THE IMPACT OF CENTRAL BANK INTERVENTION ON THE PROFITABILITY OF TECHNICAL TRADING RULES IN THE FOREIGN EXCHANGE MARKET IN KENYA

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DECLARATION

This project report is my original work and has not been submitted for any degree in any other University

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DEDICATION

This study is dedicated to my husband, Amos Okwiri Ogolo, who offered me unconditional love, patience and support throughout the course of this study.

It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time hence lightened up my spirit to finish this study.

ABSTRACT

This study examined the impact of central bank intervention on the profitability of technical trading rules. The study period was from July 1, 2007 to June 30, 2012. The study employed simple moving average rules with and without interest rate cost. Data was analyzed with central bank intervention data then the intervention data were removed and the data analyzed again. Then paired sample t-test was applied to profits with and without interest cost and to profits with and without central bank intervention.

The general result that central bank intervention in the market reduces the profitability of technical trading rules is interesting. This result means that central bank intervention in the market can reduce speculation in the market. However, this can only be the case when the profits after intervention are not significant. As the results demonstrate above, indeed profits decline but they are still significant. Therefore central bank intervention has not been successful in eliminating speculation in the market.

The results also show that central bank intervention reduces the volatility of technical trading profits. Therefore, when the central bank intervenes in the market speculators earn relatively low profits simply because exchange rate volatility has declined. This finding is supported by not only a decreased standard deviation but also a lower kurtosis.

The impact of central bank intervention in the market is only felt at the monthly trading interval. Thus, intervention in the foreign exchange market does not significantly reduce profitability of technical trading rules and hence speculation. Thus, the foreign exchange market is subject to large exchange rate movements with or without intervention by the central bank. The results show that including interest rate costs does not eliminate the profitability of technical trading. Also technical trading appears more profitable during periods of high volatility.

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LIST OF ACRONYMS

CBK.....Central Bank of Kenya

CRSP.....Centre for Research in Security Prices

EMH.....Efficient Market Hypothesis

LPE.....Local Polynomial Estimation

LRMA.....Long run moving average

PPPP.....Purchasing Power Parity

SRMA.....Short-run moving average

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Market efficiency is usually defined with respect to a particular set of information that market participants use to form expectations about future asset prices. Accordingly, three forms of market efficiency can be distinguished. There is the *weak-form* of efficiency in which asset prices incorporate all historical information. The next is the *semi-strong form* of efficiency where asset prices reflect all publicly available information. Lastly, there is the *strong-form* of market efficiency where asset prices impound all available information.

An efficient foreign exchange market plays two main functions. It ensures risk-sharing among market participants such that they bear only that risk they desire. Next, efficient foreign exchange markets help in the price discovery process. They help determine the fair value of financial assets thereby improving portfolio allocation decisions and better decision making within the firm.

There are two different lines of research in the analysis of foreign exchange market efficiency. The first line of research focuses on the analysis of risk sharing efficiency of the foreign exchange market. This research raises issues of the existence of arbitrage opportunities in the foreign exchange market which is the strongest contradiction of EMH. Fama (1965; 1970; 1991) provides survey of this literature. The analysis of the presence of arbitrage opportunities has a long and illustrious tradition in empirical finance (Frenkel and Levich, 1975, 1977). Indeed, in efficient markets it is possible to determine the fundamental exchange rate. Thus any deviations from this exchange rate represent arbitrage opportunities that can be exploited for profit by technical trading rules. The advantage of this approach over others is that it only assumes that market participants are rational. It also provides accurate predictions.

Studies by Frenkel and Levich (1975, 1977) have demonstrated that most profitable opportunities disappear after the introduction of transaction costs. In this study market efficiency is taken to mean the absence of profitable opportunities and no transaction

costs. This study answers one fundamental question: Does Central Bank intervention in the foreign exchange market increase arbitrage profit?

In summary, the EMH can be tested with respect to a particular information set and the profit derived from trading on such information. The empirical evidence available strongly suggests that the foreign exchange markets could be inefficient (Froot and Thaler, 1990).

1.1.2 Foreign Exchange Markets in Kenya

The foreign exchange market in Kenya was liberalized in 1993. Trade in foreign currency is now open individuals and corporations. The Central Bank of Kenya only intervenes only occasionally when exchange rates move wildly from their fundamental values. However, sometimes intervention by the CBK does not reduce volatility in the market. It does contribute to increased volatility and some times creates opportunities for arbitrageurs to earn significant profits in the market. The Exchange Control Act was repealed in 1995 to allow more commercial banks and foreign exchange bureaus to deal in foreign currency. The increase in the number of participants in the foreign exchange market was intended to increase market efficiency. However, empirical evidence done on the foreign exchange market in Kenya indicates that it is not efficient (Sifunjo, 2011).

The foreign exchange markets are international markets. The foreign exchange markets are geographically dispersed and activity on the foreign exchange markets takes place throughout the day around the world. Key players in the foreign exchange markets in Kenya are commercial banks, the Central Bank of Kenya, forex bureaus, insurance companies and pension funds, corporations, NGOs, SMEs and individuals. Given the participants, the foreign exchange markets increased their liquidity and foster an efficient price discovery process. %

The foreign exchange rate system in Kenya has also evolved through time. Since independence, the exchange mechanism in Kenya was fixed against major world currencies. The value of the Kenya shilling was fixed against that of major foreign currencies and could be adjusted but not as frequently as fundamental dictated. This was

later changed to a crawling peg, where the value of the Kenya shilling is allowed to fluctuate against foreign currencies within targets set by the Central Bank of Kenya. Financial liberalization programs initiated in the late 1980s saw the value of the Kenya shilling freely fluctuate against foreign currencies. From 1994 the exchange rate was fully flexible subject to the market forces of demand and supply. The CBK only intervenes in the market when the movements in the exchange rates deviated from market fundamentals. For instance, between July 1, 2007 and February 29, 2012 the Kenya shilling was devalued by more than 20% against the US dollar. The Kenya shilling was ranked among the worst performing currency in the world.

In summary, despite the increase in the number of commercial banks and foreign exchange bureaus in Kenya volatility of the exchange rate has increased. Thus, transaction and information costs have increased hence the liquidity of the foreign exchange markets has significantly declined. CBK intervention in the market could have contributed to volatility of foreign exchange market. Commercial banks have also recorded abnormal profits from currency trade in Kenya. Thus, it is important to examine the impact of central bank intervention on the profits of arbitrageurs in the foreign markets in Kenya.

1.2 The Research Problem

There are several studies that have examined the efficiency of the foreign exchange markets in Kenya (Kurgat, 1998; Ndunda, 2002; Muhoro, 2005; Kimani, 2007; Sifunjo, 2011). Kurgat (1998) analyzed the spot markets efficiency using data from the foreign exchange bureaus in Kenya. The results were that significant arbitrage profits existed in this market consequently the market is inefficient. Ndunda (2002) studied the efficiency of the forward exchange markets in Kenya. She tested the forward unbiased hypothesis in the major foreign currency markets in Kenya. She found that the forward rate is not a un-biased predictor of the future spot rate.

Kimani (2007) re-examined the efficiency of the forward market but focusing on the irrational behavior of market participants. After performing a battery of tests on several

major currencies against the Kenya shilling, she concluded that the forward exchange market is inefficient. She attributed this to the irrationality of key players in the foreign exchange markets in Kenya. Further, two studies were carried out focusing on the existence of arbitrage profits in the foreign exchange markets (Kurgat, 1998; Muhoro, 2005). The focus of Muhoro (2005) study was on triangular arbitrage using two major currencies - the US dollar and the Euro against the Kenya shilling, and a large sample (57 bureaus). The results showed that the respective foreign exchange markets are inefficient due to the existence of significant arbitrage profits.

Sifunjo (2011) analyzed the efficiency of the Ksh/USD exchange rate. The study covered the period from January 1, 1994 to June 31, 2007. He focused on both the spot and forward markets. Applying a battery of tests, he concluded that the market is inefficient. The causes of inefficiency were irrational behavior of market participants and speculation in the market.

In summary, there is a consensus among empirical studies that foreign exchange markets in Kenya are not efficient. However, the findings are limited only to the major currencies in the world and the period up to June 31, 2007. During the period starting July 1, 2007 and ending April 29, 2012, the Kenya shilling depreciated significantly against the USD. This created a lot of hue and cry across the economy. Indeed, a parliamentary select committee was set up to examine the behavior of key players in the foreign exchange market around this period. There have been accusations against the regulator, the CBK that it was sleeping on the job. Among the key accusations is the argument that the CBK colluded with commercial banks to rip-off the public in order to raise money to finance the 2012 election campaigns. This has necessitated the study of the behavior of the exchange rates at specific points in time i.e. before, during and after CBK intervention in the market to shed more light on this issue. The fundamental question here is: What is the impact of CBK interventions on the profitability of technical traders in the market?

Several general hypotheses were formulated to analyze the above issues. First, it was hypothesized that CBK intervention in the market increases arbitrage profits. Second, it

was hypothesized that the failure of the EMH could be attributed to speculation in the Ksh/USD spot market.

1.3 Objectives of the Study

This study aimed at achieving the following objective:

1. To determine the impact of CBK intervention on the profitability of technical trading rules in the foreign exchange rate market in Kenya.

1.4 Importance of the Study

The results of this study are relevant to a number of stakeholders.

First, the CBK can use the results to select the most appropriate strategy and tool for intervening in the foreign exchange market. It is a fact that instrument choice presents a lot of challenges to the regulator. Empirical evidence adduced on the performance of the policy tools used over the specific period under study will illuminate this particular matter.

Second, speculators would use the rules developed and tested in this study to trade and optimize their profitability. The amount of profit earned depends on several factors among the technical trading rule actually employed in the market.

Thirdly, this study contributes to the empirical literature on the effect of central bank intervention on the profitability of technical trading rules from the developing markets. Little research exists on this important topic from the emerging markets, especially in Africa.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the relevant literature. It is organized as follows. Section 2.2 examines the problem of serial correlation among exchange rates changes. Section 2.3 discusses the issue of long range dependence among exchange rates. Section 2.4 examines the profitability of trading rules in the financial markets. Lastly, section 2.5 is the summary of the chapter.

2.2 Dependence in the Foreign Exchange Rate Market

The main objective of examining dependence in returns on the foreign exchange market is to uncover any patterns in their behavior. The various approaches to analyzing dependence in the literature are reviewed in the subsequent sections.

2.2.1 Stationarity of Foreign Exchange Rate Returns

The unit root test is designed to test whether the spot rate (S_t) is difference-stationary (null hypothesis) or trend-stationary (the alternate hypothesis). Though the RWH is contained in the unit root null hypothesis, its primary focus is on the permanent/temporary nature of shocks to the spot rate or exchange rate return.

The case that real exchange rates are non-stationary means that the principle of purchasing power parity (PPP) is no longer valid as a representation of the long run equilibrium relation between the exchange rate and relative prices.

Empirical studies indicate that most macroeconomic time series data follow random walks. For instance, Baillie and Bollerslev (1989) and Meese and Singleton (1982) found a unit root process in the exchange rates. If time series variables are non-stationary all regression results with such series will be different from the classical theory of regression with stationary time series. This implies that regression coefficients with non-stationary time series will be misleading. Indeed, Lobato and Savin (1998) argued that inferences about the presence of long term memoiy in financial time series data can be partly explained by non-stationarity in the data.

In the recent past, a view that the real exchange rates may be stationary but highly persistent is emerging in the literature (Rogoff, 1996; Lethian and Taylor, 1996; Olekalns and Wilkins (1998). However, Engel (1998) challenges this view, arguing that the power of the unit root tests in such studies is very low. Similarly, Caner and Kilian (1998) argued that tests of the stationarity null hypothesis may suffer from severe distortions. In fact, the random walk behavior of the real exchange rate was contrasted with chaotic dynamics. This is motivated by the idea that the real exchange rate follows a deterministic nonlinear process which generates output that indistinguishable from the output of stochastic systems. Thus, it is possible for the real exchange rate to appear random but not to be really random. For instance, Gogas and Serletis (2000) studied the random walk behavior of the real exchange rate and concluded that real exchange rate movements might not be really random.

Gil-Alana (2000) applied fractionally-based tests to real exchange rate data between US and industrialized countries and his results indicated that the series are fractionally integrated with mean reversion. Gil-Alana (2002) studied the monthly real exchange rates (relative to the US dollar) from black markets of eight Asian developing countries and concluded that there is mean reversion in the long-run. Henry and Olekalns (2002) examined the post Bretton-Woods experience of Australian real exchange rate, and found no evidence of the long run equilibrium relation between the exchange rate and relative prices.

Despite the extensive literature on the time series behavior of exchange rates, evidence so far provided is not conclusive. Several reasons have been put forward to explain these mixed results. These include the traditional forms of price stickiness (Dornbusch, 1976), trading costs (Dumas, 1992), and price discrimination (Chari, Kehoe and McGrattan 2000). The empirical literature on time series properties of the real exchange rate has focused mainly on real factors and cross-country differences in productivity growth (Ceglowski, 1996). The use and application of panel methods have typically allowed the production of more evidence favorable to real exchange rate mean reversion (Wu, 1996; Papell, 1997; Oh, 1996). Cheung and Lai (2001) focused on the possibility of long memory dynamics. They considered eight bilateral exchange rates looking for evidence

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of fractional integration and found that the order of integration of all the series considered is between zero and one. The use of fractionally integrated processes allows long cycles and long term memoiy and provides a flexible enough framework simultaneously to describe large swings and mean-reverting dynamics that may characterize real exchange rate behavior. There is also a growing literature on modeling exchange rates using non-linear models such as TAR and STAR (Sarantis 1999; Baum, Barkoulas and Caglayan, 2001; Taylor, Peel and Sarno, 2001).

The other possible reason for nonstationarity in the real exchange rate could be the presence of structural breaks in the series. Perron (1989, 1990) and Perron and Vogelsang (1992) have shown that when a time series have structural breaks in the mean, the unit root hypothesis is often accepted before structural breaks are taken into account; while it is rejected after structural breaks are considered. Therefore, it becomes necessary to establish the level of stationarity or non-stationarity of the spot rate before further analysis.

2.2.2 Serially Correlated Exchange Rate Returns

The focus here is on uncorrelated increments in foreign exchange returns. The use of unit root test for randomness is not sensitive to some departures from the random walk process. Early empirical studies of the behavior of foreign exchange rates indicated that they follow a random walk. The evidence is based on testing for uncorrelated increments in foreign exchange rates.

2.2.3 Evidence Based on Ljung-Box Q-Statistics Test

Auto-correlation test is a reliable measure for testing of either dependence or independence of random variables in a series. The serial correlation coefficient measures the relationship between the values of a random variable at time *t* and its value in the previous period. Autocorrelation test provides evidence whether the correlation coefficients for residuals are significantly different from zero. Giddy and Dufey (1975), Cornell and Dietrich (1978), Logue, Sweeny and Willet (1978), and Hsieh (1989) found uncorrelated increments in exchange rates. However, this does not imply that foreign

exchange rates markets are efficient (Levich, 1985). In the foreign exchange market there are several causes of serial correlation such as exchange rate overshooting or undershooting, risk aversion, and government intervention in the market. However, evidence of profitability of technical trading rules, fat tails and skewness indicate the presence of inefficiencies in exchange rate market. Some of the evidence against market efficiency is reviewed below.

2.2.4 Evidence Based on the Variance-Ratio Test

Since the seminar work of Cochrane (1988) and Lo and MacKinlay (1988, 1989), the standard variance ratio (VR) test or its improved modifications have been used to test the random walk hypothesis. Examples of applications of the variance ratio test are found in Fong et al. (1977), Ronen (1997), Choi (1999), Yilmaz (2003) and the references cited in Tse and Zhang (2002, 2004). A well known problem with the VR test, namely that the VR statistic is a biased and right -skewed infinite samples, is addressed and a solution is provided in a series of theoretical papers such as those by Tse and Zhang (2004), Perron (2005) and Chenn and Deo (2006).

This section examines empirical evidence on the EMH using the variance-ratio test developed by Lo and MacKinlay (1988). The variance-ratio test is applied first assuming homoscedasticity and then assuming heteroscedasticity. The variance ratio test **(VR)** exploits the fact that the variances of the increments of the random walk are linear in the sampling interval. This implies that if a series follows a random walk, the variance of its ^-differences would be q times the variance of its first differences. Thus, if we have n_q + 1 observations, s_{lf} s_{nq} sampled at a regular interval, the ratio of 1/q of the variance s_t - s_{t-q} to the variance of $s_r s_{r-i}$ would be equal to unity. The variance ratio test is a Z statistic developed in Lo and Mackinlay (1988). It has two unique characteristics. First, it provides an asymptotic normal test for the variance-ratio test. Second, the more refined Z* statistic can be used with overlapping data. Furthermore, it has more power and is efficient. Liu and He (1991) tested the RWH in the foreign exchange market. They applied the variance-ratio test on five pairs of weekly nominal exchange rates sampled from August 7, 1974 to March 29, 1989. The evidence does not support the RWH.

Furthermore, since the restrictions are not robust to heteroscedasticity, they argued that failure of the RWH is due to serial correlation in the data.

Lee and Kim (2006) considered a simple random walk process that exhibits a deterministic break in its drift term, for instance, from positive to negative. They demonstrated both theoretically and by simulation that when the standard variance ratio that is applied to this process, the phenomenon of spurious rejections of the random walk hypothesis can occur. They further proposed a modified version of the variance ratio test to avoid such a problem. Finally, they discussed some implications of there results on the previously revealed empirical evidence against the random walk hypothesis for exchange rates. In summary, evidence available on the randomness of foreign exchange rates using the variance ratio test is not conclusive.

2.3 Long-Range Dependence in Exchange Rate Returns

Long-range dependent time series display a significantly high degree of persistence so that observations in the remote past are highly correlated with observations in the distant future, even as the interval between the two observations increase without bound. Interest in long-range dependence is financial markets started with Mandelbrot (1971) who proposed the application of the range over the standard deviation, or *R/S statistic*, the rescaled range, to detect long-range dependence in economic data. The R/S statistic was, however, developed and used in hydrology by Hurst (1951) in the studies of river discharges.

The R/S statistic is the range of partial sums of deviations of a time series from its mean rescaled by its standard deviation. Mandelbrot, Taqqu and Wallis in several seminal papers (Mandlebrot, 1972, 1975, Mandlebrot and Wallis 1969; Mandlebrot and Taqqu, 1979) showed that the R/S statistic is superior to the more common methods of determining long-range dependence such as analyzing autocorrelations, variance ratios and spectral analysis. Indeed, Mandlebrot (1972) contended that unlike spectral decomposition, which detects periodic cycles, R/S analysis can detect non-periodic cycles, cycles with periods equal to or greater than the sample period.

In the recent past Lo and MacKinlay (1988) and Poterba and Summers (1988) provided evidence that highly suggests the presence of long-range dependence in stock market prices. Specifically, Lo and MacKinlay (1988) demonstrated that the variance of ***K*** times J£-week stock return variances to ***K*** times the variance of one-week returns generally are greater than one when ***K*** is small (2 to 32). However, Poterba and Summers (1988) provide further evidence that this variance falls below one when ***K*** is much larger (K>96).

The first application of the R/S statistic was by Greene and Fielitz (1977) who analyzed common stock returns of 200 individual stocks on the New York Stock Exchange from December 23, 1963 to November 29, 1968. They found significant evidence for long-term dependence. However, Lo (1991) challenged these results on the grounds that this evidence is due to short-term correlation. He suggested a modified R/S statistic to test robustly for long-range dependence. He found no evidence in favor of long run dependence of daily and monthly returns on the Centre for Research in Security Prices (CRSP) stock indexes. The study by Bossaerts, Hafner, and Hardle (1996) applied Local Polynomial Estimation (LPE) to data for the Yen/Mark, Mark/US dollar, and Yen/US dollar. They provided evidence on the presence of long-range dependence in the foreign exchange market. However, the observed dependence in the data is not symmetrical.

Mulligan (2000) applied the R/S statistic to examine foreign exchange markets of 22 countries in the developed world. These included US, Canada, Austria, UK, Japan, Germany, and Malaysia. They found significant long-term dependence and fractals in all these countries. He therefore concluded that the examined markets are not efficient. Barkoulas, et al. (undated) examined the presence of long-term memory in foreign exchange rates of 18 industrial countries using semi-parametric fractional estimation method. They also performed a sensibility analysis of the temporal stability of the long-term memory parameter. They found no evidence of long-range dependence in the data.

Sarkar and Barat (2005) examined long-range dependence in the Indian foreign exchange market. They found evidence of long memory in the time series data of the Rupee against the US dollar, Euro, British Pound and the Japanese Yen. Most recently, Da Silva, et al.

(2007) employed the R/S statistic to examine the efficiency of the Brazilian foreign exchange market. They found evidence of weak informational efficiency using the daily exchange rates data for the period starting from January 2, 1995 to August 31, 2006. Other studies employing the R/S statistic are Booth et al (1982) in the foreign exchange market and Helms et al. (1984), in the futures market.

In summary, evidence on the presence of long-term dependence in the foreign exchange rates is mixed. There is also limited evidence on the factors explaining this phenomenon in the financial markets. Therefore, this study contributed to this debate by examining long-range dependence in foreign exchange market in Kenya.

2.4 Profitability of Technical Trading Rules

In this section the restriction that exchange returns are identically distributed is relaxed. The rationale is that most financial data collected over a number of years cannot be identically distributed. Technical analysis of exchange rates bases forecasts solely on past prices. It extrapolates past price trends. Technical analysis searches for recurrence of certain price patterns. Once the beginning of such a price pattern has been detected, it automatically suggests what the short-run behavior of the exchange rate will be. The models employed attempt to detect both major trends and turning points. Such models are usually very simple and they utilize *moving averages, filters* or *momentum.* The main objective of all these models is to detect when a sustainable trend has begun.

In the moving average models, buy and sell signals are usually triggered when the short-run moving average (SRMA) of past rates crosses the long run moving average (LRMA). The objective of a moving average is to smooth erratic daily movements of exchange rates in order to uncover major trends. An LRMA will always lag an SRMA because the LRMA gives a smaller weight to recent movements of exchange rates than SRMA does. If currency is moving downward, its SRMA will be below LRMA. When it starts rising again, it soon crosses its LRMA, generating a buy signal. The converse is true for sell signals.

Filter methods generate buy signals when an exchange rate rises / percent (the filter) above its most recent trough and sell signals when it falls / percent below the previous peak. Likewise, the idea is to smooth (filter) daily fluctuations in order to detect persistent trends. Momentum techniques determine the strength of a currency by examining the change in velocity of currency movements. If an exchange rate climbs at increasing speed, a buy signal is issued.

In summary these models monitor the slope of the time-series graph. Buy and sell signals are generated when the slope varies significantly. The use of technical trading rules entails two steps. The first, identifying the trends in the exchange rates. The second, taking market positions to exploit the persistent trend. The null hypothesis of market efficiency is that the cost of taking on the foreign exchange position should exactly offset the anticipated exchange rate return yielding zero excess returns. Therefore, if patterns have been identified based on a series of foreign exchange rates then no profit should be made using any technical trading strategy. The alternate hypothesis is that technical trading rules are profitable (even after adjusting for risk).

Dooley and Shafer (1976, 1984) were the first empirical studies to adduce evidence on the profitability of technical trading rules in the foreign exchange market. Their study covered the period starting 1973 and ending 1981. The data consisted of nine major currencies against the US dollar. Dooley and Shafer adjusted their calculations to reflect interest expense and interest income of long and short positions. They incorporated transaction costs by using bid-ask spreads on the spot rates of the respective currencies. They found that filter rules *if* = 1, 3 or 5 percent) would have been profitable for all currencies over the entire sample period.

However, they also found that for larger filters *(f*= 10, 15, 20, and 25 percent), the results changed from one currency to another over the whole sample period but were profitable in more than one-half of the sub-periods. However, even in small filters there was an element of risk involved in using these trading rules. Dooley and Shafer went further and applied filter rules to hypothetically generate random prices and found that filter rules actually generated loses. This finding is not surprising because it is consistent with the

randomness or lack of any pattern in the random numbers used. However, this only underscored the puzzle about the existence of patterns of serial dependence in the foreign exchange market that could not be used in money markets to off-set short-term exchange rate changes.

In a similar study, Sweeny (1986) used filter rules on daily exchange rates for ten currencies over the period April 1973 to December 1980 and arrived at the same conclusions. Filters of 0.5, 1, 2, 3, 4, 5, and 10 percent led to trading profits in more than 80 percent of the cases. The results of small filters (0.5, 1, and 2 percent) were again superior. Furthermore, Sweeny divided his sample data into periods of two and a half years followed by a five-year post sample period. He found that filter rules that were profitable in the first period tended to be profitable in the second. Assuming constant exchange rate volatility, Sweeny determined that the profits from filter rules were significant in about one-third of the cases. Again, small filters rules were more profitable than larger filters rules

Schulmeister (1987, 1988) studied the US S/DM rate for the period starting April 1973 to October 1986. He used filter rules, moving average models and momentum models, and a combination involving moving average models and momentum models. The findings suggested that the technical models would have been profitable even after adjusting for interest expense and transaction costs. He noted that both moving average and momentum models generated equally superior and statistically significant profits (14 to 15 percent) compared to filter rules (8.2 percent for 2% filters). Schulmeister correctly argued that one reason behind the profitability of trading rules is that exchange rate changes and speculative profits are non-normally distributed. There are too many extreme exchange rate changes relative to a normal distribution. This implies that once an exchange rate move has started, it is likely to persist and this allows technical traders to spot profitable investment opportunities.

From the literature reviewed above, at least three points are worth noting. First, including transaction costs and interest rate costs does not eliminate the profitability of technical trading (Cornell and Dietrich, 1978; Sweeny, 1986; Schulmeister, 1987). Second,

technical trading appears more profitable during periods of high volatility (Cornell and Dietrich, 1978; Sweeny, 1986; Dooley and Shafer, 1983). The profitability of technical trading rules is highly variable from on period to another (Logue, Sweeny and Willet, 1978).

More evidence on the profitability of filter rules and moving average crossover rules is provided in an extensive study by Levich and Thomas (1993). They used the largest sample of any study covering the period January 1976 to December 1990 for the currency futures prices, an equivalent of 3,800 daily observations. They found that filter rules and moving average crossover rules appeared to generate profitable trading signals. They also found lower profits for the Canadian dollar, which had the lowest volatility compared to other currencies in their sample. The profits of the moving average rules are also higher than those for the filter rules.

LeBaron (1999) provided further evidence on the government intervention in the foreign exchange market and profitability of technical trading models. Using data from 1979 to 1992 for the DM/Yen exchange rate, he found that if days when the Federal Reserve actively intervened in the market are removed from the sample, there is a dramatic decline in the level and significance of technical trading profits. However, LeBaron advised caution in the interpretation of these results, "It is not clear that the Federal Reserve causes inefficiencies in the foreign exchange market, or just happens to be around when they occur."

Empirical studies done in the early 1990s provide further support for the findings of earlier studies. For instance LeBaron (1999), Saacke (2002) and Neely, Weller and Ulrich (2006) provide evidence of profitability of technical trading rules after considering the transaction costs and interest rate costs. Lee and Mathur (1996), Neely and Weller (1999) adduce evidence that high volatility periods in currency markets are the most profitable for technical traders. While LeBaron (2000) and Neely, Weller and Ulrich (2006) showed that profits from technical trading are unstable over time. Unlike earlier studies, these studies have been characterized by sophisticated techniques like bootstrapping (Osier, 2000, 2003), momentum strategies (Okunev and White, 2003), complex forms of

technical trading combining nonlinear exchange rate modeling and technical analysis on one hand (DeGrauwe and Grimaldi, 2006) and regime switching and technical trading on the other (Dewatcher, 2001); while other studies have examined profitability of technical trading using high frequency data (Osier, 2003; Neely and Weller, 2003; Neely, Weller and Ulrich, 2006).

2.5 Summary

In summary, all the empirical studies reviewed above on profitability of technical trading models indicate that significant patterns exist in the market for spot exchange rates that can be profitably exploited by technical traders. Hence the market is inefficient. Though it is difficult to rationalize these findings, available evidence suggests that government intervention in the foreign exchange market (LeBaron, 1999), irrational market participants and long term dependence could be possible causes.

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CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This section presents the research methodology used in this study. In section 3.2 the research design is discussed. Section 3.3 examines the population and sample. Section 3.4 examines the data analysis. Lastly, in section 3.5 the data employed in this study is described.

3.2 Research Design

This study employs a quasi-experimental design to test for dependence in the exchange rates that can be exploited for profits. This design allows for the actual determination of patterns in the time series of exchange rates and the development trading rules. The currency traders can employ these patterns to signal buy and sell decision.

Though the patterns in the exchange rates can be used to make profits, the level of control on the activities is not that high as the case may be in a laboratory setting. Therefore, the use of the quasi-experimental design in this relevant study is justified.

3.3 Population and Sample

The population of this study consists of the data covering the entire period of floating exchange rates, from January, 1993 to the present. The sample data covers only the period starting July 1, 2007 to February 29,2012.

The choice of the period was determined by the level of depreciation of the exchange rate of the Ksh/USD and the frequency of CBK intervention in the foreign exchange market. This period allows the examination of the impact of CBK intervention on the profitability of the technical trading rules more than any other since liberalization.

3.4 Data Analysis - Test of Profitability of Technical Trading

This section presents the tests that were done to meet the objectives of this study.

This section presents the procedures used to test the forecasting ability of a simple technical trading rule. Forecasts were examined over daily and weekly intervals. The rule

compares the current price to a moving average of past prices. Using R_t as the KSh/USD exchange rate returns at time the moving average MA is defined as,

$$m = \text{i x V , .} \qquad (3.i)$$
$$M \text{ j=0}$$

where M is the length of the moving average. For daily data M=150 and for weekly M =30.

A buy or sell signal S_t is defined as

$$S_t = \backslash \qquad (3.2)$$

Though the rule looks simple this is what is commonly used in practice.

Let $p_t = log\ (Pi)$, and /t and i^* be the domestic and foreign interest rates, respectively. Dynamic returns from the trading strategy are defined as

$$r, = S_t(p_{l+l} \sim Pt \sim (\log(\text{l} + /,) - \log(\text{l} + \text{f}))) \qquad (3.3)$$

The right hand side gives the log difference on the exchange rate corrected for the interest differential. This return is multiplied by +1 or -1 depending on the generated signal, S_t. This rule is a zero cost strategy of borrowing in one currency to go long in the other. The interest rates used are the weekly 91-day Treasury Bills rates in the US and in Kenya.

Lastly, the strategy was implemented without the interest rate differential, as follows

$$n=S_t(p_M-p_t). \qquad (3.4)$$

3.5 Data

The data used in this study was collected from the Central Bank of Kenya covering the period from Januaiy 1994 up to June 2007. This is the period for floating exchange rates for the KSh/US$. The choice of the currency was influenced by the fact that it is the major trading currency across the world and is commonly used in empirical research. This study uses the closing prices of the daily exchange rates. The daily foreign exchange rate returns were computed as follows:

intervention compare to when there is no central bank intervention in the market. In general, the results in Table 4.1 and Table 4.2 shows that central bank intervention reduces but does not eliminate the profitability of technical trading rules.

Table 4.3a Paired Samples Statistics with Central Bank Intervention

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Dret	.0004504	1247	.00532462	.00015078
	Dreti	.0009992	1247	.07838619	.00221976
Pair 2	WlcRet	.0012235	1247	.00642522	.00018195
	WkReti	-.0075685	1247	.07893145	.00223520
Pair 3	MnRet	.0024878	1247	.00606329	.00017170
	MnReti	.0026434	1247	.07930336	.00224573

Table 4.3b Paired Samples Test of Differences in Profitability of Technical Trading Rules Returns with Central Bank Intervention

		Paired Differences					
		Mean	Std. Deviation	Std Error Mean	t	df	Sig. en-tailed)
Pair 1	Dret - Dret_i	-.00054876	.07819963	.00221448	-.248	1246	.804
Pair 2	WkRet - WkRet i	.00879203	.07854540	.00222427	3.953	1246	.000
Pair 3	MnRet - MnRet i	-.00015564	.07908674	.00223960	-.069	1246	.945

Table 4.3a displays the sample statistics of paired profits of technical trading rules with central bank intervention with and without interest cost. The results show that profits with interest expense are higher but more volatile than profits without interest expense. Table 4.3b shows the results of the paired sample r-test of the difference in the profits from technical trading rules with and without interest cost with central bank intervention in the foreign exchange market. The results indicate that profits are only statistically significant at 1% level from each other at the weekly trading interval.

$$\ln \qquad = R, \qquad (3\text{-}5)$$

where Pt is the current closing price and Pt-1 is the previous closing price of the Kenya shilling against the US dollar when trading activities ended on the market. The value Rt is the return at time t.

Data for the interest rates were the Kenya government 91-days Treasury bill rates and the US government 91-days Treasury bill rates averaged over one month.

The accuracy of the data was checked to ensure that the daily price data used are valid. Efforts were made to ensure that all available observations are collected and correctly recorded. Price changes of more than one half percent were double checked for accuracy. Missing observations were checked to determine if the omitted data could be found. When the data was not available, the observation was treated as a holiday.

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the data analysis and their discussions. Section 4.2 presents the summary statistics. Section 4.3 analyses the determinants of persistence among poor undergraduate students. Section 4.4 discusses the implication of the findings of the data analysis. Section 4.5 summarizes the results of the studies. Section 4.5 is the summary.

4.2 Summary Statistics

The description of the foreign exchange rate returns is summarized in Table 4.1.

Table 4.1 Summary Statistics of Foreign Exchange Returns

Number	Returns (With Intervention)	Returns (Without Intervention)
Mean	**1.879 X 10^**	2.4160 X 10^
Median	**8.935 X 10***	7.13 X 10"[6]
Mode	.000000	.000000
Standard Deviation	.000000	.007614
Skewness	.010	-.720
Kurtosis	11.874	15.289
Range	.093931	.094393
Minimum	-.049971	-.067950
Maximum	.044219	.044422
Sum	.234123	.232415

The mean return without central bank intervention is higher than the mean return with central bank intervention. This suggests that central bank intervention reduces the profitability of technical trading rules. However, this finding needs to be examined further to determine whether the difference in mean returns is statistically significant. The standard deviation of the returns is also lower with central bank intervention than without intervention. This implies that central bank intervention reduces the volatility of returns and hence the exchange rate risk. While the returns are slightly positively skewed with central bank intervention they are negatively skewed without central bank intervention. Therefore, this indicates that intervention in the foreign exchange market tends to strengthen the Ksh/USD exchange rate. However, central bank intervention has not effectively reduced the kurtosis of the returns. Thus, central bank intervention in the

market does not reduce the occurrence of extreme returns on foreign exchange rate trading. Indeed, as it has been empirically demonstrated by Sifunjo (2011) the foreign exchange market displays chaotic tendencies.

4.2 Profitability of Technical Trading Rules

Series	With Central Bank Intervention						Without Central Bank Intervention				
	N	Mean	Std	t-ratio	Sharpe	Trade Fraction	Mean	Std	t-ratio	Sharpe	Trade Fraction
Ksh Daily - No interest rate	1247	O.OOOS	0.0053	0.0014	2.5200	0.53	0.0006	0.0062	0.0020	2.57	0.56
Ksh Daily • Interest	1247	0.0010	0.0784	0.3263	-2.1664	0.53	-0.0081	0.0693	0.0001	-5.16	0.56
Ksh Weekly - No interest	312	0.0012	0.0064	0.0000	6.1200	0.58	0.0016	0.0074	0.0000	6.24	0.60
Ksh Weekly • interest	312	-.0076	0.0789	0.0004	-3.1181	0.58	-0.0113	0.0701	0.0000	-4.22	0.60
Ksh Monthly • No interest	56	0.0025	0.0061	0.0000	13.4200	0.51	0.0031	0.0069	0.0000	13.65	0.53
Ksh Monthly • interest	56	0.0026	0.0793	0.1197	0.8149	0.51	0.0006	0.0711	0.3873	1.39	0.53

Table 4.2 displays the results of the profitability of technical trading rules with and without central bank intervention it the foreign exchange market. Table 4.2 also shows the results with and without interest cost at the daily, weekly and monthly trading intervals. The analysis shows that at the daily level with central bank intervention, profits from technical trading rules are significant only when the interest cost is not considered. However, profits remain significant with or without interest cost when there is no central bank intervention in the foreign exchange market. Therefore, central bank intervention in the foreign exchange market reduces profitability of technical trading rules at the daily interval. At the weekly trading interval the profits from technical trading rules are statistically significant with or without intervention and with or without interest cost. Profits with intervention are on average lower than profits without intervention. However, the profits are negative when interest costs are subtracted from the total returns. Monthly trading profits are only significant without interest cost with or without central bank intervention. Again, profits with central bank intervention are lower that profits without intervention. The Sharpe ratios are all smaller with central bank

Table 4.4a Paired Samples Statistics without Central Bank Intervention

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Dret	.0005673	988	.00619520	.00019710
	Dreti	-.0080519	988	.06933108	.00220572
Pair 2	WkRet	.0015455	988	.00736386	.00023428
	WkReti	-.0113416	988	.07012590	.00223100
Pair 3	MnRet	.0030859	988	.00687914	.00021885
	MnReti	.0006477	988	.07110466	.00226214

Table 4.4b Paired Samples Test without Central Bank Intervention

		Paired Differences					
		Mean	Std. Deviation	Std. Error Mean	t	df	Sig.
Pair 1	Dret-Dret i	.00861918	.06896234	.00219398	3.929	987	.000
Pair 2	WkRet - WkRet i	.01288706	.06946209	.00220988	5.832	987	.000
Pair 3	MnRet - MnRet i	.00243819	.07067173	.00224837	1.084	987	.278

Table 4.4a displays the sample statistics of paired profits of technical trading rules without central bank intervention with and without interest cost. The results show that profits with interest expense are lower and more volatile than profits without interest expense. Table 4.4b shows the results of the paired sample Mest of difference in the profits from technical trading rules with and without interest cost without central bank intervention in the foreign exchange market. The results indicate that profits are only statistically insignificant at 1% level from each other at the monthly trading interval.

Table 4.5 Paired Samples Test of Differences in Profitability of Technical Trading Rules With and Without Central Bank Intervention

		Paired Differences					
		Mean	Std. Deviation	Std. Error Mean	t	df	Sig-
Pair 1	DailyReturnsI - DailyReturns	-.00012	.00796	.00025	-.469	987	.639
Pair 1	Weekly_Returns_I - Weekly_Returns	-.00042	.00980	.00031	-1.349	987	.177
Pair 1	Monthly_Retums-I - Monthly_Returns	-.00073	.00847	.00027	-2.718	987	.007

Table 4.5 shows the results of the paired sample Mest of difference in the profits from technical trading rules with and without central bank intervention in the foreign exchange market. The results indicate that the mean differences in profits are all negative and only statistically significant at 5% level from each other at the monthly trading interval.

Therefore, central bank intervention in the foreign exchange market reduces profitability of technical trading rules and significantly so at the monthly interval.

4.4 Discussion

The general result that central bank intervention in the market reduces the profitability of technical trading rules is interesting. This result means that central bank intervention in the market can reduce speculation in the market. However, this can only be the case when the profits after intervention are not significant. As the results demonstrate above, indeed profits decline but they are still significant. Therefore central bank intervention has not been successful in eliminating speculation in the market.

The results also show that central bank intervention reduces the volatility of technical trading profits. Therefore, when the central bank intervenes in the market speculators earn relatively low profits simply because exchange rate volatility has declined. This finding is supported by not only a decreased standard deviation but also a lower kurtosis as shown in Table 4.1.

The impact of central bank intervention in the market is only felt at the monthly trading interval. Thus, intervention in the foreign exchange market does not significantly reduce profitability of technical trading rules and hence speculation. Thus, the foreign exchange market is subject to large exchange rate movements with or without intervention by the central bank.

The results show that including interest rate costs does not eliminate the profitability of technical trading (Cornell and Dietrich, 1978; Sweeny, 1986; Schulmeister, 1987). Second, technical trading appears more profitable during periods of high volatility (Cornell and Dietrich, 1978; Sweeny, 1986; Dooley and Shafer, 1983).

4.5 Summary

In summary, central bank intervention in the foreign exchange rate market reduces profitability of technical trading rules. Intervention also decreases the standard deviation of returns and the kurtosis. Hence, profits from technical trading rules decline to reflect

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the reduction in foreign exchange rate risk in the market following central bank intervention. The largest impact of intervention on profitability of technical trading rules is achieved at the monthly trading interval. Evidence adduced shows that including interest rate costs does not eliminate the profitability of technical trading.

CHAPTER FIVE: SUMMARY AND CONCLUSION

5.1 Introduction

This chapter presents the summary and conclusions of the study. Section 5.2 summarizes the whole study. Section 5.3 draws the main conclusions from the data analysis in chapter four. Section 5.4 discusses the main limitations of the study. Lastly section 5.5 presents recommendation for further research.

5.2 Summary of the Study

This study examined the impact of central bank intervention on the profitability of technical trading rules. The study period was from July 1, 2007 to June 30, 2012. The study employed simple moving average rules with and without interest rate cost. Data was analyzed with central bank intervention data then the intervention data were removed and the data analyzed again. Then paired sample t-test was applied to profits with and without interest cost and to profits with and without central bank intervention.

The general result that central bank intervention in the market reduces the profitability of technical trading rules is interesting. This result means that central bank intervention in the market can reduce speculation in the market. However, this can only be the case when the profits after intervention are not significant. As the results demonstrate above, indeed profits decline but they are still significant. Therefore central bank intervention has not been successful in eliminating speculation in the market.

The results also show that central bank intervention reduces the volatility of technical trading profits. Therefore, when the central bank intervenes in the market speculators

earn relatively low profits simply because exchange rate volatility has declined. This finding is supported by not only a decreased standard deviation but also a lower kurtosis.

The impact of central bank intervention in the market is only felt at the monthly trading interval. Thus, intervention in the foreign exchange market does not significantly reduce profitability of technical trading rules and hence speculation. Thus, the foreign exchange market is subject to large exchange rate movements with or without intervention by the central bank. The results show that including interest rate costs does not eliminate the profitability of technical trading. Also technical trading appears more profitable during periods of high volatility.

5.3 Conclusion

Three conclusions can be drawn from the results of this study. First, central bank intervention in the foreign exchange market reduces profitability of technical trading rules.

Secondly, including interest rate costs does not eliminate the profitability of technical trading.

Thirdly, the impact of central bank intervention in the market is only felt at the monthly trading interval.

5.4 Limitations of the Study

This study examined the profitability of technical trading rules in the Ksh/USD exchange rate. However, there are over fourty currencies currently trading in the foreign exchange market. Whether the findings of this study can hold in the other currency markets is still an open question.

The study did not consider the effect of intervention in the US dollar market. It is certain that activities of the Federal Reserve Bank influence the exchange rate of the US dollar against other currencies. This may influence the trade in the US dollar.

5.5 Recommendations for Further Research

There are two recommendations for further study arising from the limitations stated above. First, there is need to extent this study by examining other currency markets so that general statements can be made about the impact of central bank intervention in the foreign exchange markets on the profitability of technical trading rules.

Secondly, the study should be extended by considering the effect of central bank intervention in the US currency market.

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