4167	2.22245536	10.65%	12%	0.5	1.74E-23	13.430112
3	86.8722	2.22440576	10.65%	11%	0.5	9.9E-21	12.591048
6	86.8228	2.16951160	10.65%	11%	0.5	7.89E-22	12.637804
7	86.9583	2.17260704	10.65%	13%	0.5	4.12E-24	13.328501
8	86.9611	2.17246001	10.65%	13%	0.5	4.18E-24	13.325877
9	86.8639	2.17682923	10.65%	13%	0.5	2.46E-24	13.41696
10	86.6306	2.17735939	10.65%	11%	0.5	2.75E-22	12.819718
13	86.4372	2.16228371	10.65%	11%	0.5	3.45E-23	13.002769
14	86.2806	2.15263655	10.65%	11%	0.5	6.85E-24	13.150988
15	86.2344	2.14730416	10.65%	12%	0.5	1.29E-25	13.601795

Finally, looking at the option prices at strike price of 100 where the strike price of 100 is now above the spot exchange rates which are above 86 for the simulation period of January 2014 and hence its advantageous for the currency put holders to exercise the puts as they would gain for they can buy the currency from the foreign currency market at a lower exchange rate of 86 and then sell it at 100 hence gaining from exercising their put options. while for call holders they would lose out by exercising the currency call options as they will be buying the currency at 100 and can only sell the currency to the market at only 86 hence no call holder would exercise their call currency options. For this reason based on the laws of demand and supply and practical options trading we have a higher demand for currency put options hence the higher price compared to the currency call options. The price of the currency put option ranges between 12.59-13.60, while the currency call option prices for this period of simulation are statistically Zero as shown in the above table. From above we can see that the currency put prices are higher

for the strike price of 100 compared to that of 90 and this is due to the fact that at strike price of 100 is further away from the spot exchange rates of 86 hence you will be gaining more when you exercise the put currency options hence the higher price.

4.4 Discussion of Findings

The study sought to establish the applicability of the GK Model in pricing foreign currency options in the Kenyan foreign exchange market. This was achieved by operationalization of the variables to measurable components. Descriptive statistics and graphical analysis (time series analysis and histograms) were used to determine the trend of the foreign exchange rates and check for normality of the data.

From the simulated foreign currency option prices as shown in tables 4.2 - 4.5 where we have strike prices of 70,80,90 and 100, the foreign currency call price is higher than the currency put price. This is due to the fact that when the strike is below the spot exchange rate, exercising the currency call options, a holder of the currency call option would gain as he can buy the currency at the lower strike price and sell it in the market at the higher exchange rate. While for the foreign currency put option holders, they would lose out if they exercised the puts for they would have to sell the currency at a lower price than that that they can freely obtain from the foreign exchange market.

When the strike price is above the daily spot exchange rate as shown in tables 4.4 and 4.5 the foreign currency options the foreign currency put price is higher than the currency call price which is almost statistically zero when the strike price is above the daily spot exchange rates for strike prices of 90 and 100. This is due to the fact that when the strike is above the spot exchange rate, exercising the currency put options a holder of the currency put option would gain as he can

buy the currency at the lower spot exchange rate and sell it at the higher spot exchange rate. While for the foreign currency call option holders, they would lose out if they exercised the calls for they would have to pay more than the market spot exchange rate for the currency and hence they would not exercise them.

From simulation as shown in tables 4.2, 4.3, 4.4 and 4.5 using January 2014 USD/KES exchange rate data, foreign currency options can be priced in Kenya and the results obtained show that the pricing is consistent with previous literature and studies done on the pricing of foreign currency options especially the studies that used the GK Model like Shastri and Tandon (1986) in pricing of foreign currency options. The exchange rates between January 2-15 range between 86.0769-86.6853 and using the strike prices of 70, 80, 90 and 100 this study yields results consistent with previous theories and literature. From theory and previous studies done in the area of currency options pricing of call options, the higher the strike price, the cheaper the currency call option and for put option the lower the strike price the cheaper the currency put option. This model results also shows that the GK Model is applicable in pricing of foreign currency options in the Kenyan foreign exchange market.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this chapter, conclusions are drawn from the discussed results and findings from previous chapter. The implications of the study is then examined, the applicability of the GK Model, policy recommendation and limitation of the study are clearly outlined. The generated findings relate with prevailing literature and conceptual framework. This study focused on testing the applicability of GK Model in pricing currency options in the Kenyan foreign exchange market. Exchange rate data was obtained from the CBK Website. From the analysis and data collected, the following discussions, conclusion and recommendations were made. The analysis was based on the objective of the study.

5.2 Summary of Findings

This study sought to test the applicability of Garman Kohlhagen Model to price foreign currency options in the Kenyan foreign exchange market. This research used descriptive research design which is a scientific method which involves observing and describing the behavior of a subject without influencing it in any way. The research looked at USD/KES exchange rate in the past and analysed it to come up with a pricing model for foreign currency options in Kenya. The study first sought to establish the nature of the underlying asset i.e. foreign exchange rates of the five years study period (2010-2014), This was to determine the basic features of the data in the study as a result of foreign exchange trading over a range of time period . The descriptive statistics show that FX rates had a mean of 107.0670 and standard deviation of 4.5665, further the Time Plot of the FX rates indicated presence of an upward trend, presence of trend indicated

that the time series is non-stationary. The standard deviation of the series was proportional to the level of the series, and then transforming to logarithms produced a series with approximately constant variance over time. Also, the level of the series changed roughly exponentially; the log-transformed series exhibited a linear time trend. On applying the first difference filter on the natural logarithms of the data, the transformed data series looked much more stationary when compared with the original time series, the histogram of the transformed data resembled a normal distribution.

The research looked at various literatures on pricing of foreign currency options identifying the major models used. The research sought to show how currency options can be priced in Kenya by use of the GK Model. The study used Garman Kohlhagen model for pricing of foreign currency options whereby two interest rates of domestic and foreign risk free rate. The study used historical data to obtain volatility that is plugged into the Garman Kohlhagen model. The research had various findings that were consistent with previous research done in the area of pricing of currency options by Scott and Tucker (1989), Ritchken (1996), Bharadia et al (1996). The research found out that for call options when the spot exchange rate is below the strike price, the option has statistically zero value and when above strike price the option has a positive value. On the other hand, the price of a put currency option is positive when the spot exchange rate is, below the strike price and statistically zero when the spot exchange rates are above the strike prices and the further away from the strike price the spot exchange rate is the higher the value of the option.

5.3 Conclusions

From the findings various conclusions can be drawn. First, from the findings the historical data is used for deriving the volatility used in pricing of foreign currency. From the study another conclusion is that the prices of currency call and put option obtained from the model are consistent with historical literature and empirical studies in the area of foreign currency options pricing. From the research findings, we can conclude that if the spot exchange rate is below or above the strike price of the foreign currency, this will to a great extent deter the price of the foreign currency option.

When the spot exchange rate is below the currency option strike price, the price of the currency call option is statistically zero and the price of the currency put option is positive as a holder of the put option would gain from exercising them hence high demand and price subsequently. On the other hand, when the spot exchange rate is above the strike price, the price of the currency put option is statistically zero and the price of the currency call option is positive as the holders of the currency options would gain by exercising the call options and hence high demand and price of the currency call options. Hence, the further the spot exchange rate is from the strike price, the higher the price of the foreign currency calls and put option.

The study also concludes that GK model is applicable for pricing foreign currency options in the Kenyan Foreign exchange market since various study findings, were consistent with previous research done in the area of pricing of currency options by Scott and Tucker (1989), Ritchken (1996), Bharadia et al (1996), that affirms the suitability of the GK model in pricing foreign currency options.

5.4 Recommendations

For introduction of currency options in Kenya the first policy recommendation is to formulate a good and robust regulation framework. Under this, the Central bank of Kenya should formulate an adequate regulatory framework for introduction of derivative trading in Kenya. The regulatory framework should give definitions of the various derivative instruments like swaps, calls, puts and clearly spell out the procedures that will be followed when trading in the derivatives. For currency options, the regulatory framework should indicate the minimum trade of the currency options allowable, clearly spell out conditions that you need to fulfill in order to be allowed to trade in the currency options for the dealers.

The Central Bank of Kenya and the Capital markets authority should also spearhead faster introduction of an options market in Kenya where options and other derivatives and futures can be traded. The options market will be very important as it will provide increased liquidity in the financial market. The options market will also be another source of capital and it will be very essential in management of risks associated with various underlying assets like foreign exchange rates which are volatile. The options market will also enhance stability of importers and exporters cash flows and this will in turn lead to a more stable economy.

5.5 Limitations of the Study

When conducting this study, various limitations were encountered. The first limitation was the lack of an options market in Kenya and this is the main limitation to this study for one to ascertain how good the model is in pricing of foreign currency options you need to compare the price obtained from the model and the prices that are in the options market. The prices given by

the model should be consistent with the prices of the same options in the actual options market for foreign currency options.

Another limitation is the lack of high levels of efficiency in the foreign exchange market especially informational efficiency and the foreign exchange market in Kenya is subject to interference through various macroeconomic policies. This interference inhibits the foreign exchange market which affects foreign exchange rates which in turn affects the quality of the model obtained.

Another limitation of the study is the assumptions in the study of no taxes and no transaction costs some of which are not realistic. This has an impact for in today's financial markets, taxes are in all financial transactions and transaction costs are in all financial dealings as the financial intermediaries usually charge a commission and in this study, an assumption that no transaction costs are incurred is made.

Another limitation of this study is that some variables used do not exist like the strike prices where pricing of the foreign currency options have to be priced by simulation of prices of the foreign currency options at various strike price of 70, 80, 90 and 100.

5.6 Suggestions for Further Research

Further studies relating to this study can be done in the following areas. First, pricing of currency options under constant volatility using Black Scholes model can be conducted and here volatility would be constant and not vary as in this study and the resulting pricing of currency options can be compared with the prices of the foreign currency options obtained in this study.

Hedging with foreign currency options is another area where additional studies can be conducted and here one can look at how you can use the currency options to hedge against foreign currency risk. Here one will be able to come up with hedging strategies, whether to purchase a call or a put and the volume to purchase.

Another area that further studies can be conducted is the pricing of currency Swap. Currency swap is the best way to fully hedge a loan transaction as the terms can be structured to exactly mirror the underlying loan. It is also flexible in that it can be structured to fully hedge a fixed rate loan with a combined currency and interest rate hedge via a fixed-floating cross currency swap. The currency swaps will be an additional tool for hedging against financial risk..

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APPENDICES

Appendix 1:

Date-January(2014)	Exchange Rate(S)	Price Relative	Ln(Natural Log)	σ	Annualised Volality(σ)	σ%
1	-					
2	86.4167	1.001239722	0.001238954	0.00140002	0.0222245536	2.22245536
3	86.8722	1.005270972	0.005257129	0.00140124	0.02224405756	2.224405756
4	-					
5	-					
6	86.8228	0.999431349	-0.000568813	0.00136666	0.021695116	2.1695116
7	86.9583	1.00156065	0.001559433	0.00136861	0.02172607045	2.172607045
8	86.9611	1.000032199	3.21988E-05	0.00136852	0.02172460005	2.172460005
9	86.8639	0.998882259	-0.001118366	0.00137127	0.02176829226	2.176829226
10	86.6306	0.997314189	-0.002689424	0.00137161	0.02177359394	2.177359394
11	-					
12	-					
13	86.4372	0.997767532	-0.002234963	0.00136211	0.02162283715	2.162283715
14	86.2806	0.99818828	-0.001813363	0.00135603	0.02152636547	2.152636547
15	86.2344	0.999464538	-0.000535606	0.00135267	0.02147304159	2.147304159
16	85.8508	0.995551659	-0.004458264	0.00135464	0.02150430594	2.150430594
17	85.8972	1.000540473	0.000540327	0.00132354	0.02101056962	2.101056962
18	-					
19	-					
20	85.4572	0.994877598	-0.005135567	0.00132615	0.02105195189	2.105195189
21	85.8792	1.004938144	0.004925992	0.00128256	0.02035995421	2.035995421
22	85.8806	1.000016302	1.63018E-05	0.00124861	0.01982106248	1.982106248
23	85.8181	0.999272245	-0.00072802	0.00125118	0.0198618391	1.98618391
24	85.5333	0.996681353	-0.003324166	0.00125229	0.01987943649	1.987943649
25	-					
26	-					
27	85.8125	1.003264226	0.00325891	0.00123318	1.957605095	1.957605095
28	85.8278	1.000178296	0.00017828	0.00121987	1.936488367	1.936488367
29	85.9611	1.00155311	0.001551905	0.00122249	1.940649264	1.940649264
30	86.0833	1.001421573	0.001420564	0.00122204	1.93993293	1.93993293
31	86.2361	1.001775025	0.001773451	0.00122215	1.940106015	1.940106015

Appendix 2: Data Collection Instrument

Date-January(2014)	**Exchange Rate(S)**	**σ%**	**364 day T-Bill-CBK(r_d)**	**r_f**	**T**
1					
2	86.4167	2.22245536	10.65%	12%	0.5
3	86.8722	2.22440576	10.65%	12%	0.5
4	-				
5	-				
6	86.8228	2.16951160	10.65%	11%	0.5
7	86.9583	2.17260704	10.65%	13%	0.5
8	86.9611	2.17246001	10.65%	13%	0.5
9	86.8639	2.17682923	10.65%	13%	0.5
10	86.6306	2.17735939	10.65%	11%	0.5
11	-				
12	-				
13	86.4372	2.16228371	10.65%	11%	0.5
14	86.2806	2.15263655	10.65%	11%	0.5
15	86.2344	2.14730416	10.65%	12%	0.5
16	85.8508	2.15043059	10.65%	10%	0.5
17	85.8972	2.10105696	10.65%	11%	0.5
18	-				
19	-				
20	85.4572	2.10519519	10.65%	11%	0.5
21	85.8792	2.03599542	10.65%	11%	0.5
22	85.8806	1.98210625	10.65%	10%	0.5
23	85.8181	1.98618391	10.65%	10%	0.5
24	85.5333	1.98794365	10.65%	10%	0.5
25	-				
26	-				
27	85.8125	1.95760509	10.65%	10%	0.5
28	85.8278	1.93648837	10.65%	10%	0.5
29	85.9611	1.94064926	10.65%	10%	0.5
30	86.0833	1.93993293	10.65%	9%	0.5
31	86.2361	1.94010601	10.65%	9%	0.5

Appendix 3: Daily Mean Exchange Rates (January 2010-December 2014)

	Date	Mean Exchange Rate
	31-12-09	75.82
2010	**04-01-10**	**75.8406**
	05-01-10	75.5903
	06-01-10	75.5528
	07-01-10	75.6686
	08-01-10	75.5708
	11-01-10	75.3764
	12-01-10	75.3619
	13-01-10	75.5258
	14-01-10	75.4269
	15-01-10	75.4389
	18-01-10	75.8639
	19-01-10	76.0528
	20-01-10	75.9911
	21-01-10	75.9811
	22-01-10	75.9339
	25-01-10	75.9622
	26-01-10	76.0989
	27-01-10	76.2778
	28-01-10	76.3236
	29-01-10	75.8856
	01-02-10	75.9653
	02-02-10	76.0458
	03-02-10	76.1231
	04-02-10	76.0889
	05-02-10	76.5819
	08-02-10	76.8764
	09-02-10	76.9253
	10-02-10	76.7242
	11-02-10	76.4111
	12-02-10	76.5042
	15-02-10	77.0236
	16-02-10	77.3736
	17-02-10	77.3403
	18-02-10	77.0403
	19-02-10	77.045
	22-02-10	76.7814
	23-02-10	76.8386
	24-02-10	76.9681
	25-02-10	77.0556
	26-02-10	76.8972
	01-03-10	76.8083
	02-03-10	76.9378
	03-03-10	76.8931
	04-03-10	76.8486
	05-03-10	76.7447
	08-03-10	76.7944
	09-03-10	76.6653
	10-03-10	76.7778
	11-03-10	76.6608
	12-03-10	76.7197
	15-03-10	76.6639
	16-03-10	76.8444
	17-03-10	76.8292
	18-03-10	76.8569
	19-03-10	76.9714
	22-03-10	76.9539
	23-03-10	77.0489
	24-03-10	77.0531
	25-03-10	77.4586
	26-03-10	77.3089
	29-03-10	77.3017
	30-03-10	77.3025
	31-03-10	77.3314
	01-04-10	77.2975
	06-04-10	77.2083
	07-04-10	77.2097
	08-04-10	77.2994
	09-04-10	77.2767
	12-04-10	77.1708
	13-04-10	77.175
	14-04-10	77.0978
	15-04-10	76.9472
	16-04-10	77.0281
	19-04-10	77.3481
	20-04-10	77.4953
	21-04-10	77.2729

	22-04-10	77.2854
	23-04-10	77.3784
	26-04-10	77.3048
	27-04-10	77.3305
	28-04-10	77.3442
	29-04-10	77.3512
	30-04-10	77.266
	03-05-10	77.1642
	04-05-10	77.2255
	05-05-10	77.4243
	06-05-10	77.7528
	07-05-10	78.0936
	10-05-10	77.9713
	11-05-10	77.8241
	12-05-10	77.8899
	13-05-10	77.8009
	14-05-10	78.0468
	17-05-10	78.3497
	18-05-10	78.6397
	19-05-10	78.7834
	20-05-10	79.1712
	21-05-10	79.4427
	24-05-10	79.2471
	25-05-10	79.5467
	26-05-10	79.7868
	27-05-10	79.7463
	28-05-10	79.7171
	31-05-10	79.7453
	02-06-10	79.8929
	03-06-10	80.0085
	04-06-10	80.2228
	07-06-10	81.5586
	08-06-10	82.1028
	09-06-10	81.9486
	10-06-10	81.7458
	11-06-10	80.6889
	14-06-10	80.6806
	15-06-10	80.6958
	16-06-10	80.55
	17-06-10	80.7194
	18-06-10	80.7117

21-06-10	80.5264
22-06-10	80.6361
23-06-10	80.9936
24-06-10	80.9375
25-06-10	81.6153
28-06-10	81.4694
29-06-10	81.7583
30-06-10	81.9167
01-07-10	81.7958
02-07-10	81.6583
05-07-10	81.4225
06-07-10	81.4919
07-07-10	81.5422
08-07-10	81.4847
09-07-10	81.4475
12-07-10	81.5097
13-07-10	81.8106
14-07-10	81.6839
15-07-10	81.6033
16-07-10	81.4375
19-07-10	81.5417
20-07-10	81.5861
21-07-10	81.8403
22-07-10	81.8153
23-07-10	81.5783
26-07-10	81.4014
27-07-10	81.1506
28-07-10	80.6639
29-07-10	80.6806
30-07-10	80.2297
02-08-10	80.2667
03-08-10	80.1458
05-08-10	79.9014
06-08-10	79.6019
09-08-10	79.4403
10-08-10	79.6408
11-08-10	79.705
12-08-10	80.0458
13-08-10	80.3983
16-08-10	80.4208
17-08-10	80.4872

	18-08-10	80.5286
	19-08-10	80.7806
	20-08-10	81.0153
	23-08-10	81.085
	24-08-10	81.3628
	25-08-10	81.2428
	26-08-10	80.7819
	30-08-10	80.8731
	31-08-10	81.0711
	01-09-10	80.9742
	02-09-10	80.7689
	03-09-10	80.7272
	06-09-10	80.6708
	07-09-10	80.9442
	08-09-10	81.1514
	09-09-10	81.2619
	10-09-10	81.2703
	13-09-10	80.8933
	14-09-10	80.9303
	15-09-10	80.8592
	16-09-10	80.8403
	17-09-10	80.5903
	20-09-10	80.7869
	21-09-10	80.9917
	22-09-10	80.8358
	23-09-10	80.9486
	24-09-10	81.1597
	27-09-10	80.8917
	28-09-10	80.9375
	29-09-10	80.8503
	30-09-10	80.7781
	01-10-10	80.8444
	04-10-10	80.8361
	05-10-10	80.8411
	06-10-10	80.7172
	07-10-10	80.63
	08-10-10	80.5369
	11-10-10	80.5589
	12-10-10	80.735
	13-10-10	80.7306
	14-10-10	80.5861

15-10-10	80.5047
18-10-10	80.6694
19-10-10	80.7561
21-10-10	80.8406
22-10-10	80.8028
25-10-10	80.6428
26-10-10	80.6819
27-10-10	80.75
28-10-10	80.8344
29-10-10	80.7869
01-11-10	80.7539
02-11-10	80.7394
03-11-10	80.5586
04-11-10	80.5308
05-11-10	80.1356
08-11-10	80.3333
09-11-10	80.6236
10-11-10	80.6344
11-11-10	80.5469
12-11-10	80.5986
15-11-10	80.5147
16-11-10	80.4572
17-11-10	80.45
18-11-10	80.1639
19-11-10	80.1006
22-11-10	80.0397
23-11-10	80.1625
24-11-10	80.3486
25-11-10	80.2931
26-11-10	80.3892
29-11-10	80.7764
30-11-10	80.9742
01-12-10	80.8972
02-12-10	80.3208
03-12-10	80.4625
06-12-10	80.4364
07-12-10	80.4831
08-12-10	80.5525
09-12-10	80.5736
10-12-10	80.5578
14-12-10	80.5153

	15-12-10	80.5239
	16-12-10	80.6325
	17-12-10	80.5375
	20-12-10	80.5308
	21-12-10	80.4886
	22-12-10	80.4906
	23-12-10	80.5733
	24-12-10	80.5903
	27-12-10	80.6625
	28-12-10	80.6144
	29-12-10	80.6292
	30-12-10	80.6714
	31-12-10	80.7519
2011	**03-01-11**	**80.7961**
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	05-01-11	80.9389
	06-01-11	81.1322
	07-01-11	81.1444
	10-01-11	81.1747
	11-01-11	81.2181
	12-01-11	81.0708
	13-01-11	80.9417
	14-01-11	80.7431
	17-01-11	80.9736
	18-01-11	81.0708
	19-01-11	80.9333
	20-01-11	81.0661
	21-01-11	81.0764
	24-01-11	81.0147
	25-01-11	81.0217
	26-01-11	81.0031
	27-01-11	80.9986
	28-01-11	81.025
	31-01-11	81.2722
	01-02-11	81.1917
	02-02-11	81.1014
	03-02-11	81.0667
	04-02-11	81.1889
	07-02-11	81.1472
	08-02-11	81.2042
	09-02-11	81.2167

10-02-11	81.2375
11-02-11	81.3014
14-02-11	81.4428
15-02-11	81.3869
16-02-11	81.3583
17-02-11	81.3942
18-02-11	81.4456
21-02-11	81.7936
22-02-11	81.8611
23-02-11	81.875
24-02-11	81.8917
25-02-11	81.9992
28-02-11	82.3639
01-03-11	82.6014
02-03-11	82.8031
03-03-11	82.9278
04-03-11	83.0542
07-03-11	83.0081
08-03-11	83.0833
09-03-11	83.4667
10-03-11	84.0447
11-03-11	84.6569
14-03-11	84.9294
15-03-11	86.3239
16-03-11	85.8572
17-03-11	85.8108
18-03-11	85.0417
21-03-11	84.5917
22-03-11	85.1486
23-03-11	84.7847
24-03-11	84.9931
25-03-11	84.9444
28-03-11	84.2944
29-03-11	83.8206
30-03-11	83.5511
31-03-11	82.9889
01-04-11	83.1583
04-04-11	83.3722
05-04-11	83.7444
06-04-11	83.7325
07-04-11	84.7664

	08-04-11	84.2917
	11-04-11	84.1431
	12-04-11	84.2428
	13-04-11	83.9431
	14-04-11	84.0736
	15-04-11	84.1472
	18-04-11	84.0056
	19-04-11	83.8417
	20-04-11	83.9181
	21-04-11	83.9828
	26-04-11	83.9278
	27-04-11	83.5708
	28-04-11	83.625
	29-04-11	83.4194
	03-05-11	83.4583
	04-05-11	83.5278
	05-05-11	83.6556
	06-05-11	84.05
	09-05-11	84.2208
	10-05-11	84.7056
	11-05-11	85.2222
	12-05-11	85.9244
	13-05-11	86.1139
	16-05-11	85.9333
	17-05-11	86.2514
	18-05-11	86.5611
	19-05-11	87.0486
	20-05-11	86.0261
	23-05-11	86.1528
	24-05-11	86.1472
	25-05-11	86.4208
	26-05-11	86.0111
	27-05-11	85.4417
	30-05-11	85.5161
	31-05-11	85.7044
	02-06-11	86.375
	03-06-11	86.7514
	06-06-11	86.8292
	07-06-11	87.0422
	08-06-11	87.7219
	09-06-11	87.5569

10-06-11	87.6625
13-06-11	88.0931
14-06-11	89.3708
15-06-11	89.2361
16-06-11	88.9764
17-06-11	90.0444
20-06-11	89.8
21-06-11	90.7333
22-06-11	91.6556
23-06-11	90.5597
24-06-11	90.4486
27-06-11	90.4625
28-06-11	90.8278
29-06-11	90.0236
30-06-11	89.8639
01-07-11	89.3597
04-07-11	88.6856
05-07-11	88.4514
06-07-11	88.9694
07-07-11	89.8583
08-07-11	89.9389
11-07-11	90.2417
12-07-11	90.4417
13-07-11	89.6708
14-07-11	89.475
15-07-11	89.5833
18-07-11	89.6847
19-07-11	90.1861
20-07-11	90.1681
21-07-11	90.0583
22-07-11	89.9611
25-07-11	90.2878
26-07-11	90.375
27-07-11	90.5111
28-07-11	90.8444
29-07-11	91.1
01-08-11	90.975
02-08-11	91.2111
03-08-11	91.5847
04-08-11	91.9361
05-08-11	92.3528

	08-08-11	92.7667
	09-08-11	93.7375
	10-08-11	94.5167
	11-08-11	93.9131
	12-08-11	93.2328
	15-08-11	92.7183
	16-08-11	92.85
	17-08-11	93.1431
	18-08-11	93.1361
	19-08-11	92.9028
	22-08-11	93.0097
	23-08-11	92.8056
	24-08-11	92.7306
	25-08-11	92.4042
	26-08-11	92.8931
	29-08-11	92.8489
	30-08-11	93.6222
	01-09-11	93.6806
	02-09-11	94.1097
	05-09-11	94.4278
	06-09-11	94.7722
	07-09-11	93.4597
	08-09-11	93.9903
	09-09-11	93.7083
	12-09-11	94.1111
	13-09-11	95.4306
	14-09-11	94.7819
	15-09-11	94.9708
	16-09-11	94.8056
	19-09-11	95.1928
	20-09-11	95.8361
	21-09-11	96.0278
	22-09-11	97.5806
	23-09-11	98.8944
	26-09-11	99.0556
	27-09-11	101.949
	28-09-11	102.011
	29-09-11	101.232
	30-09-11	99.8319
	03-10-11	100.479
	04-10-11	101.674

05-10-11	101.715
06-10-11	100.949
07-10-11	101.947
10-10-11	102.811
11-10-11	103.908
12-10-11	105.961
13-10-11	104.01
14-10-11	101.426
17-10-11	100.512
18-10-11	99.1861
19-10-11	99.5181
21-10-11	99.7014
24-10-11	100.117
25-10-11	100.596
26-10-11	101.443
27-10-11	100.632
28-10-11	99.0319
31-10-11	99.7783
01-11-11	99.3347
02-11-11	96.5222
03-11-11	96.8097
04-11-11	96.975
07-11-11	97.3819
08-11-11	96.9706
09-11-11	96.2694
10-11-11	95.6903
11-11-11	94.7989
14-11-11	93.2164
15-11-11	93.7208
16-11-11	94.1458
17-11-11	93.6806
18-11-11	92.5433
21-11-11	91.0417
22-11-11	90.6722
23-11-11	90.0611
24-11-11	90.3097
25-11-11	90.2681
28-11-11	90.5611
29-11-11	90.1681
30-11-11	89.7208
01-12-11	89.5972

	02-12-11	89.7125
	05-12-11	89.8281
	06-12-11	89.5467
	07-12-11	89.6236
	08-12-11	89.6669
	09-12-11	89.4986
	13-12-11	89.55
	14-12-11	88.9764
	15-12-11	87.2792
	16-12-11	84.5972
	19-12-11	83.6939
	20-12-11	83.8306
	21-12-11	83.5167
	22-12-11	83.5542
	23-12-11	83.6864
	27-12-11	83.6472
	28-12-11	83.7167
	29-12-11	84.6667
	30-12-11	85.0681
2012	**03-01-12**	**85.0906**
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	05-01-12	88.4403
	06-01-12	87.0361
	09-01-12	86.9786
	10-01-12	87.1778
	11-01-12	87.3164
	12-01-12	87.4208
	13-01-12	87.5889
	16-01-12	87.4958
	17-01-12	86.9583
	18-01-12	86.3331
	19-01-12	86.2197
	20-01-12	85.6778
	23-01-12	86.0444
	24-01-12	86.1
	25-01-12	85.8444
	26-01-12	85.3639
	27-01-12	85.0306
	30-01-12	84.9167
	31-01-12	84.5875
	01-02-12	83.8833

02-02-12	83.5861
03-02-12	83.8708
06-02-12	83.8125
07-02-12	83.4903
08-02-12	83.1403
09-02-12	82.7167
10-02-12	83.9278
13-02-12	82.8125
14-02-12	82.9583
15-02-12	82.93
16-02-12	83.1667
17-02-12	83.0722
20-02-12	82.9097
21-02-12	83.2972
22-02-12	83.2944
23-02-12	82.7569
24-02-12	82.6986
27-02-12	82.6519
28-02-12	82.7514
29-02-12	82.9708
01-03-12	83.2625
02-03-12	83.2561
05-03-12	83.2347
06-03-12	83.3625
07-03-12	82.8222
08-03-12	82.8292
09-03-12	82.7514
12-03-12	82.7125
13-03-12	82.2686
14-03-12	82.2694
15-03-12	82.3472
16-03-12	82.9617
19-03-12	82.9611
20-03-12	82.6344
21-03-12	82.8489
22-03-12	82.8611
23-03-12	83.1083
26-03-12	83.0324
27-03-12	83.1042
28-03-12	83.0278
29-03-12	83.0153

	30-03-12	83.0556
	02-04-12	83.1014
	03-04-12	83.0694
	04-04-12	83.1764
	05-04-12	83.0667
	10-04-12	83.1031
	11-04-12	83.1961
	12-04-12	83.2541
	13-04-12	83.3681
	16-04-12	83.1611
	17-04-12	83.15
	18-04-12	83.1389
	19-04-12	83.1542
	20-04-12	83.1969
	23-04-12	83.2178
	24-04-12	83.2293
	25-04-12	83.2531
	26-04-12	83.265
	27-04-12	83.25
	30-04-12	83.2164
	02-05-12	83.2903
	03-05-12	83.4053
	04-05-12	83.2806
	07-05-12	83.2703
	08-05-12	83.2831
	09-05-12	83.2958
	10-05-12	83.3972
	11-05-12	83.6181
	14-05-12	83.6764
	15-05-12	83.9469
	16-05-12	84.9572
	17-05-12	84.5639
	18-05-12	85.1625
	18-05-12	85.1625
	21-05-12	84.9572
	22-05-12	84.5639
	23-05-12	85.1625
	24-05-12	85.2558
	25-05-12	85.3153
	28-05-12	85.3958
	29-05-12	85.5819

30-05-12	85.9556
31-05-12	86.825
04-06-12	86.1167
05-06-12	85.9569
06-06-12	85.6486
07-06-12	85.5111
08-06-12	84.6722
11-06-12	84.8125
12-06-12	85.2431
13-06-12	85.4556
14-06-12	85.2667
15-06-12	85.1306
18-06-12	84.8847
19-06-12	84.525
20-06-12	84.1556
21-06-12	83.6403
22-06-12	84.0125
25-06-12	83.9472
26-06-12	84.2519
27-06-12	84.1625
28-06-12	84.1478
29-06-12	84.2333
02-07-12	84.1322
03-07-12	84.1231
04-07-12	84.0278
05-07-12	84.0347
06-07-12	84.5292
09-07-12	84.0972
10-07-12	83.9368
11-07-12	83.9588
12-07-12	83.9292
13-07-12	84.0265
16-07-12	84.1222
17-07-12	84.1889
18-07-12	84.1794
19-07-12	84.1558
20-07-12	84.1447
23-07-12	84.1917
24-07-12	84.2617
25-07-12	84.2997
26-07-12	84.2292

	27-07-12	84.2011
	30-07-12	84.2014
	31-07-12	84.2125
	01-08-12	84.2383
	02-08-12	84.2264
	03-08-12	84.2506
	06-08-12	84.2022
	07-08-12	84.095
	08-08-12	83.9367
	09-08-12	84.0875
	10-08-12	84.0139
	13-08-12	84.0506
	14-08-12	83.8975
	15-08-12	83.9333
	16-08-12	83.9833
	17-08-12	84.0672
	21-08-12	83.975
	22-08-12	84.0056
	23-08-12	83.9903
	24-08-12	84.0056
	27-08-12	84.0236
	31-08-12	84.3208
	30-08-12	84.1422
	29-08-12	84.1181
	28-08-12	84.0961
	03-09-12	84.1483
	04-09-12	84.2667
	05-09-12	84.8653
	06-09-12	84.3872
	03-09-12	84.1483
	07-09-12	84.4056
	10-09-12	84.3389
	11-09-12	84.2403
	12-09-12	84.1417
	13-09-12	84.2139
	14-09-12	84.4042
	17-09-12	84.3817
	18-09-12	84.7531
	19-09-12	84.8847
	20-09-12	84.8275
	21-09-12	84.8264

24-09-12	84.8667
27-09-12	85.1764
25-09-12	84.8444
26-09-12	85.0097
28-09-12	85.2833
01-10-12	85.2764
02-10-12	85.1764
03-10-12	84.9714
04-10-12	84.925
05-10-12	84.9125
08-10-12	84.9153
09-10-12	85.1019
10-10-12	85.0978
11-10-12	85.1175
12-10-12	85.1339
15-10-12	85.1383
16-10-12	85.1261
17-10-12	85.0342
18-10-12	85.0422
19-10-12	85.1667
22-10-12	85.1819
23-10-12	85.2328
24-10-12	85.2208
25-10-12	85.1472
26-10-12	85.1342
29-10-12	85.1692
30-10-12	85.1678
31-10-12	85.1775
01-11-12	85.2361
02-11-12	85.3083
05-11-12	85.4456
06-11-12	85.55
07-11-12	85.5069
08-11-12	85.41
09-11-12	85.3778
12-11-12	85.3994
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14-11-12	85.6428
15-11-12	85.6261
16-11-12	85.645
19-11-12	85.6597

	20-11-12	85.7139
	21-11-12	85.7114
	22-11-12	85.7097
	23-11-12	85.7211
	26-11-12	85.7975
	27-11-12	85.9903
	28-11-12	85.9708
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	04-12-12	85.9639
	05-12-12	85.9417
	06-12-12	85.9889
	07-12-12	85.9575
	10-12-12	85.9889
	11-12-12	86.0522
	13-12-12	86.0422
	14-12-12	86.0383
	17-12-12	86.0672
	18-12-12	86.0611
	19-12-12	86.0744
	20-12-12	86.0472
	21-12-12	86.0008
	24-12-12	85.9039
	27-12-12	85.8628
	28-12-12	85.9611
	31-12-12	86.0286
2013	**02-01-13**	**86.0769**
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	04-01-13	86.4417
	07-01-13	86.4264
	08-01-13	86.4775
	09-01-13	86.5242
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	14-01-13	86.6844
	15-01-13	86.6853
	16-01-13	86.6989
	17-01-13	86.7042
	18-01-13	86.8653
	21-01-13	86.8531

22-01-13	86.9792
23-01-13	87.3794
24-01-13	87.4694
25-01-13	87.5206
28-01-13	87.5828
29-01-13	87.5906
30-01-13	87.5861
31-01-13	87.6111
01-02-13	87.5828
04-02-13	87.5669
05-02-13	87.5775
07-02-13	87.6133
06-02-13	87.6025
08-02-13	87.5539
11-02-13	87.5681
12-02-13	87.5756
13-02-13	87.4519
14-02-13	87.3428
15-02-13	87.4194
18-02-13	87.4108
19-02-13	87.6094
20-02-13	87.6336
21-02-13	87.5964
22-02-13	87.5419
25-02-13	87.4764
26-02-13	87.3194
27-02-13	87.2319
28-02-13	86.2361
01-03-13	86.1403
05-03-13	86.0375
06-03-13	86.1667
07-03-13	86.5833
08-03-13	86.1639
11-03-13	85.8236
12-03-13	85.5889
13-03-13	85.3222
14-03-13	85.34
15-03-13	85.6361
18-03-13	85.6014
19-03-13	85.8083
20-03-13	85.7139

	21-03-13	85.725
	22-03-13	85.7628
	25-03-13	85.8258
	26-03-13	85.8486
	27-03-13	85.8083
	28-03-13	85.6386
	02-04-13	84.9833
	03-04-13	84.9903
	04-04-13	84.8569
	05-04-13	84.8639
	08-04-13	84.7917
	10-04-13	84.6792
	12-04-13	84.1861
	11-04-13	84.3039
	15-04-13	83.9889
	16-04-13	83.8781
	17-04-13	83.8989
	18-04-13	83.7933
	19-04-13	83.82
	22-04-13	83.8831
	23-04-13	83.8836
	24-04-13	83.7833
	25-04-13	83.7681
	26-04-13	83.7944
	29-04-13	83.8131
	30-04-13	83.8208
	02-05-13	83.795
	03-05-13	83.7553
	06-05-13	83.7164
	07-05-13	83.8906
	08-05-13	83.8989
	09-05-13	83.7917
	10-05-13	83.725
	13-05-13	83.8609
	14-05-13	83.8361
	15-05-13	83.8069
	16-05-13	83.8242
	17-05-13	83.7972
	20-05-13	83.8375
	21-05-13	83.8508
	22-05-13	84.2597

23-05-13	84.4764
24-05-13	84.37
27-05-13	84.4261
28-05-13	84.9833
29-05-13	85.2861
30-05-13	84.9042
31-05-13	85.1236
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04-06-13	85.2208
05-06-13	85.0972
06-06-13	85.1806
07-06-13	84.95
10-06-13	84.8806
11-06-13	85.0528
12-06-13	85.0539
13-06-13	85.3531
14-06-13	85.3878
18-06-13	85.7103
17-06-13	85.6083
19-06-13	85.7236
20-06-13	85.6772
21-06-13	85.7375
24-06-13	85.8875
25-06-13	86.0603
26-06-13	86.025
27-06-13	86.0269
28-06-13	86.0075
01-07-13	85.8347
02-07-13	85.8561
03-07-13	85.9897
04-07-13	86.2
05-07-13	86.2583
08-07-13	86.6831
09-07-13	86.7969
10-07-13	86.8972
11-07-13	86.8556
12-07-13	87.1725
15-07-13	87.2364
16-07-13	86.9986
17-07-13	86.7875
18-07-13	86.8919

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	25-07-13	87.4056
	26-07-13	87.4028
	29-07-13	87.2361
	30-07-13	87.2333
	31-07-13	87.2797
	01-08-13	87.3978
	02-08-13	87.4075
	23-07-13	87.1697
	05-08-13	87.3731
	06-08-13	87.3844
	07-08-13	87.3983
	08-08-13	87.3908
	12-08-13	87.3858
	13-08-13	87.6083
	14-08-13	87.7042
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	19-08-13	87.4711
	20-08-13	87.5389
	21-08-13	87.4606
	22-08-13	87.4572
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	26-08-13	87.5611
	27-08-13	87.525
	28-08-13	87.4928
	29-08-13	87.5775
	30-08-13	87.5967
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	09-09-13	87.4028
	10-09-13	87.4792
	11-09-13	87.5158
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	13-09-13	87.5444
	16-09-13	87.5806

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23-09-13	87.4194
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25-09-13	87.4097
26-09-13	87.2292
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	03-12-13	86.7192
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	16-12-13	86.5542
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23-01-14	85.8181
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27-01-14	85.8125
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25-02-14	86.2458
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26-09-14	89.125
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Source: Central Bank of Kenya