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Impact of Exchange Rate Volatility on Inflation Rates in Kenya: GARCH Model Approach

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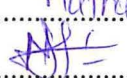
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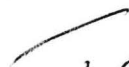
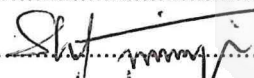
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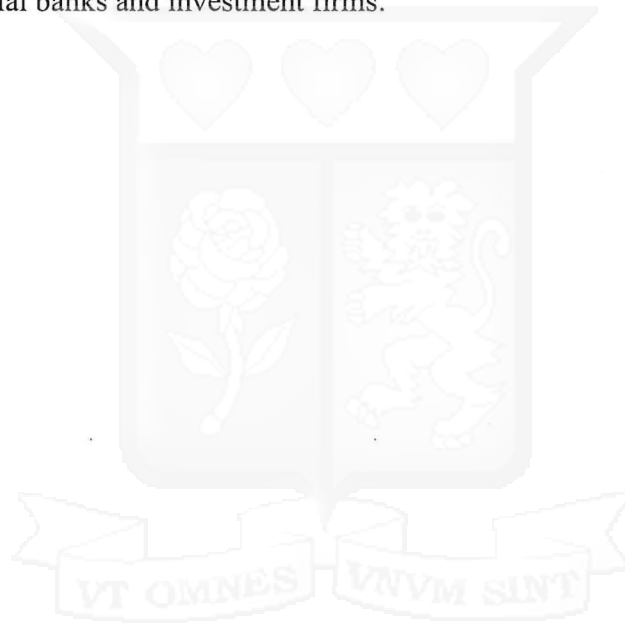
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ABSTRACT

The purpose of this research is to find out the effect of exchange rate volatility on inflation rates in Kenya. The methodology involves the use of generalized autoregressive conditional heteroskedastic (GARCH) approach in modeling exchange rate volatility in Kenya and finding the effect it has on the inflation rate. The research applies both asymmetric and symmetric models that capture most common stylized facts about exchange rate returns such as volatility clustering and leverage effect. The period of focus is between 2005 and 2015 and the empirical results show that there is volatility clustering and that exchange rates have an impact on inflation rates. The study is valuable to the central bank of Kenya, research institutes, commercial banks and investment firms.



CHAPTER ONE:

1. INTRODUCTION

1.1. Background of the study

In various developing countries, capital investment plays a critical role in ensuring that such economies are able to sustain themselves. The governments of such countries have devoted their resources by attracting foreign investments to ensure that there is economic growth and development, higher employment rates, sustainable inflation rates, stable interest rates and favorable GDP that will attract more investors (OECD, 2002).

Currency Rate Volatility

Ideally, an exchange rate¹ is a nation's currency in relation to another. Therefore, depending on the direction of the conversion, an exchange rate may be a multiplier or a ratio (divisor). The foreign exchange rates may be classified into three major categories²: pegged floating exchange rate, the floating exchange rate and the fixed exchange rate.

After the fall of the Bretton Woods system in 1971, the floating exchange rate system was adopted and it was dependent on the dynamics of demand and supply³. This therefore effectively raised the concern levels of governments, investors, analysts, bankers, shareholders and managers. These changes in the demand and supply are caused by various factors, majorly exogenous, lead to fluctuations in the currency rates (Grier & Mark, 2000).

Due to these fluctuations in demand and supply it gave the rise to fluctuating currency rates which in turn exposed most corporations to foreign exchange rate risk. The traditional types of exchange rate risks that firms are exposed to include: transaction, translation and economic risks (Micheal, 2006).

Volatility is the fluctuations in the prices of trade securities (currency rates in this case). It is used as a measure of risk (in terms of standard deviation or variance) and has various

¹ <http://www.investopedia.com/terms/e/exchangerate.asp>

² <https://www.boundless.com/economics/textbooks/boundless-economics-textbook/open-economy-macroeconomics-32/exchange-rates-130/exchange-rate-systems-518-12614/>

³ <https://www.imf.org/external/about/histend.htm>

applications risk management, asset pricing, option pricing, portfolio optimization⁴. These fluctuations also influence the economic decisions made. Volatility of exchange rates explains the level of uncertainty in the commodities and international assets.

Exchange rates are a real concern to various stakeholders such as: shareholders, managers, analysts and investors. Within the economy in general, exchange rates help in filling the gap present in terms of revenue generation, given that most developing countries usually have a deficit amount when the revenues are compared to the expenses incurred by such countries (Côté, 1994).

Inflation Rates

Inflation is the general increase in prices and fall in the purchasing power of money. It has various effects on the performance of an economy many of which are negative. This is why governments through their respective central banks try to minimize or prevent such effects of either inflation or deflation through various methods. Some of the methods used to control inflation include: inflation targeting, monetary targeting and exchange rate pegging (Mishkin, 1997)

There are various types of inflation within an economy and they include: demand-pull inflation, cost-push inflation, wage push inflation and imported inflation (Totonchi, 2011) (Parkin, 2011). In order for policies on inflation to be made, governments will tend to look at the determinants first before deciding on the strategies to use to counter the inflation levels. Different determinants lead to different types of effects, and some determinants of inflation include: monetary expansion driven mainly by expansionary fiscal policies (Moser, 1995) and foreign exchange movements.

Inflation requires consistent monitoring in order to contain it. Otherwise, it would lead to adverse effects within the economy. Inflation can be decomposed into two: the supply side inflation and the demand side inflation. In Kenya, inflation emanates from the supply side factors.

On the other hand some degree of inflation is important to the economy because through it, unemployment can be reduced. This simply means that firms survive on some degree of

⁴ <https://economictimes.indiatimes.com/definition/volatility>

inflation through price increase, which will enable them to pay employees and purchase more machinery to increase the level of output. Therefore, inflation too can be used to stimulate the economy. This is explained through the Phillip's curve (Phillips, 1958) (Parkin, 2011). However, care is taken to prevent stagflation⁵.

The inflation rates in Kenya have been on the rise and its effects can be largely felt because of the high prices and shortage of the basic goods. This can be explained by the political factors, this being a political year and also due to the imported inflation. The consumer price indices as provided by the KNBS⁶ (Kenya National Bureau of Statistics) show that the prices of commodities have been fluctuating and in this year alone, the trend in the inflation rates shows how inflation has been on the rise (Figure 1). The problem arises when the inflation rates go above and beyond the benchmark i.e. $5\% \pm 2$.

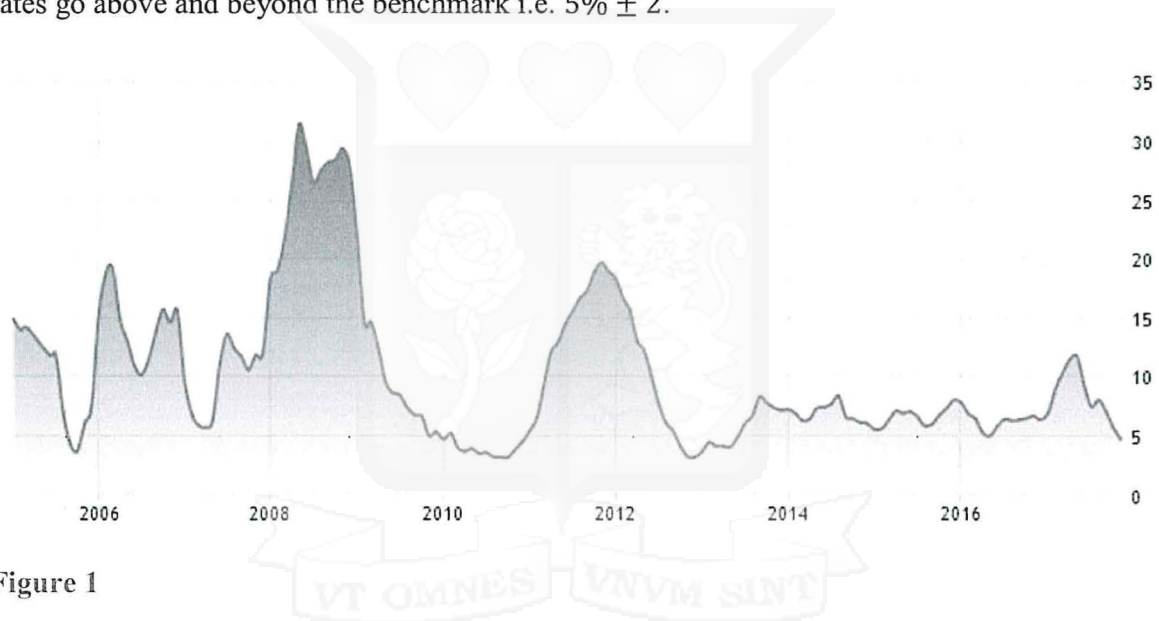


Figure 1

Foreign exchange rates are essential because of the potential influences on welfare, inflation, international trade and degree of external sector competitiveness (through foreign direct investments) of the economy and also its role in security valuation, investment analysis, profitability and risk management. According to (Engel, 2004) foreign exchange rates are not only expected to contribute to economic growth through foreign capital provision but also by bringing in additional domestic investment. This can be achieved by promoting linkages (both forward and backward) with the domestic economy (Al Samara, 2009) which implies

⁵ Stagflation is a type of inflation where there are high levels of inflation and rising unemployment at the same time.

<http://www.investopedia.com/ask/answers/111414/how-can-inflation-be-good-economy.asp>

⁶ <https://www.knbs.or.ke/consumer-price-indice/>

that a negative correlation exists between trade integration and exchange volatility movements (Hau, 2002).

Modern theories and applications in finance and economics have been concerned with the effects of changes in exchange rates on returns and cash flows of corporations (Bergen, 2010). After the events of the 'European Exchange Mechanism' crisis (1992), banks in 'Latin America' (1970s), The Asian crisis (late 1990s) and the global financial crisis (2008) (Claessens & M., 2013), most corporations throughout the world viewed exchange rates as significant risk factor, especially when it comes to industries that have been subject to a great deal of globalization. The fluctuations in the exchange rates have an impact on domestic and international corporations that is also known as the 'exposure' of the corporation to fluctuating foreign exchange rates. Such exposures to foreign exchange rate fluctuations usually manifest itself as an impact on: first, the value of fixed income securities and second, the real assets held by the corporations themselves (Bergen, 2010).

As the developing countries adjust their development strategies, it is important to consider how the economy will be affected if there would be any form of alteration in the exchange rates. The consideration should be placed on both: the real exchange rates and the nominal exchange rates (Stancik, 2007).

Kenya has been subject to drought and the evidence shows that 23 of the 47 counties have been subject to drought with three sub-counties (Turkana North, North Hor and Mandera) having GAM's (global malnutrition rates) being greater than 30% which is double the emergency threshold⁷. This therefore forces the government to seek other alternatives that would help in managing the drought crisis. The other alternative of getting food to the country is importation from other countries. Some of the countries that Kenya has imported from are: Mexico and Brazil.

The main risk involved with importation of products is the issue of imported inflation because importation is done in terms of another currency. Seeing how volatile the exchange rates have been in the past (Figure 2), it clearly shows that Kenya is subject to imported inflation.

⁷ <http://reliefweb.int/disaster/dr-2014-000131-ken>

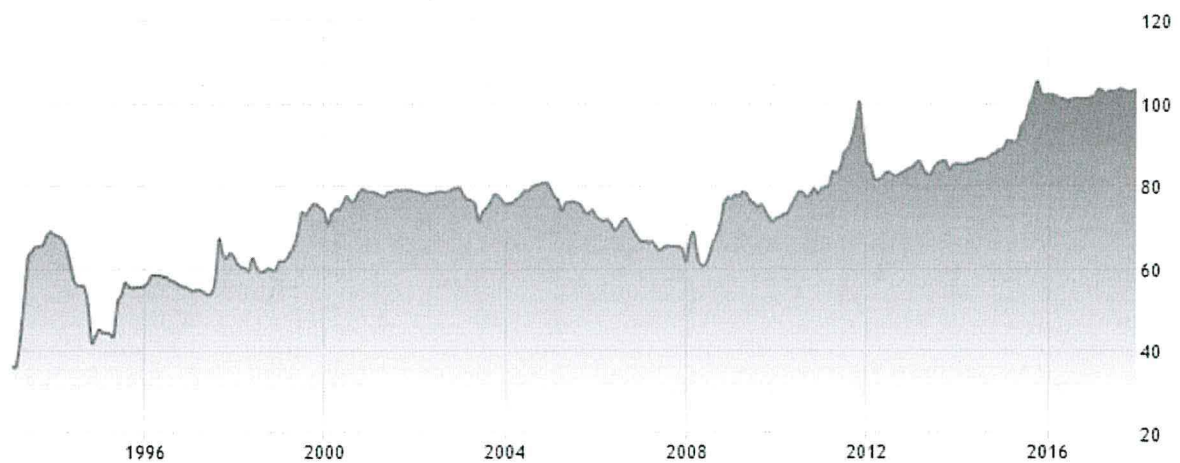


Figure 2

How the exchange rate movement affects inflation.

Exchange rate movements can influence domestic prices via their effect on aggregate supply and demand. On the supply side, exchange rates could affect prices paid by the domestic buyers of imported goods directly. In an open small economy (an international price taker), when the currency depreciates it will result in higher import prices and vice versa. Exchange rate fluctuations could have an indirect supply effect on domestic prices. This type of inflation is known as imported inflation⁸.

The potentially higher cost of imported inputs associated with an exchange rate depreciation increases marginal cost and leads to higher prices of domestically produced goods (Mishkin, 2008). Further import-competing firms might increase prices in response to an increase in foreign competitor price in order to improve profit margins. The extent of such price adjustment depends on a variety of factors such as market structure, nature of government exchange rate policy, or product substitutability. Exchange rate variations can also affect aggregate demand.

To a certain extent, exchange rate depreciations (appreciations) increase (decrease) foreign demand for domestic goods and services, causing increase (decrease) in net exports and hence aggregate demand (Obstfeld & Rogoff, 1995). This may increase real output.

⁸This is the inflation due to an increase in the price of imports.
www.investorwords.com/15442/imported_inflation.html

Furthermore, the expansion in domestic demand and gross national product may bid up input prices and accelerate wage demands by workers seeking higher wages to maintain real wages. The nominal wage rise may result in further price increases.

1.2 Problem statement

Some of the few issues facing policy makers are: the price stability (due to inflation rates) and economic growth (due to investments made in the country). These issues are brought about by the degree of uncertainty in the continuously fluctuating exchange rates (Mulwa, 2013). These fluctuations affect various factors that ensure the survival of a country; however, the main focus will be on inflation rates.

Studies that have been carried out on the impact of exchange rate volatility on various macroeconomic variables and the emphasis on the GARCH and EGARCH models are limited. (Maana, Mwita, & Otieno, 2010) modeled the GARCH process on the exchange rates in Kenya and applied a quasi-maximum likelihood estimation method but the focus wasn't placed on the impact that the volatility had on inflation rates in Kenya.

(Suliman Abdalla, 2012) focused on the volatility clustering in the Arab countries. The focus was on the countries that interact with the Arab countries in terms of oil trade.

(Nortey, Ngoh, Kwabena, & Ofori-Boateng, 2015) examined the exchange rate volatilities and the relationship it has with the inflation rates in Ghana. Most studies have focused on developed countries and the few that have been specified to Kenya use the ordinary least squares regression and the results are summarized using ANOVA (Mulwa, 2013).

Research in this area can be tailored to study data of foreign exchange depending on the timeline specified by the researcher. In this paper, data will be focused between 2005 and 2015.

The reasons stated above therefore form the basis of this study, which is to answer the question: what impact does the exchange rate volatility have on inflation rates in Kenya?

1.3 Research objectives

The main objective of this study is to investigate impact of exchange rate volatility on the inflation rates in Kenya.

The study shall investigate the volatility characteristics of exchange rates in Kenya using the GARCH models

1.4 Importance of the research

This research is expected to be of value to the following groups:

a) The Central bank

The findings of this study are expected to be of great help to Central Bank of Kenya for the purpose of policy making when it comes to dealing with fluctuations in exchange rates. The Central bank plays a crucial role in terms of money supply (monetary policy), managing inflations through active duties such as managing interest rates and foreign exchange rates.

b) Commercial Banks and Investment Firms

The research will give the commercial banks and investment firms a clear picture of how inflation is affected by the fluctuations in exchange rates, therefore enabling them to make more informed decisions when it comes to FOREX (foreign exchange) trade.

c) Research Institutes

This research will be an addition to the vast pool of knowledge in the area of foreign exchange and its dynamics. It might serve as an area of interest that researchers and scholars may want to look into and expound on the area.

CHAPTER TWO

2. Literature Review

Introduction

This chapter reviews the relevant theories and literature on the basis of the empirical data⁹ analysis. The section presents review of related literature in line with the objectives as stipulated in the first chapter.

2.1 Theoretical review

When it comes down to explaining the link between exchange rates and inflation rates, it is important to consider theories of inflation. In this context, two schools of thought are looked into: the monetarists approach and the structuralists' approach. The monetarists associate inflation with monetary causes and they employ monetary measures to control it (Nitisha, 2016). The structuralists on the other hand believe that inflation is caused by lack of balance within the economy and they employ monetary and fiscal measures in trying to curb the inflation rates.

Theories on the determinants of inflation rates are pegged to the factors that push the market prices. These factors include:

- i. Excess demand of goods and services that is met with low supply (also known as demand-pull inflation).
- ii. Increase in the cost of production of goods and services (also known as cost push inflation).
- iii. Structural theories.

2.1.1. Structural Inflation

According to structural theory of inflation, market power is one of the factors that cause inflation, but it is not the only factor (Ackley, 1978). It is related to the effect of structural factors on inflation. Structural analysis attempts to recognize how economic phenomena and

⁹ <http://www.economicdiscussion.net/inflation/top-3-theories-of-inflation-with-diagram/4071>

finding the root of the permanent destruction of inflation that evaluates lawful relationship between the phenomena. Inflation cannot occur alone by demand and cost factors, but it is the cumulative effect of demand-pull and cost-push activities (Totonchi, 2011).

2.1.2. Demand-pull inflation

The theory was developed by John Maynard Keynes (1883-1946) and it stipulates that an increase in aggregate demand is a source of demand-pull inflation. The aggregate demand comprises consumption, investment and government expenditure (Totonchi, 2011).

When the value of aggregate demand exceeds the value of aggregate supply at full employment level, the inflationary gap arises and the larger the gap between aggregate demand and aggregate supply, the more rapid is the inflation. Further, in full employment condition, the economy reaches to its maximum production capacity. At this point, the supply of goods and services cannot be increased anymore while the demand of products and services increases rapidly. Due to this imbalance between demand and supply, inflation takes place in the economy.

Keynesian followers do not deny this fact that even before reaching full employment production factors and various appearing constraint can cause increase in public price. This inflation constraint that appears quickly during prosperity is originally resulting from non-proportioned section, branches and or various economic resources that are accounted from natural properties of discipline based on market. Therefore, in one period of prosperity it is completely natural.

According to Keynes, policy that causes decrease in each component of total demand is effective in reduction of pressure demand and inflation. One of the reductions in government expenditure is tax increase and to control volume of money alone or together, can be effective in reducing effective demand and inflation control (Keynes, 1936).

2.1.3. Cost push inflation

Cost-push inflation is caused by wage increases enforced by unions and the employer's motivation to increase profits. Many economic theorists claimed it to be the principle cause of inflation within an economy (between 1950's and 1970's).

The root cause of cost-push inflation is that the wages increase at a rate that is higher than the labor productivity. Since the labor unions advocate for proper pay from employers, the cost of production goes up because the employers have to cover the extra cost they incur per production due to the increase in labor.

Other than unions, cost-push may be driven by other factors such as: increase in the prices of raw materials, profit-push inflation and price-push. Higher wages increase the purchasing power, in spite of higher prices. This is known as the wage-price spiral theory (Kandil, 2003). If the prices continue to increase, then the unions will continue demanding more wages so that the employees can be indemnified. In this way, the wage-cost spiral countries, thereby, leading to cost-push or wage-push inflation.

Another way of looking at cost push inflation is by looking at the cost of production incurred by firms operating in a foreign country. If the cost of production is high, it will be reflected in the prices and therefore as we import products from foreign countries, we become subject to imported inflation.

(Totonchi, 2011) argues that cost-push inflation may be further aggravated by upward adjustment of wages to compensate for rise in cost of living but (Thomas, 1987) goes on to add that the policy makers are not obligated to increase the money stock in order to curb unemployment (to full unemployment) and that the more they tend towards price-stabilization, the more they tend to digress from it. This therefore simply means that there's no linkage between cost-push and money stock, which essentially the cost-push fallacy (Thomas, 1987).

2.1.4. The Monetary Approach to Balance-of-Payments

This theory states that the exchange rate of the currency of a country depends upon the demand and supply of foreign exchange. If the demand for foreign exchange is greater than its supply, then the price of foreign currency will appreciate in value. (Mussa, 1976) argues that both the balance of payments and the exchange rates are essentially monetary phenomena. The proximate determinants of exchange rates and balances of payments are the

demands for and the supplies of various national monies. (Kanamori & Zhao, 2006) explains that there are two sides when looking at foreign exchange, the demand and supply sides, which are characterized by the debit and credit sides respectively. Each of the side involves import and export of goods and services (respectively). Depending on the direction of the equilibrium shift in the exchange rates, the balance of payments may either be adverse or favorable.

If the exchange rates fall below the equilibrium, it leads to the balance of payments being adverse. The exports therefore increase hence eliminating the adverse balance of payments. The inverse is also true that, if the exchange rates are above the equilibrium (appreciated) then the balance of payments become favorable, therefore for the balance of payments to return back to equilibrium, then the imports need to increase.

2.1.5. Inflation Determinants

Inflation as a field of study has a considerable amount of research done on it. Most of the work done on it is aimed at finding out what really determines inflation. One aspect of the relationship between exchange rate volatility and trade (international or domestic) that needs to be mentioned is the role of “retrospective costs”.¹⁰

For any kind of trade, whether local or international, manufactured products need some form of product differentiation for it to survive in the market. Product differentiation is an unavoidable cost and therefore makes it retrospective in nature.

Based on the logic behind business management, firms usually have an expectation of recouping the retrospective costs once they are incurred, therefore, they tend to adopt a complacent approach in dealing with the short-run effects of the exchange rates given the dynamics involved. This therefore, makes firms stay in the export market as long as they can recover their variable costs. This is a phenomenon known as the sunk cost fallacy and it was explained by (Tversky & Kahneman, 1986). The main reason why individuals fall prey to this phenomenon is because of loss aversion¹¹.

¹⁰ Retrospective costs are simply the costs that have already been incurred and cannot be recovered.

<http://www.investopedia.com/terms/s/retrospectivecost.asp>

Retrospective costs are also known as sunk costs

¹¹ People tend to have a strong urge of avoiding losses rather than acquiring gains

Since firms are likely to be subject to the sunk cost fallacy, their cost of production is likely to go up because firms will be willing to stay in a given position in an investment because of the ex ante estimates of the returns they are likely to gain from it despite the costs involved (Mishkin, Exchange Rate Pass-Through and Monetary Policy, 2008).

2.2 Empirical Review

(Mulwa, 2013) found out that there was a relationship between inflation and exchange rates in Kenya and the emphasis in the methodology section of the study was placed on the simple regression without modeling the volatility clustering that is involved with exchange rate volatility.

(Maana, Mwita, & Otieno, 2010) came up with the intuition behind modeling the GARCH processes and considered a quasi-maximum likelihood estimation procedure in estimating the parameters before fitting the GARCH model. The period of the study was between 1992 and 2006 in Kenya. The research concluded that volatility clustering was present but the focus of the study wasn't placed on explaining the kind of relationship that exchange rate volatility had on inflation rates.

According to (Goyal, 2012) research, propagation mechanisms that allow relative prices to affect aggregate prices include governance failures, the effect of food prices on wages, exchange rates on costs and the response to cost shocks in firm price-setting.

An econometric model was created by (Chhibber, Cottani, Firuzabadi, & Walton, 1989) and the study covered Zimbabwe. In the study, they showed that nominal monetary growth, foreign prices, exchange and interest rates, unit labor costs and real income are the determinants of inflation in Zimbabwe.

The study done by (Tegene, 1989) indicated a unit-directional causality from monetary growth to inflation. The test adopted was the Granger and Pierce causality test in order to establish the role of domestic money supply on inflation in the six African countries studied. (Agénor & Montiel, 1996) showed that exchange rate depreciation only have a short-run impact on inflation in small, open developing countries. They also showed that high inflation rates are present when large unsustainable amounts of deficits are financed through money creation.

(Catão & Marco, 2003) pointed out that the relationship between fiscal deficit and inflation is only strong in high inflation countries but find no obvious relationship between fiscal deficit and inflation in low inflation countries.

2.3 Summary of the literature review

This study has shown that even if firms don't engage in international trade, they are still subject to risks caused by fluctuations in the exchange rates. From the theories of inflation, the factors that cultivate inflation include: wage increases by trade unions, profit motives of firms that gain market power, increase in the prices of raw materials imported from abroad through currency depreciation and price increase in the world commodity market and the presence of external shocks such as a dramatic change in oil prices, crop failure and war. However, the theories did not address cross-border convergence of prices, monetary policy rule, shilling trade against foreign currency and level of aggregation of trade out-flows and in-flows.

Some of the studies conducted in Kenya had not placed much emphasis on modeling the GARCH processes. (Mulwa, 2013) used a simple regression and used the analysis of variance to explain the relationship between inflation and exchange rate volatility. (Maana, Mwita, & Otieno, 2010) concentrated on the GARCH model alone and found out that there was volatility clustering.

Based on the facts of the studies carried out in this area, there is a notable research gap that the leverage effects of the exchange rate volatility were not considered and that the methodology used in modeling the GARCH process in Kenya was a quasi-maximum likelihood estimation was used. This study therefore serves as a springboard for future researchers to investigate and widen their scope on the effect of exchange rates on the inflation rates.

CHAPTER THREE

3. METHODOLOGY

Introduction

This section discusses the competing GARCH models used to investigate volatility characteristics. In presenting these models, there are two distinct specifications, the first for the conditional mean and the other for the conditional variance. The models are estimated using maximum likelihood method under the assumption of Gaussian normal error distribution. *The log likelihood function is maximized using Marquardt numerical iterative algorithm to search for optimal parameters.*

There are certain aspects that are looked into in carrying out the research. They include: the volatility as a measure of risk, test for heteroskedasticity and the volatility model.

3.1. Research Design

The research design is aimed at highlighting how and where the data that the researcher is using can be obtained from. It also describes how the researcher is going to conduct the study i.e. the models. The research is quantitative in nature and therefore advantageous to conduct this study over other forms because it involves secondary sources which can easily be obtained from various sources.

3.2. Sources of Data

The data on currencies is secondary and it was obtained from the central bank of Kenya's website and the data on inflation rates is obtained from the KNBS (Kenya National Bureau of Statistics)

3.3.The Model

3.3.1. Volatility description and measurement

The risk of an asset return is at times explained by the volatility of the asset return. Statistically, it's represented by the standard deviation.

$$\sigma_{\bar{x}} = \frac{1}{T-1} \sqrt{\sum_{i=1}^T (r_t - \mu)^2}$$

Where, r_t is the return on day t and μ is the average return over the T-day period. Risk is associated with undesirable outcome, whereas volatility as a measure strictly for uncertainty could be due to a positive outcome (Poon, 2005). *This paper uses the variance as a measured of volatility.*

3.3.2. Test for heteroskedasticity

Heteroskedasticity occurs when the variance of the error terms differ across observations. It is one of the issues that need to be looked into before implementing any type of GARCH model. The residuals of the return series of the exchange rates are examined for heteroskedasticity.

There are various methods that one may use to test for this heteroscedasticity but the Lagrange Multiplier (LM) test proposed by (Engle, 1982) is applied.

In summary, the test procedure is performed by first obtaining the residuals e_t from the ordinary least squares regression of the conditional mean equation which might be an autoregressive (AR) process, moving average (MA) process or a combination of AR and MA processes; i.e. (ARMA) process.

For example, in ARMA (1,1) process the conditional mean equation will be:

$$r_t = \phi_1 r_{t-1} + \varepsilon_t + \theta_1 \varepsilon_{t-1}$$

After obtaining the residuals e_t , the next step is to regress the squared residuals on a constant q lags as in the following equation:

$$e_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 e_{t-2}^2 + \dots + \alpha_q e_{t-q}^2 + v_t$$

The null hypothesis that there is no ARCH effect up to order q can be formulated as:

$$H_0: \alpha_0 = \alpha_1 = \alpha_2 \dots \alpha_q = 0$$

Against the alternative: $H_1: \alpha_i > 0$ for at least one $i = 1, 2, \dots, q$

The test statistic for the joint significance of the q-lagged squared residuals is the number of observations times the R-squared (TR^2) from the regression. TR^2 is evaluated against $\chi^2(q)$ distribution. This is an asymptotically locally most powerful test (Rachev, Mittnik, Fabozzi, Focardi, & Jašić, 2007).

In this paper, an autoregressive moving average ARMA (1,1) model for the conditional mean in the returns series is employed as an initial regression, then, test the null hypothesis that there are no ARCH effects in the residual series.

3.3.3. Volatility Model

The Generalized Autoregressive Conditional Heteroskedastic (GARCH) Model

The GARCH model is used in this paper to investigate the volatility clustering and persistence. The model has three parameters that allows for an infinite number of squared errors to influence the current conditional variance (volatility). The conditional variance determined through GARCH model is a weighted average of past squared residuals. However, the weights decline gradually but they never reach zero. In essence, the GARCH model allows the conditional variance to be dependent upon previous own lags. The general framework of this model, GARCH (p, q), is expressed by allowing the current conditional variance to depend on the first p past conditional variances as well as the q past squared innovations. That is,

$$\sigma_t^2 = \omega + \sum_{j=1}^q (\alpha_j + \varepsilon_{t-j}^2) + \sum_{i=1}^p (\beta_i + \sigma_{t-i}^2)$$

Where, p is the number of lagged σ^2 terms and q is the number of lagged ε^2 terms.

The specification in this paper will be the *GARCH(1,1)* where:

$$\text{Mean} = r_t + \mu + \varepsilon_t$$

$$\text{Variance equation } \sigma^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

where $\omega > 0$ and $\alpha_1 \geq 0$ and $\beta_1 \geq 0$, and

$r_t =$ return of asset at time t .

$\mu =$ average returns.

$\varepsilon_t =$ residual returns, defined as: $\varepsilon_t = \sigma_t z_t$

Where z_t is standardized residual returns (i.e. identically independent random variables with a mean of zero and a variance of 1), and conditional variance σ^2 is conditional variance.

The constraints $\alpha_1 \geq 0$ and $\beta_1 \geq 0$ are needed to ensure σ_t^2 is the one – period ahead of forecast variance based on past information, it's called conditional variance. The conditional variance equation specified as a function of three terms: (i) A constant term: ω ; (ii) News about volatility from the previous period, measured as the lag of the squared residuals from the mean equation: ε_{t-1}^2 (the ARCH term); and (iii) Last period forecast variance: σ_{t-1}^2 (the GARCH term).

The conditional variance equation models the time varying nature of volatility of the residuals generated from the mean equation. In a financial context, the specification is interpreted as: where an agent or trader predicts this period's variance by forming a weighted average of a long term average (the constant), the forecast variance from last period (the GARCH term), and information about volatility observed in the previous period (the ARCH term). If the asset return was unexpectedly and significantly large in either the upward or the downward direction, then the trader will increase the estimate of the variance for the next period.

I. The Exponential GARCH (EGARCH) Model

Even if the GARCH models successfully capture the thick tail returns, and the volatility clustering, they aren't the best models to use if one wishes to capture the leverage effect. This is because the conditional variance is a function only of the magnitudes of the past values and not their sign.

In financial time-series, volatility behaves differently depending on if a positive or negative shock occurs. This asymmetric relationship is known as the leverage effect and it describes how a negative shock causes volatility to rise more than if a positive shock with the same magnitude had occurred.

To capture this asymmetry, different models have been developed and the one used in this research study is the EGARCH model. This model captures asymmetric responses of the time-varying variance to shocks and, at the same time, ensures that the variance is always positive. The model was developed by (Nelson, 1991). In the general form, the conditional variance is written as:

$$\ln(\sigma^2) = \omega + \sum_{j=1}^p \beta_j \ln(\sigma_{t-j}^2) + \sum_{i=1}^q \alpha_i \left\{ \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right| - \sqrt{\frac{2}{\pi}} \right\} - \gamma_i \frac{\varepsilon_{t-i}}{\sigma_{t-i}}$$

The EGARCH model is asymmetric because the level $\frac{|\varepsilon_{t-1}|}{\sigma_{t-1}}$ is included with coefficient γ_i .

Since this coefficient is negative, positive returns shocks generate less volatility than negative return shocks assuming other factors remains unchanged.

In financial markets and macroeconomic analysis, a negative shock usually implies bad news, leading to a more uncertain future. It means that any investor would require a higher expected return to compensate for bearing increased risk in their investment (Wang, 2003).

In order to capture asymmetric responses of the time-varying variance to shocks, the paper employs EGARCH(1,1) model, which has the following specification:

Mean equation $r_t = \mu + \varepsilon_t$

Variance equation $\ln(\sigma^2) = \omega + \beta_1 \ln(\sigma_{t-1}^2) + \alpha_1 \left\{ \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - \sqrt{\frac{2}{\pi}} \right\} - \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}}$

3.3.4. The Analytical Model

The regression model is as follows

$$Y = \alpha + \beta_i X_i + e_i$$

Where:

$Y = \text{Inflation}$

$\alpha = \text{Constant}$

$\beta_i = \text{Exchange rate}$

$e_i = \text{Error term}$

To test for significance of the model, the method to be used will be a one-way ANOVA with repeated measures because the data will be related, not independent groups, and it is an extension of the dependent t-test.



CHAPTER FOUR:

4. Data Analysis

Introduction

This chapter discusses the findings upon analyzing the data on the exchange rates and the inflation rates. The software used was Eviews.

4.1. Descriptive statistics of the exchange rates

The data was for the period 2005 - 2015 and it had a few gaps but this was taken care of by interpolating for the missing values using the cubic spline method of interpolation.

The summary statistics give a general overview of the data and a picture of whether the data may be normally distributed. According to the Jarque Bera test carried out on the data, the probability is lower than 0.05, therefore nullifying the null hypothesis that the data is normally distributed. Only two currencies have a negative skew: the Australian dollar and the Tanzanian shilling. The Australian dollar had the biggest deviation compared to the other currencies even though most of the imports and exports in Kenya are denominated in US dollars.

According to the graphs (Table 2 and 3), the mean on every currency is not at zero and therefore it influences the model by providing for a constant term for the equation. Table 1 highlights the descriptive statistics of the different data sets.

4.2. Testing for stationarity

Before testing for the ARCH effects, it is inherent to find out whether the series is stationary. The augmented-dickey fuller test was used to find out whether the series is stationary. The graphs of the currencies show that the data has an intercept and has a trend line. Its mean doesn't oscillate around zero therefore in performing the ADF test, the criteria chosen was the constant term and a trend-line.

At level, the different currencies are not stationary because, even though the p-values suggest that the coefficients are significant, the absolute value of the t-statistic is less than the 1%, 2% and 10% confidence intervals. However upon differencing, the coefficients are significant (as seen on table 1) according to the t-statistic and the p-values therefore rejecting the null hypothesis that there are unit roots.

4.3. The Langrage Multiplier

It is important to test for the ARCH effects within the model before estimating for the GARCH model. It is the first step to fitting the GARCH model and the proposed test for the ARCH effects is the langrage multiplier as proposed by (Engle 1982). The test requires that an ordinary least square regression is carried out to obtain the residuals. The squared residuals are then regressed against a constant.

Upon performing the test, the p-values of the coefficients were less than 0.05 therefore the null hypothesis, which means that there are ARCH effects and therefore the GARCH model can be estimated and fitted.

4.4. The GARCH Model

Table 4 shows the results of the variance equation: ω is the constant, α is the ARCH term and β is the GARCH term. The type of distribution was the t-distribution because initially, the J-B test had shown that the data isn't normally distributed and therefore it wouldn't have been prudent to use the gauss-markov assumption in estimating the GARCH(1,1).

The statistical significance of α proves that there is volatility clustering across the different currencies. The significance of both α and β prove that the information about the volatility of the previous period affects/has an impact on the current volatility.

The 10 currencies had α and β summed up together to find out the persistence coefficient. The DIRHAM, TSH and the UG had a persistence coefficient that was greater than one which implies that they were explosive. In summary, the analysis shows that the shocks on the volatility will remain persistent since the GARCH model is associated with heteroskedastic variance.

The ARCH-LM test after the GARCH model estimation did not show any ARCH effects which therefore means that the model was specified correctly.

4.5. The EGARCH (1, 1) Model

As part of the stylized facts, exchange rates are subject to leverage effects. This means that a period of high or low movement in prices is negatively correlated with volatility.

Table 5 shows the coefficients of the EGARCH (1, 1) terms of the equation. They are significant and the ARCH -LM test shows that there are no ARCH effects left after the model has been fitted. This means that the model was well fitted.

4.6. The Analytical Model

The regression model: $Y = \alpha + \beta_i + \varepsilon_i$ is meant to show the relationship between inflation rates and exchange rate volatility. The X_i term acts as a representative of the different exchange rates used during the research, which are ten in number.

The regression model shows that a relationship exists between the two variables because the p-values are significant because they are below the threshold 0.05. The volatility of the exchange rates as modeled by the GARCH model shows that there is volatility clustering which explains the relationship between the two variables.

Dependent Variable: INFLATION_MONTH_ON_MONTH				
Method: Least Squares				
Date: 11/24/17 Time: 16:08				
Sample: 1 2748				
Included observations: 2748				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	34.09660	2.069329	16.47713	0.0000
AUST	0.067926	0.008603	7.895434	0.0000
CAN_\$	-0.196149	0.023119	-8.484143	0.0000
DIRHAM	-4.981845	5.147764	-0.967769	0.3332
IND_RUPEE	-2.801748	0.752053	-3.725466	0.0002
EURO	0.152013	0.016374	9.283983	0.0000
POUND	-0.101404	0.010382	-9.767689	0.0000
RAND	-0.104714	0.032565	-3.215555	0.0013
TSH	-0.495470	0.109298	-4.533189	0.0000
UG	-0.853797	0.090428	-9.441782	0.0000
USD	1.604147	1.400984	1.145014	0.2523
R-squared	0.244221	Mean dependent var	8.542231	
Adjusted R-squared	0.241460	S.D. dependent var	4.898276	
S.E. of regression	4.266114	Akaike info criterion	5.743279	
Sum squared resid	49812.66	Schwarz criterion	5.766970	
Log likelihood	-7880.265	Hannan-Quinn criter.	5.751839	
F-statistic	88.44310	Durbin-Watson stat	0.017156	
Prob(F-statistic)	0.000000			

Figure 3

The analysis of variance methodology concludes that the independent variables explain about 24% of the variability of the data. The result remains almost the same if the squared residual is adjusted.

CHAPTER FIVE:

Conclusions and Recommendations

5.1. Conclusion

The study investigates the impact of exchange rate volatility on inflation rates for the period 2005-2015. The GARCH (1, 1) model shows that there is volatility clustering and therefore prompting the investigation on the impact of exchange rate volatility on inflation. The EGARCH (1, 1) shows the leverage effects of exchange rate volatility as a stylized fact therefore proving that indeed exchange rates experience an upward movement if there is a positive increment and a downward movement if there is a decline. The results show that there is a relationship between inflation and exchange rates though it's not big impact.

The small impact may be because exchange rates have a bigger impact on the balance of trade than on inflation rates.

5.2. Recommendations

Conclusively, the results of the study exhibit that there is a relationship between exchange rates and inflation rates. This relationship may benefit the central bank of Kenya to align the monetary policy with the fiscal policy. Research institutes may expound further on the area especially in defining the parameters that are used in fitting the GARCH model. There are other forms of the GARCH model that haven't been expounded on in this paper that could be looked into as a way of extending the research.

List of Tables

Table 1 - Descriptive Statistics

	AUSTRALIAN_\$_INT	CAN_\$	DIRHAM	EURO	IND_RUPEE	POUND	RAND	TSH	UG	USD
Mean	68.83653819	73.98970913	21.96629429	105.8560987	1.618487518	134.7946792	9.868295378	18.06816645	27.65028049	80.67881918
Median	71.11925	75.5549	21.9251	106.709	1.5963	134.8535	9.7652	18.4278	27.7	80.5297
Maximum	106.061	103.148	28.9261	144.597	2.1531	165.318	137.609	23.7181	35.7713	106.2455
Minimum	8.841	58.7594	16.7476	84.9071	1.2855	108.518	6.4778	13.219	22.0224	61.5106
Std. Dev.	18.00884317	9.913861493	2.609978217	11.00594047	0.141340472	10.37894185	2.8946045	1.513768224	2.820137253	9.587342646
Skewness	-1.171635108	0.218380748	0.33491173	0.274070475	0.880962128	0.281737683	31.32828316	-0.29922833	0.337435126	0.334403743
Kurtosis	5.566789028	1.997834576	2.792544864	2.856805491	4.217018093	3.022004636	1381.396532	3.774213116	2.717968041	2.792865428
Jarque-Bera	1383.082279	136.8385082	56.29977622	36.75028285	525.040909	36.40970533	217996875.8	109.6401988	6.13E+01	56.12883709
Probability	0	0	5.95E-13	1.05E-08	0	1.24E-08	0	0	5.00E-14	6.48E-13
Sum	189162.8069	203323.7207	6.04E+04	290892.5591	4447.6037	370415.7784	27118.0757	49651.3214	75982.9708	221705.3951
Sum Sq. Dev.	890902.734	269987.9327	1.87E+04	332746.1032	54.87717324	295913.5263	23016.38562	6294.734663	21847.36932	252496.3809
Observations	2748	2748	2748	2748	2748	2748	2748	2748	2748	2748
ADF	-53.01953986	-56.2654801	-41.2346634	-39.7663639	-39.4742931	-57.2772218	-22.3923147	-28.6600897	-33.9302163	-40.9530801

Table 2 - Combined Graphs

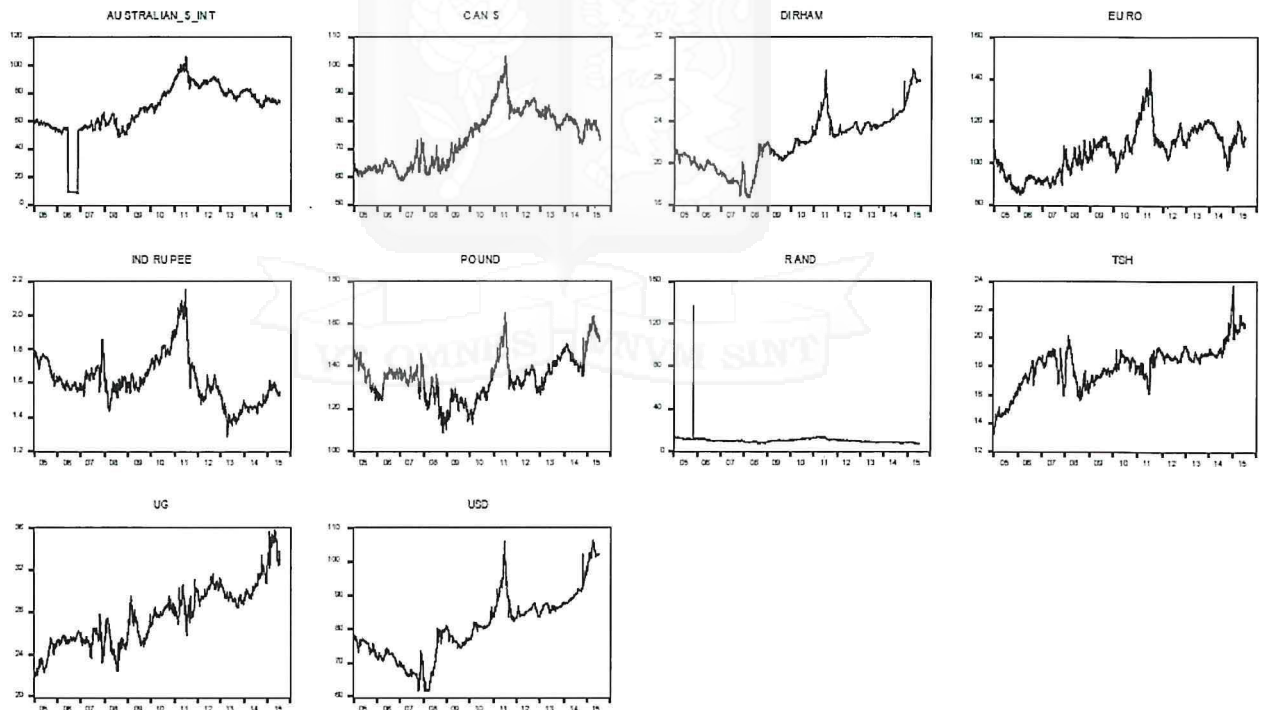


Table 3 - Volatility clustering

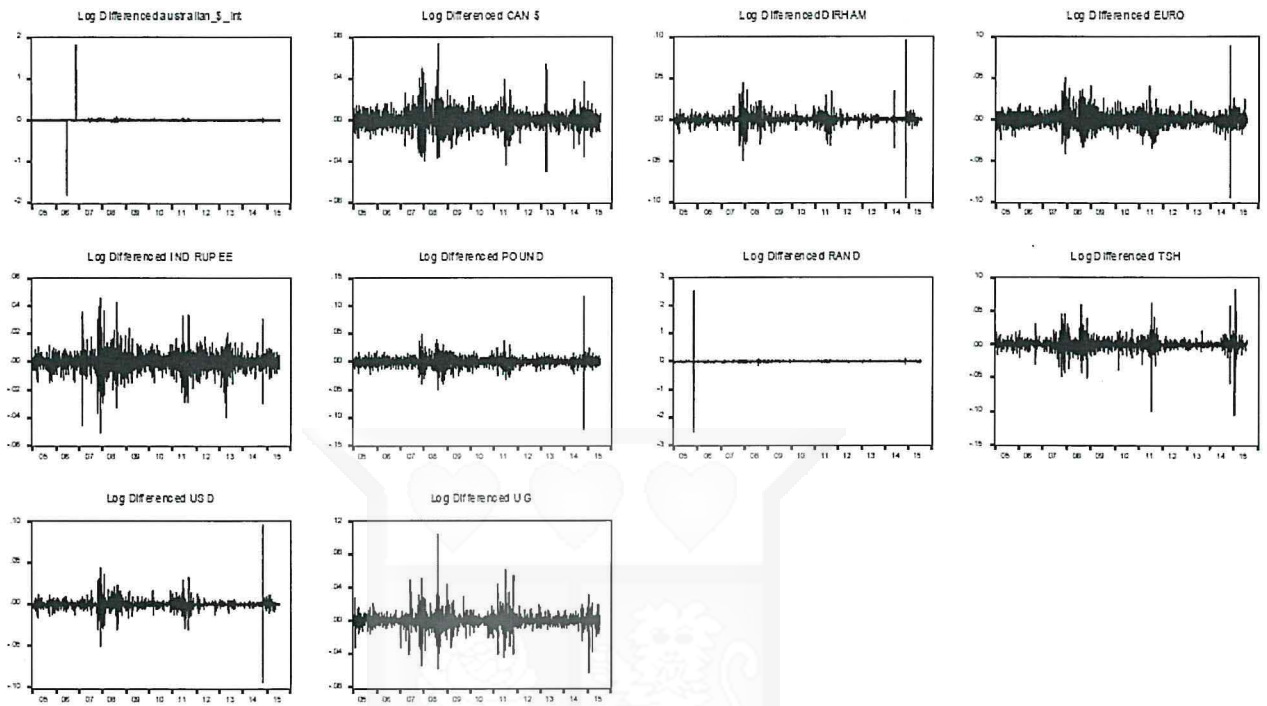


Table 4 – GARCH Model

Currency	ω	α	β	$\alpha+\beta$	Log likelihood	ARCH LM TEST	
						F- statistic	prob
Australian_\$	0.001448990706	-0.000799632249	0.458167075103	4.573674428536780E-01	5637.32009277	0.00099368836	0.9748548837543
CAN_\$	0.000000780585	0.073653695006	0.914127155976	9.877808509823450E-01	9954.64713631	1.66522181767	0.0056206191713
DIRHAM	0.000000592788	0.950484971996	0.677385879921	1.627870851917250E+00	12217.60891496	0.00026400000	0.9870000000000
EURO	0.000000250186	0.055042395733	0.942220592211	9.972629879440660E-01	-6893.94566887	1.41152357643	0.0743352403156
IND_RUPEE	0.000000662930	0.114721163472	0.876793793641	9.915149571127030E-01	10496.95650570	16.43168000000	0.0000518377209
POUND	0.000000631231	0.074288699335	0.915019421734	9.893081210686730E-01	10000.67926540	4.07049424891	0.0437356791131
RAND	0.000028563913	0.264197845384	0.535139299158	7.993371445413720E-01	8696.34477385	0.00023580679	0.9877492812550
TSH	0.000001474660	0.373923177613	0.727134374719	1.101057552331870E+00	10630.13645847	1.06379203432	0.3024427977177
UG	0.000002106462	0.226229295828	0.805057715738	1.031287011566040E+00	10440.96140522	0.45981528755	0.4977674867503
USD	0.000000481997	0.810770488699	0.689437728519	1.500208217218090E+00	12247.05769690	0.00002130445	0.9963175736645

Table 5

	Currency	Australian_\$	CAN_\$	DIRHAM	EURO	IND_RUPEE	POUND	RAND	TSH	UG	USD
	ω	-7.530864734	-0.226969755	-0.812114795	-0.159017055	-0.376289562	-0.200324336	-1.221567798	-0.788790193	-0.513177878	-0.790453463
	α	0.231450518	0.144947753	0.671187068	0.117972238	0.226220069	0.132595382	0.323268755	0.484058265	0.29020659	0.65582496
	β	-0.231521327	0.022359093	0.001223233	-0.035577688	-0.007858855	-0.00667819	-0.042169219	-0.050443189	0.006370683	0.007631848
	γ	0.127917413	0.987918912	0.955947608	0.993062027	0.979630969	0.990030869	0.892427417	0.952961595	0.966497535	0.958661586
	Log likelihood	9193.395018	9963.938851	12237.34622	9862.514019	10499.35142	10010.98376	8733.553277	10636.91122	10454.34245	12264.9431
ARCH-LM	F- statistic	0.000364326	111.0851528	1.582812173	288.3637001	48.33084657	48.50873214	0.045291328	4.245720296	2.863594727	1.406848202
	prob	0.98477284	1.73E-25	0.20846313	1.42E-61	4.48E-12	4.10E-12	0.83148505	0.03944344	0.090718343	0.235683006

Table 6 - Regression results

Variable	Coefficient	Std Error	P-Value	t-Statistic
C	34.0966	2.0693	0.0000	16.4771
AUST	0.6793	0.0086	0.0000	7.8954
CAN_\$	-0.1961	0.0231	0.0000	-8.4841
DIRHAM	-4.9818	5.1478	0.3332	-0.9678
IND_RUPEE	-2.8017	0.7521	0.0002	-3.7255
EURO	0.1520	0.0164	0.0000	9.2840
POUND	-0.1014	0.0104	0.0000	-9.7677
RAND	-0.1047	0.0326	0.0013	-3.2156
TSH	-0.4955	0.1093	0.0000	-4.5332
UG	-0.8538	0.0904	0.0000	-9.4418
USD	1.6041	1.4010	0.2523	1.1450
Diagnostics				
R-Squared	0.2442	Mean dependent var	8.5422	
Adjusted R-Squared	0.2415	S.D. dependent var	4.8983	
S.E. of regression	4.2661	Akaike info criterion	5.7433	
Sum of squared resid	49812.6600	Schwarz criterion	5.7670	
Log likelihood	-7880.2650	Hannan-Quinn criterion	5.7518	
F-Statistic	88.4431	Durbin-Watson statistic	0.0172	
Prob(F-Statistic)	0.0000			

Table 7 – ANOVA

Model	SS	df	Mean Square	F	Significance	R ²
Regression	16096.4051	10	1609.64051	88.44310133	2.02E-158	0.244221417
Residual	49812.65933	2737	18.19972938			
Total	65909.06443	2747	23.99310682			



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