THE PREDICTIVE POWER OF THE TERM STRUCTURE OF INTEREST RATES: THE CASE OF JORDAN

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ABSTRACT

This thesis investigates whether the short end of the term structure has the ability to predict the future movements in short term rates and the inflation rate using data from a developing country: the case of Jordan. A number of econometric techniques are employed to examine the predictability of the term structure and to deal with the low quality data.

In order to examine the ability of the term structure to predict the future movements in short term rates, the validity of the Expectations Hypothesis (EH) is tested. The EH implies that the term spread is an optimal predictor of the future changes in short term rates. For the empirical testing, two sets of data are used; the term structure in the Jordanian interbank market and the term structure in the primary market.

The information content of the term structure about inflation rate is examined by investigating whether there is a long run equilibrium relationship between the short term rates and the inflation rate; that is, testing the Fisher Hypothesis, and between the domestic term spread and the inflation rate. Moreover, given that the exchange regime in Jordan is pegged to the US Dollar, the information content of the US term spread is also examined.

The cointegration analysis is the only technique that provides evidence that the EH holds. In addition, it provides evidence that the domestic and the US term spreads contain some information about the inflation rate.

As a result of dealing with low quality data, the Monte Carlo simulation provides evidence that the size distortion of the Dickey Fuller (DF) test becomes larger as the noise increases in the data and faster as the sample size becomes bigger. This evidence supports the literature that discusses the size distortion of the DF test.

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I DEDICATE THIS THESIS

- *TO THE MEMORY OF MY BELOVED PARENTS SAMEEH AND NABILAH*

- *TO MY ANGELS ON EARTH, MY SOUL MATES, MY FRIENDS, MY SISTERS*

HANADA, HANAN , HELEN

WHOSE LOVE, SUPPORT, FAITH AND PRAYERS
HAVE HELPED ME WRITE EACH WORD IN THIS THESIS.

THANK YOU FOR LOVING ME THIS MUCH
YOU MAKE MY LIFE WORTH LIVING.

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ABBREVIATIONS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
AR	Autoregressive
CBJ	Central Bank of Jordan
CDs	Certificates of Deposits
Corr	Correlation Coefficient
CPI	Consumer Price Index
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMSQ	Cumulative Sum Squares
d.f.	Degrees of freedom
DF	Dickey Fuller
ECM	Error Correction Model
ECT	Error Correction Term
EH	Expectations Hypothesis
FH	Fisher Hypothesis
GMM	Generalised Method of Moments
I(0)	Integrated Variable of Order 0
I(1)	Integrated Variable of Order 1
i.i.d.	Identically and Independently Distributed
JODIBOR	The Jordanian Dinar Interbank Offered Rate
JORSPD	The domestic term spread
LIBOR	London Interbank Offered Rate
MA	Moving Average
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PEH	Pure Expectations Hypothesis
PFS	Perfect Foresight Spread
PP	The Phillips-Perron
r_t^m	Short Term Interest Rate with Maturity (m)
R_t^n	Long Term Interest Rate with Maturity (n)
REHTS	Rational Expectations Hypothesis of the Term Structure
REPO	Repurchase Agreement
S_t = SPD	Actual spread
$S_t^{(n,m)}$	Spread Between (n) Period Interest Rate and (m) Period Interest Rate at Time (t)
S_t^*	Theoretical Spread
s.d.	Standard Deviation
SDR	Standard Deviation Ratio
SE	Standard Error

TVP	Time Varying Parameter
USTBSPD	The US term spread
VAR	Vector Autoregression
VECM	Vector Error Correction Model

INTRODUCTION

The relationship between interest rates of different maturities is, and will remain, one of the main concerns for all market players in any financial market. Monetary authorities, market practitioners, investors and economists pay great attention to the characteristics of the term structure of interest rates because it is the main tool that relates interest rates of different maturities together.

One of the main characteristics that have been the centre of attention for a long time is the predictive power of the term structure, particularly its ability to predict future economic activities such as the future movements in interest rates, the output growth and inflation. Market players, and in particular policy makers, use the slope of the term structure to extract important information about the market's expectations of future economic activities.

A substantial body of the empirical literature concentrates on testing the predictive power of the term structure of interest rates. A significant proportion of the empirical work examines the ability of the term structure to predict the future movements in short term interest rates while the remaining work examines whether the term structure contains useful information about macroeconomic variables such as the output growth and inflation. The majority of the studies focus on using data from developed countries where the financial markets are well developed such as the US, OCED countries, and other European countries, whereas few studies focus on using data from emerging and developing economies where the financial markets are either emerging markets or underdeveloped markets such as Malaysia, India, Mexico, Turkey and Sri Lanka.

Testing the predictive power of the term structure, particularly its ability to predict the future changes in short term interest rates, is normally done by testing the validity of the Expectations hypothesis (EH). One of the main purposes of testing the validity of EH in most of the empirical works that use data from developing and emerging economies is to investigate the efficiency of the financial markets and the ability of these markets to be used as an efficient vehicle for monetary policy implementation. Moreover, the commonality among all these studies is the type of the interest rates that have been used for testing. Most of these studies use the money market interest rates as the main data set for testing mainly because the money market is the only well developed market in these economies. There is a common belief that the low quality of the economic data in the emerging and developing economies could be one of the reasons for the lack of proper research in this area. The main characteristics of the low quality data are: the data are not available for long periods, they may contain many missing values and or they may contain noise within.

This thesis focuses mainly on investigating whether the short end of the term structure has the ability to predict the future movements in short term interest rates and the inflation rate using data from a developing country: the case of Jordan. The main challenge in this thesis is dealing with low quality data. The first data set, the Jordanian Dinar interbank offered rate (JODIBOR), belongs to a newly established market; that is the Jordanian interbank market of different maturities, and the main limitation of this data set is that it is only available for a very short period. Moreover, due to the absence of regular issues of Government securities in the Jordanian financial market and due to the fact that the secondary market for Government securities is very thin during the period of the study, the second data set, the Central Bank of Jordan Certificates of Deposits (CDs), is chosen from the Jordanian primary market instead of the secondary market. The main limitations of the second data set are that it contains many missing values and there are just two maturities available for testing; i.e. the three and six months' interest rates. The first and the second data sets are used for testing the validity of the EH. The third data set is the monthly inflation rate and the main limitation of this set is that it contains noise within. The second and the third data sets are used for examining the information contents of the term structure about future inflation rate.

In this thesis, several advanced and most up-to-date econometrics techniques are used to examine the predictive power of the short end of the term structure and to deal with the limitations of the data sets particularly the missing values and the noisy data. In the case of the missing values, the main goal was to retain the main properties of the data set while estimating the missing values. Moreover, the noise within the monthly inflation rate series leads us to question whether the standard unit root tests are qualified enough to identify the true order of integration of the monthly inflation rate. This thesis provides robust evidence, through the Monte Carlo simulation, that in the case of noisy data the results of the standard unit root test; i.e. the Dickey Fuller (DF) test, are misleading and implausible.

The main objectives of this thesis are:

- Contributing to the literature by testing the ability of the short end of the term structure to predict the future movements in short term interest rates and the inflation rate for a developing country where part of the financial market is emerging and the other part is still underdeveloped.

- Exploring the efficiency and the potential of the newly established market; that is the Jordanian interbank market of different maturities, by studying the evolution of the market players' behaviour which is considered as one of the main issues that leads to the development of any market.

- Dealing with the low quality of the economic data in developing countries and this includes dealing with data sets that contain many missing values or contain noise within.

- Contributing to the literature that discusses the size distortion of the Dickey Fuller (DF) test by providing evidence that the size distortion of the DF test increases when the data set contains noise using Monte Carlo simulation.

The structure of the thesis is as follows:

Chapter two discusses the literature review that is related to the predictive power of the term structure of interest rates. The first part of this chapter concentrates on the empirical works that examine the ability of the term structure to predict the future movements in short term interest rates through testing the validity of the EH. The main focus is on the main theories that explain the term structure of interest rates and the empirical testing of the EH including the theoretical framework, the large variation in the methodologies and techniques, the countries involved, the data sets, the sample periods that have been used for testing and the findings of the empirical testing. In addition this part discusses the other implications of the Expectations theory such as the relationship between the Expectations theory and both the concept of market efficiency and the transmission mechanism of monetary policy.

The second part of this chapter concentrates on the empirical works that examine the ability of the term structure to predict the macroeconomic variables, particularly the inflation rate. Therefore, this part includes the empirical works that focus on examining whether the short term nominal interest rates contain useful information about the inflation rate through testing the validity of the Fisher hypothesis (FH) and the empirical works that focus on examining whether the slope of the term structure; i.e. the term spread, is an optimal predictor of the future inflation rate.

In chapter three, the validity of the EH is tested for the purpose of identifying whether the short end of the term structure has the ability to predict the future movements in short term interest rates. The Jordanian Dinar interbank offered rate (JODIBOR), which represents the term structure of interest rates in the Jordanian interbank market of different maturities, is used for testing. Three well known econometric techniques are employed to test the validity of the EH; the single equation regression, the VAR methodology (Campbell and Shiller 1987, 1991) and the cointegration analysis using the Johansen approach.

The first contribution of this chapter is to examine the predictive power of the short end of the term structure for Jordan for the first time. Since the data set that is used in this chapter belongs to the Jordanian interbank market of different maturities which is a relatively new market, the second contribution is to explore the evolution of the market players' behaviour; that is, studying the market players' ability to learn. The Time Varying Parameter test (TVP) is used as the main tool to examine the learning process. The empirical evidence of this chapter will shed light on the predictive power of the term structure in the Jordanian interbank market and accordingly on the efficiency of this market including identifying which part of the market is more active and has the highest potential for further development.

In chapter four, another attempt is carried out to examine the predictive power of the term structure; in particular the term structure in the Jordanian primary market. This chapter concentrates on testing the long run equilibrium relationship between interest rates of different maturities, using the EH as the main tool, and the Granger Causality relationship. A financial instrument from the Jordanian primary market is chosen for testing which is the Central Bank of Jordan Certificates of Deposits (CDs). The CDs are a monetary policy instrument and they are mainly used for liquidity management by the Central Bank of Jordan (CBJ). Moreover, the CDs have existed in the market for approximately ten years and they are considered by all market players to be a risk-free benchmark instrument. The main shortcomings of the CDs are that the CDs' term structure only consists of two main maturities; the three and six months, and the six month series contains many missing values.

In this chapter, several econometric techniques are employed for the empirical testing: the Spline smoothing function to estimate the missing values in the six month interest rate series, the cointegration analysis to test for the long run equilibrium relationship, the Error Correction Model (ECM) to test for the Granger Causality and the Impulse Response Function to test for the stability of the cointegrated systems. Moreover, in order to check the robustness of the findings that concern the direction of causality, a forward recursive cointegration analysis is employed. Furthermore, in this chapter the effect of structural breaks is addressed, particularly their effect on the results of the forward recursive cointegration analysis.

The main contribution of this chapter is to detect whether the EH holds for the term structure of interest rates in the Jordanian primary market. The subsidiary contribution is dealing with a data set that contains many missing values, and arguing that the Spline function that is used as a tool to estimate the missing values does not change the main properties of the data. The empirical evidence may imply important information about the predictive power of the CDs' term structure and accordingly the efficiency of the primary market.

In summary, chapters three and four have the same main objective, which is examining the ability of the short end of the term structure to predict the future movements in short term interest rates and identifying the efficiency of the Jordanian money market; that is, the Jordanian interbank market of different maturities and the primary market for the Central Bank of Jordan Certificates of Deposits.

Chapter five focuses on another important issue of the predictability of the term structure which is the ability of the term structure to predict the inflation rate. In this chapter, the main objective is to find out whether the short end of the term structure of interest rates contains useful information about the inflation rate in Jordan. Given the major outcome of chapter four which shows that the CDs' term structure has some predictive power, in this chapter the CDs' term structure is used with the monthly inflation rate for testing.

Two main tests are carried out to identify the information contents of the CDs' term structure. First the information content of the short term nominal interest rates is identified by testing the validity of the Fisher Hypothesis (FH). Second the information content of the slope of the term structure; i.e. the domestic term spread, is identified by testing whether there is a long run relationship between the domestic term spread and the inflation rate; that is, testing whether the two variables are bound together by a common trend.

Moreover, investigating the information contents of the term structure is extended to examine the influence of an additional variable on the predictability of the domestic term spread, particularly the variables that reflect the monetary policy stances, and for this purpose the Repo rate which is one of the CBJ key interest rates is used. Furthermore, given that the exchange rate regime in Jordan has been pegged to US dollars for a long time (since 1995), an investigation is carried out to test whether the US term spread contains important information about the Jordanian inflation rate.

The long run equilibrium relationship and the causality relationship between the variables are used as the major tools to define the information contents of the term structure. Several econometrics techniques are used for the empirical testing; the cointegration analysis to identify the long run equilibrium relationship, the Error Correction Model (ECM) to test for the Granger Causality and the Impulse Response and Variance Decomposition analyses are employed to examine the stability of the cointegrated systems and to identify the contribution of each explanatory variable on the variance fluctuations of the inflation rate.

Moreover, identifying the true order of integration of the targeted variables becomes an issue in this chapter. Given the properties of the major variables, the standard unit root tests such as the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) provide contradicting results. Therefore, additional tests are carried out to verify the true order of integration of some variables such as the Autoregressive Fractionally Integrated Moving Average analysis (ARFIMA) and the Spectrum analysis.

In addition, a Monte Carlo simulation is employed to prove that when the data set contains significant noise within, the results of the standard unit root tests such as the DF test are misleading and implausible. The Monte Carlo simulation provides robust evidence that in the case of noisy data the distribution of the t-statistic will be different from the distribution proposed by DF where the process is a pure random walk; hence using the standard critical values of DF test leads to a severe size distortion of the test.

Instead the Monte Carlo simulation suggests new sets of critical values that can be more reliable than the standard ones. The evidence that the size distortion of the DF test becomes larger as the noise increases in the data and faster as the sample size becomes bigger provides support to the literature that discusses the size distortion of the DF test.

The main contribution of this chapter is detecting whether the short end of the term structure contains useful information about the inflation rate in Jordan for the first time. The existence of the long run equilibrium relationship and the causality relationship between the main variables provides clear evidence about the effectiveness of the information contents of the term structure. In addition, the finding of Monte Carlo simulation is another key contribution.

In chapter six, the main conclusion of the thesis is described in detail. Moreover, further remarks and areas for potential future research are addressed.

LITERATURE REVIEW

2.1 *INTRODUCTION*

The substantial theoretical and empirical literature that focuses on the predictability of the term structure is an indication of the significance and uniqueness of the information contained in the term structure of interest rates.

In this chapter, we will address the literature review that is related to the predictive power of the term structure of interest rates; in particular the empirical works that examine the ability of the term structure to predict the future movements in short term interest rates and then the empirical works that examine the ability of the term structure to predict the macroeconomic variables particularly the inflation rate.

This chapter is organised as follows: Section two describes the main theories that explain the term structure of interest rates; sections three, four and five present the literature review that is related to the empirical testing of the Expectations Hypothesis (EH); section six discusses the literature review that is related to the term structure and the predictability of future inflation rate and section seven presents the conclusion.

2.2 *THE MAIN THEORIES OF THE TERM STRUCTURE OF INTEREST RATES*

2.2.1 *THE EXPECTATIONS THEORY (ET)*

The ET is considered the main theory of the term structure of interest rates because of its important implications in the prediction of the future movements in interest rates. The ET which is introduced by Irving Fisher (1930) states that long term interest rates are an average of current and expected future short term interest rates. The ET is based on the following main assumptions:

1- Market participants are risk neutral[1] and their behaviour is rational. Campbell and Shiller (1991) state that the rational expectations of future short term interest rates are the dominant factor that determines the current level of long term interest rates. This assumption is very important because the ET states that in equilibrium the current long term rates should equal the market's expectations of the average of current and future short term rates. Accordingly the financial instruments that have the same characteristics, except the term of maturity, can be considered a perfect substitution for each other; i.e. the return from holding a bond with (n) period to maturity where (n>1) should equal the return from holding a bond with one period to maturity and then roll it over (n) periods ahead, assuming that the transaction costs are minimal.

2- Market is efficient; information is available to all market players. The current interest rates and the expectations of future short term interest rates in the efficient markets are influenced by the changes in the information that affect the expectations of market players.

[1] Risk neutral indicates that market participants are indifferent to the level of risk.

The two main versions of the Expectations Hypothesis which have been used extensively by the researchers are the Pure Expectations Hypothesis (PEH) and the Expectations Hypothesis (EH). The main assumption under the PEH which is proposed by Lutz (1940) is that the term premia is assumed to be equal to zero while under the EH the term premia is assumed to be constant. The slope coefficient between the actual spread[2] and the perfect foresight spread or the theoretical spread[3] under both the PEH and the EH is considered to be equal one. Furthermore, the ET is one of the key theories that explain the shapes (slopes) of the term structure which mainly take the following shapes:

- The term structure takes the normal shape which is upward sloping when short term rate is currently low but it is expected to rise in the future.
- The term structure is downward sloping (also called inverted term structure) when short term rate is currently high but it is expected to fall in the future.
- The term structure is flat, when short term rate is expected to remain constant; therefore both the short term and long term rates are equal.
- The term structure is humped, when short and long term rates are almost equal while the medium term rate is higher than both rates.

[2] The actual spread is the simple difference between long and short term interest rates.

[3]The theoretical spread is calculated as the weighted sum of the expected changes of short term interest rates; the full details are described in section 2.3

2.2.2 THE LIQUIDITY PREFERENCE THEORY

This theory was introduced by Hicks in 1939 and it takes into consideration the risk preferences of the market participants. The main assumption under the liquidity preference hypothesis is that investors are risk averse so they prefer to hold short term bonds because they are more liquid and less risky, whereas in order to hold long term bonds they require higher liquidity premium as a compensation; the longer the maturity of the bond, the larger the liquidity premium they require, so the premium is not constant across different maturities. Accordingly current long term interest rates reflect the investors' expectations about future short term interest rates plus the liquidity premium. Because of the liquidity premium, the long term interest rate tends to be higher than the short term interest rate. In this case the slope of the term structure will be positive and the term structure will be upward sloping.

2.2.3 THE MARKET SEGMENTATION THEORY

This theory was introduced by Culbertson in 1957 and it takes into consideration investors' preferences in respect of financial assets maturities. The main assumption of the market segmentation hypothesis is that market participants are also risk averse as in the liquidity preference hypothesis. According to Culbertson this theory explains the role that the institutions play in shaping the term structure of interest rates. The institutions normally like to invest their funds in maturities that match the maturities of their liabilities; for example if their liabilities have long term maturities then they prefer to place their funds in long term investments, so in order to invest in short term investments they need to be compensated with a premium.

This also true for the institutions that have short term liabilities, in that they prefer to invest their money in short term investments, and in order to change to longer term investments they need also to be compensated with a premium. In view of that, separate markets will be found and the yields in these markets will be determined solely by the demand and supply for the financial assets. Furthermore, the large demand for specific maturity may affect the shape of the term structure; for example when the demand for short term bonds increases significantly, the prices will increase and the yields will decrease. On the other hand, the demand for long term bonds will decrease, and this will cause the prices to decrease and yields to increase. As a result, the term structure will take the normal shape which is upward sloping.

2.2.4 *THE PREFERRED HABITAT THEORY*

This theory was introduced by Modigliani and Sutch (1966) and the main assumption within this theory is that investors are risk averse and have different investment horizons; i.e. invest only in long term debt or only in short term debt, and in order to invest in financial instruments out of their habitat they have to be compensated with premium. This theory is a combination of the market segmentation theory and the ET.

The main aspect of the last three theories is that they explain why the term premium is not constant in some cases.

2.3 *THE TERM STRUTURE AND THE PREDICTABILITY OF FUTURE MOVEMENTS IN SHORT TERM INTEREST RATES*

The ability of the term structure to predict future movements in short term interest rates is normally identified by examining the validity of the Expectations Hypothesis (EH). The EH states that the term spread; i.e. the slope of the term structure, is an optimal predictor of the expected changes in future short term interest rates.

The researchers who use the PEH or the EH believe that if the term premia is zero or constant then all the changes in the current long term interest rates should be explained only by the expected changes in future short term interest rates. The theoretical framework of the EH is described in detail in the following section. A further section covers the key elements of the empirical testing of the EH.

2.3.1 *THE THEORETICAL FRAMEWORK OF THE EXPECTATIONS HYPOTHESIS*

The ET of the term structure of interest rates is about the relationship between the long term interest rates, (n) period interest rate R_t^n, and the short term interest rates, (m) period interest rate r_t^m. The following general form of the expectations model is borrowed from Patterson (2000). It represents the simple version of the expectations model which has been used in most of the empirical studies of the term structure.

$$R_t^n = \left(\frac{1}{k}\right) \sum_{i=1}^{k} E_t r_{t+(i-1)m}^m + Tp_t^m \qquad \text{Eq2.3.1.1}$$

Where k $= \dfrac{n}{m}$

Equation (2.3.1.1) says that a long term interest rate is a weighted average of the current and expected future short term interest rates plus a term premium (Tp_t^m). According to the PEH the term premium (Tp_t^m) is assumed to be equal to zero while under the EH, the term premium (Tp_t^m) is assumed to be constant. Equation (2.3.1.1) has been derived as follows:

The long term interest rate at current time (t) is equal to the weighted average of the actual short term interest rate at current time (t) and subsequent sequence of short term forward rates.

$$R_t^n = \left(\frac{1}{k}\right) \sum_{i=1}^{k} F_{t+(i-1)m}^m \qquad \text{Eq 2.3.1.2}$$

Example: if n=3 and m=1 then k= $\dfrac{n}{m}$ = 3

$$R_t^3 = \frac{1}{3}[r_t^1 + F_{t+1}^1 + F_{t+2}^1]$$

So the actual long term interest rate R_t^3 is equal to the weighted average of the actual one period yield to maturity (r_t^1) and two subsequent sequences of one period forward rates (F^{1}_{t+1} and F^{1}_{t+2}). The idea here simply means that in an efficient market the return from holding (n) periods bond at time (t) or from holding a sequence of shorter periods (m) bonds should be equal and if it does not, any arbitrage opportunity will disappear quickly as the market is efficient.

The forward rates can be rewritten in the form of actual rates as follows:

$$\mathrm{F}^{m}_{t+j} = \mathrm{E}_{t}\ (r^{m}_{t+j})\ +\ \tau^{m}_{t+j} \qquad \text{Eq 2.3.1.3}$$

The explanation of this form is that (m) period forward rate $(t+j)$ is equal to the expected (m) period rate for the period $(t+j)$ plus an additional factor (τ^{m}_{t+j}) which represents the term premia. According to the previous example where n=3 and m=1, the forward rates can be written as follows:

$$F^{1}_{t+1} = E_{t}\ (r^{1}_{t+1})\ +\tau^{1}_{t+1}$$

$$F^{1}_{t+2} = E_{t}\ (r^{1}_{t+2}) +\ \tau^{1}_{t+2}$$

Substitute Eq (2.3.1.3) in Eq (2.3.1.2), the result will be Eq (2.3.1.1):

$$R^{n}_{t} = \left(\frac{1}{k}\right) \sum_{i=1}^{k} E_{t} r^{m}_{t+(i-1)m}\ +\ Tp^{m}_{t}$$

Where $Tp^{m}_{t} = \left(\frac{1}{k}\right)$ [$\sum_{i=1}^{k} \tau^{m}_{t+(i-1)m}$], represents the term premia.

To clarify the idea of the expectations model, the following example is about the relationship between the three month interest rate and the one month interest rate of a pure discount rate bond. This relationship had been tested extensively in the literature, especially in terms of the validity of the EH at the short end of the term structure.

n = 3 month, m = 1 month, so k = $\frac{3}{1}$ = 3.

According to equation (2.3.1.1),

$$R_t^n = \left(\frac{1}{k}\right) \sum_{i=1}^{k} E_t r_{t+(i-1)m}^m + Tp_t^m$$

$$R_t^3 = \frac{1}{3} \; [\; E_t(\; r_t^1) \; + E_t(r_{t+1}^1) + \; E_t(\; r_{t+2}^1)] + Tp_t^1$$

According to the rational expectations hypothesis:

$E_t(\; r_t^1) = \; r_t^1$ at time (t), so

$$R_t^3 = \frac{1}{3} \; [r_t^1 + E_t(r_{t+1}^1) + E_t(\; r_{t+2}^1)] + Tp_t^1$$

The above equation means that the three month interest rate is a simple weighted average of a one period actual interest rate at current time (t) and the one period expected interest rates at time (t+1 and t+2) plus a term premium. The weights are sum to one. Under the main assumption that the term premia is constant or zero, the changes in the long term interest rates will occur as a result of the expected changes in future short term interest rates. Therefore, the current three month interest rate should increase if the future one month interest rates at time (t+1 and t+2) are expected to increase.

Regarding the financial instruments that are coupon carrying, the relationship between the long term interest rate and the short term interest rate for a coupon carrying bond is described in the following model:

$$R_t^n = \left(\frac{1-\gamma}{1-\gamma^k}\right)\sum_{i=1}^{k-1}\gamma^i E_t r_{t+(i-1)m}^m + Tp_t^m$$

The long rate in this case is not a simple average of current and expected future short term interest rates. The weights are exponentially declining so the expected rates in the near future receive the largest weight while the rates in the distant future receive smaller weight, and the scale (1-γ^k) is set to ensure that the total of the weights sums to one. According to Shiller (1979) the parameter $\gamma = 1/(1+\bar{R})$ relates the long term interest rates (R_t^n) to the present value of future short term interest rates discounted by ($\bar{R}$). This model is appropriate for coupon carrying bonds which are selling near par or for consols (perpetuities bonds) with $n = \infty$.

2.3.1.1 *THE SPREAD*

According to the ET, the spread is as an optimal forecast of the expected changes in future short term interest rates plus a term premia (Campbell and Shiller (1991). The spread between the (n) period rate and (m) period rate is represented as $S_t^{(n,m)} =$

R_t^n - r_t^m. The slope of the term structure is affected by the sign of the spread; if the spread is positive then the slope of the term structure will be upward and this means that long term interest rate is higher than short term interest rate which indicates that the expected future short term rates are going to rise.

The spread model Eq (2.3.1.1.1) is derived by subtracting r_t^m from both sides of Eq (2.3.1.1) and rearranging terms,

$$(R_t^n - r_t^m) = \sum_{i=1}^{k-1} \left(1 - \frac{i}{k}\right) E_t(\Delta^m r_{t+im}^m) + Tp_t^m \qquad \text{Eq 2.3.1.1.1}$$

The left hand side describes the actual spread (i.e. $S_t^{(n,m)}$), and the right hand side represents the term premia (Tp_t^m) plus the perfect foresight spread (PFS) which was mainly developed by Campbell and Shiller (1991).

According to Campbell and Shiller (1991), the perfect foresight spread is obtained if there is perfect foresight about future interest rates. With perfect foresight, if (m) period rates are going to rise over the life of the (n) period, then the current (n) period yield needs to be higher than the current (m) period yield, so the return on the (n) period bond which is held to maturity equals the return on a sequence of (m) period bonds.

So $$PFS_t^{(n,m)} = \sum_{i=1}^{k-1} \left(1 - \frac{i}{k}\right) E_t(\Delta^m r_{t+im}^m)$$

Where the Δ^m indicates that the change is measured over (m) periods,

$$\Delta^m \, r^m_{t+im} = r^m_{t+im} - r^m_{t+(i-1)m}$$

The main idea of equation (2.3.1.1.1) is that the actual spread forecasts a weighted average of changes in short term interest rates over (n) period. To clarify the idea of equation (2.3.1.1.1), the following example represents the relationship between the six and three months' interest rates.

n = 6 month, m = 3 month, so k = $\frac{6}{3}$ = 2.

According to equation (2.3.1.1):

$$R^n_t = \left(\frac{1}{k}\right) \sum_{i=1}^{k} E_t r^m_{t+(i-1)m} + Tp^m_t \ , \quad \text{then}$$

$$R^6_t = \frac{1}{2} \ [\ E_t\ (r^3_t) + \ E_t\ (r^3_{t+3})] + Tp^3_t$$

According to the rational expectations hypothesis,

$$E_t\ (r^3_t) = r^3_t \qquad \text{then,}$$

$$R^6_t = \frac{1}{2} \ [\, r^3_t + \ E_t\ (r^3_{t+3})] + Tp^3_t$$

By subtracting (r^3_t) from both sides and rearranging the equation, the spread becomes as follows:

$$(R_t^6 - r_t^3) = \frac{1}{2} E_t (r_{t+3}^3 - r_t^3) + Tp_t^3$$

According to the rational expectations hypothesis, equation (2.3.1.1.1) can be formed as follows:

$$r^{m}_{(t+im)} = E_t (r^{m}_{(t+im)}) + \varepsilon^{m}_{(t+im)}$$

This means that the actual interest rates that will be obtained at time (t+i) will equal the expected value of the interest rate in period (t) for the period (t+i) plus an error term.

So $\quad E_t (r^{m}_{(t+im)}) = r^{m}_{(t+im)} - \varepsilon^{m}_{(t+im)}$

And $\quad E_t (r^{m}_{(t+(i-1)m)}) = r^{m}_{(t+(i-1)m)} - \varepsilon^{m}_{(t+(i-1)m)}$

$E_t(\Delta^m r^m_{t+im}) = E_t (r^{m}_{(t+im)}) - E_t (r^{m}_{(t+(i-1)m)})$, so

$$E_t(\Delta^m r^m_{t+im}) = \Delta^m r^m_{t+im} - \Delta^m \varepsilon^{m}_{(t+im)} \qquad \text{Eq 2.3.1.1.2}$$

By substituting Eq (2.3.1.1.2) in Eq (2.3.1.1.1), the spread becomes:

$$(R_t^n - r_t^m) = \sum_{i=1}^{k-1} \left(1 - \frac{i}{k}\right)(\Delta^m r^m_{t+im}) + \varpi_t^m + Tp_t^m \qquad \text{Eq 2.3.1.1.3}$$

Where $\varpi_t^m = \sum_{i=1}^{k-1} -\frac{i}{k} \varepsilon^{m}_{(t+im)}$, represents the weighted average of expectations errors.

To test the predictive power of the spread (R_t^n-r_t^m) in an acceptable form, Equation (2.3.1.1.3) is rearranged. The actual spread which is represented in the following model should predict the changes in short term rates over the (n-m) period horizon.

$$\sum_{i=1}^{k-1} \left(1-\frac{i}{k}\right)(\Delta^m\ r_{t+im}^m) = \alpha+\beta\ (R_t^n\text{-}r_t^m) + \varpi_t^m \qquad \text{Eq 2.3.1.1.4}$$

or

$$PFS\ = \alpha+\beta\ (R_t^n\text{-}\ r_t^m) + \varpi_t^m$$

The left hand side represents the perfect foresight spread. The main reason for this rearrangement is that PFS and ϖ_t^m are correlated which means that the OLS estimator of the coefficient slope β will be inconsistent. Therefore Campbell and Shiller (1991) and other economists have rearranged equation (2.3.1.1.3) to take the form of equation (2.3.1.1.4) in which the spread (R_t^n-r_t^m) is a variable at time (t) so it is uncorrelated with the expectations errors (ϖ_t^m). Accordingly the OLS estimator of β will be consistent (Patterson 2000).

Moreover, the literature shows that many researchers were interested in examining whether the term spread is an optimal predictor for the changes in long term interest rates over the short term horizon and for this purpose they use the following model which is also derived from equation (2.3.1.1).

$$(R_{t+m}^{(n-m)} - R_t^n) = \psi + \lambda\ (R_t^n\text{-}r_t^m) + \upsilon_t$$

Under this model, the following two null hypotheses are normally tested:

$H_0 : \psi = 0$ and $H_0 : \lambda = 1$.

2.3.2 *THE KEY ELEMENTS OF THE EMPIRICAL TESTING OF THE EXPECTATIONS HYPOTHESIS*

2.3.2.1 *TESTING METHODOLOGIES*

Three main methodologies have been used in the empirical testing of the EH and they are the single equation regression, the vector autoregressive (VAR) methodology and the cointegration analysis.

Based on the main idea of the EH which states that the actual spread or the perfect foresight spread (PFS) is an optimal forecast of the expected changes in future short term interest rates; that in the single equation regression the perfect foresight spread is regressed onto the actual spread and the EH is considered valid if the estimated coefficient equals one. Campbell and Shiller (1991) declare that although the single equation regression has great merit in its simplicity, this method does however contain major shortcomings. First the regression of the (PFS) onto the actual spread involves n-period overlapping errors; that is the error term of the regression equation follows a moving average process, and although the econometric methods such as Newey West (1987) provides solutions to correct for the overlapping errors, the correction does not work properly if the degree of overlapping is very large. Second, the single equation regression does not provide robust evidence of whether the movements of the actual spread and the theoretical spread are similar.

In order to overcome the shortcomings of the single equation regression, Campbell and Shiller (1987, 1991) introduced the VAR methodology[4]. The key difference between the two methods is the underlying assumption under each one. For instance, strong rationality is the main assumption under the single equation regression while weak rationality is the main assumption under the VAR methodology. Strong rationality means that economic agents have perfect foresight about the changes in future short term interest rates (Campbell and Shiller 1991), while weak rationality means that economic agents build their decisions and expectations on a limited set of information (Campbell and Shiller 1991, Cuthbertson 1996). According to Campbell and Shiller (1991) the actual spread should be one of the main components of this limited set of information because it normally contains embedded information that can help in predicting the changes in future short term interest rates. In addition, the VAR methodology does not suffer from the problem of overlapping errors.

Regarding the cointegration analysis, based on the main idea of the ET that there is a common trend between short and long term interest rates; i.e. the changes in short term interest rates have an impact on the long term interest rates, the cointegration analysis which is considered the main tool that identifies the common trend between different maturities of interest rates became the most widely used method for testing the EH

Under the cointegration analysis, two null hypothesis are normally tested; the first one is to examine whether short and long term interest rates are cointegrated; that is whether both rates share a common trend, and the second one is to test whether they are

[4] The full details of the VAR methodology are described in chapter three.

cointegrated with a cointegrating vector of (1,-1); i.e. test whether the identified cointegrating vector complies with the EH.

The above three methods have been employed in the studies in various ways. For example Hurn, Moody and Muscatelli (1995), Cuthbertson, Hayes and Nitzsche (1996), Lange (1999), Cuthbertson and Bredin (2000), and Mylonidis and Nikolaidou (2002) test the validity of the EH using the three methods in their studies. Whereas Cuthbertson (1996), and Fang and Lee (2003) use the VAR methodology supplemented by the cointegration analysis, Guest and Mclean (1998) and Konstantinou (2005) use the single equation regression and the cointegration analysis, and Boero and Torricelli (2002) use just the single equation regression. Moreover, many researchers use only the cointegration analysis for testing such as Hall, Anderson and Granger (1992), Shea (1992), Cuthbertson, Hayes and Nitzsche (1998), Bremnes, Gjerde and Saettem (2001), Drakos (2002), Ghazali and Low (2002), Cooray (2003), Shivam and Jayadev (2004) and Musti and D'Ecclesia (2008).

In addition, the empirical testing of the EH varies as well in the ways the researchers choose to conduct their regressions such as using the standard regression or the non standard regression for estimation. Under the standard regression, the estimation requires the maturity of the long term interest rates to be equal to twice that of short term interest rates, while under the non standard regression the estimation does not require this type of relationship; for instance many researchers examine the predictive power of the spread between one period interest rates and long term rates at various maturities (Cook and Hahn 1990).

Regarding the standard regression, Shiller et al. (1983), and Mankiw and Miron (1986) use the six and three months interest rates to calculate the three month forward rate three months ahead in the future. Regarding the non standard regression, Hardouvelis (1994) examines the behaviour of the three month and 10 year interest rates. Other researchers use both regressions (the standard and the non standard) in the same study such as Cuthberston (1996) who examines the predictive power of the spread with different combinations of LIBOR; under the standard regression he examines the spread of the following combinations (26,13) weeks and (52,26) weeks, while under the non standard regression he examines the following spreads; (4,1) weeks, (13,1) weeks, (26,1) weeks, (52,1) weeks, (52,4) weeks, and (52,13) weeks[5].

2.3.2.2 *THE FINANCIAL INSTRUMENTS THAT ARE USED FOR TESTING*

The empirical literature shows a great variation in the types of financial instruments, the maturities of interest rates (i.e. the short end and or the medium term and or the long end of the term structure), the chosen countries, and the samples periods that have been used for testing the EH.

[5]The following researchers also use both the standard regression and the non standard regression to examine the predictive power of the spread:
Hurn, Moody and Muscatelli (1995); under the standard regression they examine the spreads of the following combinations (6,3) months and (12,6) months, while under the non standard they examine the following spreads: (3,1) months, (6,1) months, (12,1) months, and (12,3) months. Cuthbertson, Hayes and Nitzsche (1996), under the standard regression they examine the spreads of the following combinations (52,26) weeks and (26,13) weeks, while under the non standard they examine the following spreads: (52,13) weeks, (52,4) weeks, and (39,13) weeks. Cuthbertson and Bredin (2000), under the standard regression they examine the spread (6,3) months, while under the non standard they examine the following spreads: (6,1) months, and (3,1) months. For more studies please see Engsted and Tanggaard (1995) and Cuthbertson, Hayes and Nitzsche (1998).

Regarding the financial instruments, various types of financial instruments have been used (i.e. money market instruments, capital market instruments or both). Most of the studies use the Government debt securities such as Treasury bills (i.e. discounted paper) and fixed income securities with coupon payments. The main characteristics of the Government securities such as the low default risk, the high liquidity and most importantly the availability of high quality data[6] make them the most appropriate financial instruments to be used for testing. The main instrument that has been used extensively in testing the EH is the Treasury bills which is a zero coupon bond.

Moreover, the new approaches and techniques that have been developed for testing the EH enable researchers to use various types of financial instruments besides the Government securities. Some of these financial instruments have same characteristics as the zero coupon bonds; that is, there are no coupon payments during the life of the financial instruments, such as the interbank offer rate and the Repo rate[7]. The interbank offer rate has been used in several studies such as those of Cuthburtson (1996) who uses the (LIBOR), Konstantinou (2005) who uses the (WIBOR), and Mylonidis and Nikolaidou (2002) who use the (Athibor Euribor), while the Repo rate is used in the studies of Longstaff (2000), Della Corte et al. (2008) and Brown et al. (2008).

Longstaff (2000) chooses the Repo rate to test the EH because it has similar characteristics as the yields on the Government securities; i.e. the return is risk free

[6] The high quality data means the availability of data for long periods, for example the data set that has been used in Mankiw and Miron study (1986) is a very high quality data because it covers almost 90 years from 1890 till 1979.

[7] The interbank offer rate and the Repo rate are non Government securities.

because the Repo transactions are collateralised and the Repo market is very efficient and active which means that the liquidity is very high. The key elements of this study consider the collateralised Repo rate a main instrument for riskless rate which is required by the ET and they use the extreme short end of the term structure such as the overnight and one week Repo rates. The findings of this study indicate that the EH cannot be rejected. However, Della Corte et al. (2008) extend the work of Longstaff (2000) by reexamining the validity of the EH using the Repo rate for maturities from overnight to three months and by applying two different procedures for testing. The first one is a statistical test that is designed to increase the test's power so they use the VAR methodology and test the restrictions that are imposed by the EH using Bakaert and Hodrick's (2001) procedure, and the second test assesses the economic value of the departure from the EH based on the criteria of profitability and economic significance in the context of a simple trading strategy.

The findings indicate that the EH is rejected when they use the statistical test which means that their findings do not comply with those of Longstaff. They attribute the rejection to the fact that they use different tests to Longstaff and longer maturities. Moreover, the findings of the second test comply with Longstaff's findings and indicate that the EH holds. Their main conclusion complies with Campbell and Shiller (1991) in saying that the rejection of the EH in statistical ground does not indicate that the EH is rejected on economic grounds.

Moreover, Brown et al. (2008) investigate the robustness of Longstaff's findings by reexamining the EH using the Repo rate over two different sample periods; the first one covers most of Longstaff's sample period from May 1991 until July 1997 while the second period pre-dates Longstaff's sample from February 1984 until May 1991. The findings indicate that the EH is rejected for each maturity in the sample that pre-dates Longstaff's sample while in the sample that covers most of Longstaff's period, the EH is rejected just for one and two weeks. They conclude that their results imply that the EH holds when the interest rates are less volitale and Longstaff's strong support for the EH appears to be sample specific.

Some studies use the estimated term structure and the advantage of using the estimated term structure over other types of data because it enables the researchers to examine a wide range of maturities and to provide more comprehensive results than other data sets. The main disadvantage of using the estimated term structure is the measurement errors which can be overcome by using the instrumental variables. Boero and Torricelli (2002) test the EH using new data for Germany and the main element of their data set is that it is derived from estimated term structure. In order to correct for possible measurement errors in the data they use instrumental variables which improve the estimation of the coefficient; that is, it was close to one. In addition, the findings show that the changes in long and short term interest rates are consistent with the EH under the German term structure.

Another case of testing the EH using data that is derived from estimated term structure is the study of Rossi (1996) who used two types of the UK money market rates, the London interbank middle market rates (LIMEAN) and the Gilt yields. The findings of this study were mixed; they show that the EH cannot be rejected when LIMEAN rates are used, but when Gilt yields are used the results did not support the EH. The author declares that the LIMEAN rates represent the market determined rates while Gilt yields are fitted yields and they mainly depend on the fitting procedure; therefore there is difference in the prediction.

Few studies examine the EH using survey data such as the studies of Froots (1989) and Luthman (2004). Froots (1989) was one of the leading researchers who tested the EH jointly with the rational hypothesis using survey data. The survey is designed to target specific market players and the main purpose is to collect information about their expectations of future interest rates. Froots decomposed the spread's bias into two components, the risk premium and the systematic expectation error. The main contribution of the Froots' study is determining to what extent the time varying risk premia and an expectation error can contribute to the rejection of the EH.

It is believed that the main shortcoming from using survey data is that the expectations of interest rates may not reflect the real decisions and behaviours of market participants. Market participants may provide unrealistic expectations for the survey provided that they will not bear any liability in case their expectations are wrong and they will not be rewarded either if their expectations are correct (Luthman 2004).

Regarding the maturities of interest rates, many of the researchers concentrate on the short end of the term structure using money market interest rates such as Fama (1984), Gerlach and Smets (1995), Cuthbertson (1996), Cuthbertson, Hayes and Nitzsche (1996,1998), Hsu and Kugler (1997), Gonzalez, Spencer and Walz (1999), Bredin and Cuthbertson (2000), Longstaff (2000), Mylonidis and Nikolaidou (2002), Cooray (2003), Shivam and Jayadev (2004) and Konstantinou (2005). Researchers like Longstaff (2000), who uses the extreme short end of the term structure, believe that if the EH cannot explain how the very short term interest rates are related then it cannot explain the rest of the term structure. Some researchers concentrate just on the long end of the term structure such as Fama and Bliss (1987) and Cuthbertson and Nitzche (2003), and others use the entire length of the term structure through combining both the short and long term interest rates in their studies such as Campbell and Shiller (1991), Taylor (1992), Hardouvelis (1994), Rossi (1996), Guest and Mclean (1998), Guthrei, Wright and Yu (1999), Lange (1999), Boero and Torricelli (2002), Chazali and Low (2002), and Christiansen et al. (2002).

2.4 *THE FINDINGS OF THE EMPIRICAL TESTING OF THE EXPECTATIONS HYPOTHESIS (EH)*

The findings of the empirical testing of the EH vary between rejection and non rejection of the EH. The empirical literature of the EH shows that the EH has been rejected in most of the earlier works, especially in the studies that use US data such as the studies of Campbell and Shiller (1991), Hardouvelis (1994), Johnsen (1997) and Bekaert and Hodrick (2001), and recent studies such as Sarno, Thornton and Valente (2007). In addition, the following studies test the EH using data from countries other than the US and their findings also indicate the rejection of the EH such as Shen (1998), Mylonidis and Nikolaidou (2002), and Cooray (2003).

Moreover, many studies test the EH using data from different developed and developing economies and their findings provide support to the EH such as the studies of Tease (1988), Hall, Anderson and Granger (1992), Gerlach and Smets (1995), Hurn, Moody and Muscatelli (1995), Hsu and Kugler (1997), Gonzalez, Spencer and Walz (1999), Lange (1999), Cuthbertson and Bredin (2000), Longstaff (2000), Boero and Torricelli (2002), Drakos (2002), Ghazali and Low (2002), Fang and Lee (2003), Shivam and Jayadev (2004), Konstantinou (2005), and Musti and D'Ecclesia (2008). Other studies such as Mankiw and Miron (1986), Engsted and Tanggaard (1995), Cuthbertson (1996), Cuthbertson, Hayes and Nitzsche (1996, 1998), Rossi (1996), and Christiansen et al.(2002) test the EH using the entire term structure (both the short end and the long end), different tests, different instruments and different sample periods and their findings were mixed between rejection and non rejection of the EH. In the following section we will focus on the part of the literature review that addresses the main reasons for rejection.

2.4.1 *THE REJECTION OF THE EXPECTATIONS HYPOTHESIS*

The rejection of the EH is attributed to some key reasons such as the existence of estimation problems particularly at the beginnings; that the term premia is time varying and not constant or equal to zero as assumed under the EH or the PEH respectively, the monetary policy targeting especially in the studies that use US data, the irrational behaviour of market players, and the different behaviour between long and short term interest rates; i.e. The Campbell and Shiller Paradox (CSP), where the term spread predicts the wrong direction in the subsequent changes in long term interest rates over a short term horizon.

2.4.1.1 THE ESTIMATION PROBLEMS

The extensive research and the varied results and evidences of the validity of the EH open the door for many economists to investigate the reasons behind this phenomenon. One of the main arguments about the failure of the tests especially at the beginning is the existence of estimation problems. This complies with the declaration of Campbell and Shiller (1991) that the EH is rejected on statistical grounds but not on economic grounds. Anderson et al. (1997) explain the main estimation problems under the empirical testing of the EH as follows:

First: Most of the studies identify the order of integration of interest rate in level to be on the borderline between stationarity and non stationarity. In the empirical literature the interest rate in level is assumed to be a non stationary time series; accordingly it is believed that the statistical inference from modeling the interest rate in level can be misleading and unreliable; i.e. "Spurious regression". In order to overcome this problem, researchers tend to use the term spread which is assumed to be stationary I(0) instead of the interest rate in level. Moreover, using the cointegration analysis to examine the validity of the EH provides a solution to the problem of dealing with nonstationary variables because under this technique the EH is considered valid if the non stationary interest rates with different maturities are cointegrated with a cointegrating vector of (1,-1); that is when long term interest rate is regressed on short term interest rate or vice versa and the combination of both rates; i.e. the residuals (the spread), is found to be stationary as well as having coefficient of unity.

Second: Dealing with coupon carrying bonds instead of zero coupon bonds was an issue for some studies. In most of the studies, the main instrument that has been used for testing the validity of the EH is the zero coupon bonds and the main reason behind using them is because they can easily and directly be substituted in the equation of the simple version of the EH[8] while the coupon carrying bonds cannot. The coupon carrying bonds have a series of cash flows (i.e. coupon payments) and the sizes of the coupon payments between issues are different, so there is a problem in how to compare them directly. To overcome this problem Shiller et al. (1983) propose a simple approximation that allows for a direct comparison between coupon carrying bonds.

Third: Dealing with overlapping errors problem which occurs when the maturity of the difference between long and short term interest rates is longer than the frequency of the data, so the residuals of the estimated equation ; i.e the expectation model, will be subjected to a moving average error process. In order to overcome this problem, researchers tend to lengthen the data frequency to match the maturity of the difference; but this procedure causes many observations to be lost. The researchers overcome the overlapping problem by using the GMM estimator (the Generalized Method of Moments) which provides robust standard errors in the presence of overlapping errors especially when the sample size is large. The GMM estimator is also robust for heteroskedasticity which is considered a potential problem in bond yields data.

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[8] The simple version of the EH is explained in section 2.3.

Fourth: Dealing with the measurement errors which are described by Mankiw (1986) as an econometric measurement error. This problem is solved by using instrumental variables.

2.4.1.2 THE TERM PREMIA

One of the main reasons that causes the EH to be rejected, as indicated in many key studies such as Fama (1984), Mankiw and Miron (1986) and Campbell and Shiller (1991), is that the term premia is assumed to be equal to zero or constant under the PEH and EH respectively, but in fact it may vary all the time in an unpredictable way. The researchers who investigate the properties of the term premia emphasise that the assumption of the term premia under the PEH or the EH is unrealistic and limited, such as Fama (1984).

Regarding the impact of the time varying term premia, some key studies such as Fama (1984), Mankiw and Miron (1986), and Campbell and Shiller (1991) reach a conclusion that the time varying term premia has a major impact on the long term interest rates; therefore the changes in long term interest rates can be caused by both the expected changes in short term rates and by the time varying term premia.

Fama (1984) is one of the key studies that concentrates on the subject of time varying term premia. Fama declares that the forward rates contain information about future spot rates and term premia. He uses US data and introduces a new regression approach to explore the information embedded in the forward rates for both the expected changes in future spot rates and the term premia. The findings from this study were striking and

Fama proves through his model that the forward spot differential measures the variation in both the term premia and future spot rates, so the forward rates have a power as a predictor for both. By using the new regression approach, Fama presents a new view on the joint variation of the expected term premia and future spot rates which are embedded in the forward rates.

Mankiw and Miron (1986) declare that the rejection of the EH after the Federal reserve founding is attributed to the Federal Reserve policy of smoothing the interest rates and to the time varying term premia. They declare that these reasons may cause the rejection of the EH in most of the studies that examine the EH using US data particularly over the periods after the Federal Reserve founding. Mankiw and Miron explain why the EH worked better prior to the Federal Reserve than after as follows:

The model that has been used for testing the EH takes the following form:

$$(r_{t+1} - r_t) = \alpha + \beta(R_t - r_t) + \upsilon_{t+1}$$

Where

(R_t)	is the yield on a two-period bill.
(r_t)	is the yield on a one-period bill
$(r_{t+1} - r_t)$	is the changes in short term interest rates.
$(R_t - r_t)$	is the spread between long and short term interest rates.
$\alpha = -2\theta$	is the term premia and it is assumed to be constant.
$\beta = 2$	is the coefficient of the spread $(R_t - r_t)$.

The null hypothesis that $\beta = 2$ is rejected for all the periods that have been tested after the founding of the Federal Reserve (after 1915), but it is not rejected in the period before (pre 1915). The non rejection of the null hypothesis $\beta = 2$ is attributed to the fact that the interest rates were very volatile before 1915, while after 1915 they become much smoother. Mankiw and Miron simply explain this fact by showing how the estimate of the slope (β) is affected by having very volatile interest rates and constant term premia or smoother interest rates and slightly time varying term premia.

The slope β = $\dfrac{2Var[E_t \Delta r_{t+1}] + 4Cov[E_t \Delta r_{t+1}, \theta_t]}{Var[E_t \Delta r_{t+1}] + 4Var[\theta_t] + 4Cov[E_t \Delta r_{t+1}, \theta_t]}$

The volatile interest rates will cause the $(Var[E_t \Delta r_{t+1}]$ to be very large (i.e. $(Var[E_t \Delta r_{t+1}] \rightarrow \infty)$ and assuming the term premia is constant so all the variance and covariance that are related to the parameter (θ) will equal zero; therefore the null hypothesis $\beta = 2$ most likely will not be rejected. However if the interest rates are smoother then the $(Var[E_t \Delta r_{t+1}]$ will be very small (i.e. $(Var[E_t \Delta r_{t+1}] \approx 0)$ and if the term premia is time varying then the parameter β may not equal two; i.e. $\beta \neq 2$, accordingly the EH is most likely will be rejected. The main contribution of Mankiw and Miron lies in providing important intuition behind the empirical rejection of the EH even when it is true given that certain conditions hold[9].

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[9]For further details about Mankiw and Miron paper (1986), please see the notes of Weerapana on the Web page http://www.wellesley.edu/Economics/weerapana/econ331/econ331pdf/lect331-10.pdf.

Nevertheless, Mankiw and Miron's (MM) findings have attracted criticism. Kool and Thorton (2004) study the main findings of Mankiw and Miron (1986) and show that the findings of (MM) are mainly due to the model that has been used in their study which tends to generate results that are more favorable to the EH especially when the short term interest rate are more volatile than the long term interest rates. Moreover, Kool and Thornton prove that the results of (MM) are due mainly to three extreme observations in the short term rates during the financial panic of 1907, so when the effect of these three observations is taken away, the test generates different results to the original results of (MM); i.e. “The test does not generate results that are favorable to the EH before the Fed founding than after”[10].

Moreover, Campbell and Shiller (1991) in their seminal paper state that if the EH is found to be valid then the ET adequately describes the term structure and this means that the rational expectations of future interest rates are the dominant force that determine the current long term rates; however if the EH does not hold then the predictable changes in excess returns, i.e. the term premia, could be the main reason for the movements in the term structure[11].

They examine the EH using monthly data of US Treasury bills, notes and bond prices. The yields are calculated by McCulloch (1990), where McCulloch’s monthly term structure data give pure discount (zero coupon) bond yields for US Government securities. They examine all possible pairs of maturities in the range of 1,2,3,4,6 and 9 months and 1,2,3,4,5,and 10 years.

[10] Kool and Thornton (2004), p. 3067.

[11] Campbell and Shiller (1991), p. 495.

The major contribution of Campbell and Shiller is developing the VAR methodology to test the EH. Campbell and Shiller concentrate on the spread between short and long term interest rates and their testing approach for the EH relies on a comparison of the evolution of actual and theoretical spreads. Many researchers follow Campbell and Shiller and use the VAR methodology for testing the EH such as Hurn, Moody and Muscatelli (1995), Cuthbertson (1996), Cuthbertson, Hayes and Nitzsche (1996), Lange (1999), Cuthbertson and Bredin (2000), Mylonidis and Nikolaidou (2002), and Fang and Lee (2003).

The main findings of Campbell and Shiller's study is that the EH does not hold and the rejection is attributed to the following reasons; risk premium is time varying, and the long term rates overreact to the expected changes in short term rates and irrational expectations.

2.4.1.3 *MONETARY POLICY TARGETING*

Another important reason for the rejection of the EH especially in the studies that use US data is due to the monetary policy targeting of the Federal Reserve. Many researchers pay attention to this fact and in their research they conclude that the changing of the Fed monetary policy targeting has an influence on the results. Hsu and Kugler (1997) examine the influence of the Federal monetary targeting on the empirical performance of the EH. In order to provide new evidence for the rational expectations of the EH of the term structure (REHTS), they use the model of Campbell and Shiller (1991) and Kugler (1990); and for measuring the effect of the Fed policy reaction to changes in the spread, they use McCallum (1994) policy reaction model.

They use daily and weekly data of the one and three months Euro dollar rates for the period from (Jan. 1, 1973 till Nov. 13, 1995). However they divided the sample period into four sub periods to reflect the nature of each period, (Jan. 1, 1973 till Sept.30, 1979), (Oct.1, 1979 till Sept. 30, 1982), (Oct. 1, 1982 till Sept. 30, 1987), and (Oct. 1, 1987 till Nov. 13, 1995).

The first two samples reflect the introduction of the Fed's procedures of targeting unborrowed reserves. During the eighties, the monetary policy is considered unreliable because it was distorted by financial innovations. In 1987 and 1988 a new monetary policy indicator was proposed (i.e. the spread between long and short term rates) and this policy had a big influence on the empirical performance of the (REHTS). The results indicate that the performance of the first three sub samples was very poor, while the results of the period (Oct. 1, 1987 - Nov. 13, 1995) show that the spread between long and short term interest rates has predictive power for the path of short term interest rates and accordingly the (REHTS) cannot be rejected. They attribute the last result to the Fed's monetary policy indicator at that time (i.e. the spread) and to the improvement of the predictability of the changes in interest rates.

Moreover, Mankiw and Miron provide evidence about the influence of the Fed's monetary policy targeting on the EH testing. In their seminal paper (1986) they use US data over the period from 1890 till 1979, so the data set covers the period before the founding of the Federal Reserve (1890-1914) and the period after (1915-1979) in which various monetary polices have been implemented. The key findings of this study indicate that the EH is less soundly rejected for the period before the Fed's founding than after. However Mankiw, Miron and Weil (1987) claim that the failure of the EH after the Fed's founding occurred because the short term interest rates were close to a random walk process which made the interest rates unpredictable in some periods.

According to the empirical literature on the EH, it is agreed that the EH performed better when the researchers use data from countries other than the US. The success of the EH in some of these studies is attributed to the degree of interest rate predictability which is due mostly to the degree of transparency of the monetary policy in these countries such as the studies of Gerlach and Smets (1995) and Guthrei, Wright and Yu (1999).

Gerlach and Smets (1995) examine the PEH for 17 countries using the short end of the term structure. They use the Euro market interest rates data for maturities of 1, 3, 6 and 12 months, and the main reason behind their choice is because there are no restrictions in the Euro market which may cause the observed data to drive away from equilibrium such as capital control, tax treatment or legal regulations They follow Hardouvelis' (1994) approach and perform multiperiod regressions, and to interpret the variations in the results among countries, they follow Fama’s (1984) and Mankiw and Miron’s (1986) techniques to illustrate how the variation in term premia can lead to a downward bias in the estimated coefficient of the spread.

The findings support the EH at the short end (less than one year) for a number of OECD countries such as Belgium, France, Denmark, Italy, the Netherlands, Norway, Spain, and Sweden. They attribute the success of the EH to the high degree of interest rates predictability in these countries. They conclude that if the short term interest rates are predictable then it will be hard to reject the EH.

Guthrei, Wright and Yu (1999) examine the EH using data from a country that has not been previously tested in the literature; i.e. New Zealand. They use bank bill rates of maturities 1, 2, 3, 4, 5 and 6 months and for longer terms they use Government bonds of maturities 1, 2, 5 and 10 years.

The findings support the EH. The authors make comparison between their findings and the findings of US studies and conclude that their findings reflect the nature of the interest rates in New Zealand; that is the interest rates in New Zealand are more predictable than US interest rates. They conclude that the high predictability of interest rates in New Zealand is due to the degree of transparency in the country's Monetary Policy.

2.4.1.4 *THE IRRATIONAL EXPECTATIONS*

The rational expectations hypothesis has been tested jointly with the EH in most of the studies. Irrational expectations is one of the main reasons that led to the rejection of the EH as shown by the studies of Campbell and Shiller (1991), Hardouvelis (1994) and Mylonidis and Nikolaidou (2002).

2.4.1.5 *THE TERM SPREAD PREDICTS THE WRONG DIRECTION IN THE SUBSEQUENT CHANGES IN LONG TERM INTEREST RATES OVER SHORT TERM HORIZON (CAMPBELL AND SHILLER PARADOX (CSP))*

The main conclusion of Campbell and Shiller’s (1991) seminal paper is that the EH does not hold because of the following reasons: risk premium is time varying, and the long term interest rates overreact to the expected changes in short term interest rates and irrational expectations. In addition, Campbell and Shiller (1991, p505) conclude that:

"We thus see an apparent paradox; the slope of the term structure almost always gives a forecast in the wrong direction for the short-term change in the yield on the longer bond, but gives a forecast in the right direction for long-term changes in short rates".

The last conclusion which is recognised as the Campbell and Shiller Paradox (CSP) has been at the centre of interest for many researchers such as Hardouvelis (1994), Cuthbertson, Hayes and Nitzsche (1996), Thornton (2006) and Sarno, Thornton and Valente (2007).

Hardouvelis (1994) concentrates on the puzzle that has been observed in the study of Campbell and Shiller (1991); that is the term spread predicts the wrong direction in the subsequent changes in long term interest rates over the short term horizon, while it predicts the right direction in the subsequent changes in short term interest rates over the long term horizon. For instance, the large spread forecasts rising in short term rates over the long period which complies with the EH while it forecasts declining in long term rates over the short period instead of rising. Hardouvelis considers two main alternative explanations for the puzzle:

-The first alternative assumes that the movements in current long term rates follow the general direction predicted by the EH but these movements are slow relative to the movements of current short term rates. Long term rates either under react to current short term rates or over react to future short term rates.

-The second alternative assumes that the market's expectations are rational but the information in the spread is complex information about the variation of both the expected future short term rates and risk premia.

The main purpose of this study is to detect the rationale behind the above puzzle by examining the relationship between the spread and the future movements of long and short term interest rates. For implementation, Hardouvelis chooses the G7 countries (the USA, Canada, the UK, Germany, Japan, France and Italy) and uses the Government securities and public and semi public bonds to examine the validity of the EH.

The findings indicate that in the case of France and Italy the long term rates do move in the correct direction so when the term spread widens long term rates tend to rise over the subsequent short term periods, while in the case of the USA, Canada, Japan, Germany and the UK, the long term rates move in the wrong direction so when the term spread widens long term rates tend to decline over the subsequent short term periods instead of rise. Hardouvelis (1994) declares that the movements of the long rate in the case of Canada, Japan, Germany and the UK, are due to a simple additive white noise deviation of the long term rates from the ones predicted by the EH.

The author used the instrumental variables to solve the negative correlation and this led to obtain regression slope statistically similar to the one that is predicted by the EH. However in the case of the US a white noise error on long term rates could not explain the puzzle and the use of instrumental variables led to more rejection of the EH. In addition, the time varying risk premia could not provide an adequate explanation for the puzzle.

Hardouvelis (1994) concludes that the difference between the results of the USA and the other G7 countries is attributed to the main characteristics of the financial market in these countries and to the behaviour of the traders. Hardouvelis states that the US financial market is the most liquid market in the world for the post-war period and if the traders behave rationally then this market should be the one with least overreaction (i.e. the movements of short and long term interest rates should comply with the EH), but if the traders behave irrationally (noise traders) then the higher trading volumes in the US will show a stronger presence of noise traders and the bonds prices will overreact so the movements of interest rates will not comply with the EH.

Cuthbertson, Hayes and Nitzsche (1996) state that the main goal of examining the validity of the EH is to provide new evidence on the behaviour of the term structure of interest rates at the short end of term structure. In addition, their subsidiary goal is to provide evidence about the contradictory results that are detected in the literature such as obtaining different results when employing different tests even if the same data set is used and Campbell and Shiller Paradox (CSP).

They use high quality data of UK Certificate of Deposits (CDs) rates for maturities of 1, 3, 6, 9 and 12 months. The data set is used on a pure discount base; therefore, there was no need to perform any approximation. The findings of the perfect foresight spread regression were consistent with the EH, whereas under the VAR methodology the findings of both the standard deviation ratio and the correlation coefficient for the theoretical spread relative to the actual spread were also consistent with the EH; but most of the VAR cross-equation restrictions were rejected.

The main interpretation as declared by the authors about the contradictory results between the two methods is due to the fact that the PFS regressions allow potential future events that influence expectations to be known to agents but not to econometricians. However, the VAR approach requires that both agents and econometricians use the same set of information and if the information set that is used by econometricians is different from the one that is used by agents[12] then the estimated coefficients of the VAR will be biased and accordingly the EH will be rejected.

For more clarification, the authors state that if the agents use the VAR method for forecasting then they certainly will update their information set by considering the observations of the actual spread ($S_t^{(n,m)}$), and the changes in short term interest rates ($\Delta r_t^{(m)}$) may be on a minute by minute basis, and since the authors can not mimic the agents' behaviour, as they use weekly data, then the results will not be the same.

Regarding the (CSP), the results show that when they regress the changes in long term interest rates onto the spread, the estimated coefficients take the right sign (positive) which indicates that the positive value of the spread should be followed by an increase in long term rates over short term horizon. Although the results appear to be consistent with the EH, the estimated coefficients are found to be not significant; i.e. the standard errors are very large.

[12] The econometricians do not use the same variables as the agents; for example by mistake they exclude variables affecting traders' perceptions.

Some of the researchers who tried to explain the mixed results in Campbell and Shiller's (1991) paper; i.e. the (CSP), attribute the failure of the EH to the same reasons that have been described by Campbell and Shiller themselves: i.e. risk premium is time varying, and the long term interest rates overreact to the expected changes in short term interest rates and irrational expectations. However, according to the recent empirical literature on the EH, it is believed that the conventional tests of the EH tend to produce mixed results[13] (Campbell and Shiller 1991).

Researchers such as Bekaert and Hodrick (2001), Kool and Thornton (2004) and Thornton (2005b, 2006) confirm that the conventional tests of the EH may generate misleading results. Thornton (2006) argues that as the conventional tests may generate the (CSP), then it is more appropriate to consider other alternative procedures for testing

[13]According to Thornton's (2006) declaration, the mixed results means that when the changes in short term interest rate over long term horizon are regressed on the spread, and this is called the conventional test of the EH, the results tend to be favourable to the EH; i.e. the estimated coefficient β which should equal one according to the theory is always positive and significantly different from zero but because in many cases $\beta \neq 1$ then the EH is rejected. In addition R^2 is significantly different from zero. The model of the conventional test is:

$$\sum_{i=1}^{k-1} \left(1-\frac{i}{k}\right)(\Delta^m\, r_{t+im}^m) = \alpha + \beta\ (R_t^n - r_t^m) + \varpi_t^m$$

but when the changes in long term interest rate over short term horizon is regressed on the spread, described by Thornton (2006) as the contrarian test of the EH, the results tend to be unfavourable to the EH; the estimated coefficient λ which should equal one according to the theory is always negative, and R^2 is insignificantly different from zero. The model of the contrarian test is:

$$(R_{t+m}^{(n-m)} - R_t^n) = \psi + \lambda\ (R_t^n - r_t^m) + \upsilon_t$$

the EH such as the procedure that is proposed by Campbell and Shiller (1987) and later developed by Bekaert and Hodrick (2001)[14]; that is estimating a general VAR model of long and short term interest rates and then testing the parameter restrictions that the EH imposes using the Lagrange multiplier test (LM Test).

Sarno, Thornton and Valente (2007) further extend the literature by not only applying the Lagrange multiplier test that was developed by Bekaert and Hodrick (2001) but also increasing the power of the test by adopting two major procedures such as: First, increasing the power of the test by expanding the VAR model to include some macroeconomic variables such as the unemployment and the inflation rates, where they consider the additional macroeconomic variables as conditioning information. Second, increasing the size of the VAR by including more than two bonds yields and then testing the validity of the EH on more than one pair of yields. The idea of testing the EH and dealing with more than one pair of yields has not been applied before in the empirical work of the EH.

They test the EH using US monthly bonds yields ranging in maturities from one month to 10 years over the period from 1952-2003. They first apply the Lagrange multiplier test and find that their results comply with the mixed results that have been revealed in Campbell and Shiller's empirical works (1987, 1991). Next they retest the EH using the expanded VAR model with macroeconomic variables and then use the expanded VAR model with more than one pair of yields.

[14] Bekaert and Hodrick (2001) increase the power of the EH testing by developing an easy-to-implement procedure to test the parameter restrictions that the EH imposes on a VAR model using the Lagrange multiplier test (LM Test).

The main findings indicate that the two procedures that are adopted to increase the power of the test suggest that the empirical power is higher for the expanded VAR. For example the results show that when the VAR model is expanded by including some macroeconomic variables, the EH is rejected in nearly all cases when longer rates have maturity of 4 years and in all cases when longer rates have maturity of 5 years or less. Moreover when the size of the VAR model is increased by including more than two yields, the EH is also strongly rejected. The authors attribute the rejection of the EH to various reasons, one being that the term premia is time varying and conclude that the evidence in their study suggests "that the term structure is likely to be considerably more complex than the EH suggests"[15].

2.5 *OTHER IMPLICATIONS OF THE EXPECTATIONS THEORY (ET)*

In addition to the major implication of the ET which is predicting the future movements in interest rates, the theory has other important implications such as its relationship with the transmission mechanism of monetary policy and with the concept of market efficiency.

The ET is important in explaining the transmission mechanism of monetary policy. The monetary policy has no direct control on long term rates but it has direct control on short term rates, so by influencing the short term rates and altering the market's

[15] Sarno, Thornton and Valente (2007, p. 99).

expectations of future short term rates, the monetary policy can affect the long term rates (Cooray 2003). According to Lange (1999)[16].

"Understanding the link between longer term yields and financial market expectations about the path of short term rates is important for anticipate the response of long term yields to monetary policy changes and for understanding the interest rates channel of the Monetary transmission mechanism".

Mankiw, Summers and Weiss (1984) declare that the sensitivity of long term rates to the changes in short term rates has an important implication for macroeconomic policy; for example the effectiveness of monetary policy will increase with the increase of the excess sensitivity.

The ET is also related to the concept of market efficiency. The relationship between the ET and the market efficiency is mainly investigated in the empirical works that use data from developing and emerging economies such as Sri Lanka, India, and Malaysia. The main purpose of testing the EH in these studies is to investigate the efficiency of the financial markets and the ability of these markets to be used as an efficient vehicle for monetary policy implementation.

Moreover, it is worth mentioning that the commonality among all these studies is the type of the interest rates that have been used for testing. Most of these studies use the

[16] Lange (1999, p.1).

money market interest rates as the main data set because normally the money market is the only well developed market in these economies.

Cooray (2003) examines the efficiency of the Sri Lanka money market by testing the validity of the PEH using monthly data of Treasury bills rates with maturities of 3 and 6 months. The findings of the cointegration analysis indicate that there is a long run relationship between the interest rates; however the restrictions that are imposed to test the EH have been rejected. Cooray concludes that the rejection of the EH may not imply that the market is inefficient, rather that the rejection may be attributed to the limited assumptions under the EH particularly the assumption of the term premia being constant while it is in fact time varying.

Shivam and Jayadev (2004) examine the structure of the Indian money market and evaluate its operational efficiency through testing the validity of the PEH. The data set covers five benchmark rates from the Indian money market and the findings indicate that the EH cannot be rejected; accordingly they conclude that the Indian money market can be considered an efficient vehicle for monetary policy implementation.

Chazali and Low (2002) claim that the Malaysian Government securities market is an efficient market and to verify the efficiency of this market they examine the validity of the EH. They use two different types of Government securities; for the short end of the term structure they use the 3, 6, and 12 month Treasury Bills and for longer maturities they use Malaysian Government securities with maturities of 5 and 10 years. The findings indicate that different maturities of interest rates are linked together over time and the movements of short and long term interest rates are adjusted accordingly when they are out of equilibrium path. The main findings indicate that the EH holds and this confirms the efficiency of the Malaysian Government securities market.

Moreover, some researchers from European countries with emerging markets have examined the EH and used the findings as a tool to verify the efficiency of the financial markets. Konstantinou (2005) examines the validity of the EH for the short end of the Polish interbank term structure of interest rates. The main purpose is to test the efficiency of the interbank market which is an emerging market. The author uses the Warsaw interbank offered rate (WIBOR) for maturities of one week, one month, three month, and six month. The findings provide evidence in favour of the EH; that is the actual spread contains information for the changes in future short term interest rates and it correctly predicts the direction of the changes (i.e. positive slope).

Mylonidis and Nikolaidou (2002) examine the operational efficiency of the Greek money market by testing the validity of the EH. They use 1, 2, 3, 6, 9, and 12 months Greek money market rates (Athibor Euribor). The sample period is characterised by a high volatility due to speculative behaviour against the Greek Drachma. The findings did not support the EH and the rejection is attributed to the limited efficiency of the Greek money market where the market participants appear to under react to the arrival of new information and that violate the concept of the efficient market. In addition, the sample period witnessed high interest rates volatility and this volatility in short term interest rates causes the term premia to be time varying and not constant.

2.6 THE TERM STRUCTURE AND THE PREDICTABILITY OF FUTURE INFLATION RATE

The relationship between the term structure of interest rates and macroeconomic variables has also been the centre of attention for many researchers. A large body of the empirical literature focuses on examining whether the term structure of interest rates contains useful and reliable information about the output growth and inflation; that is, examining the predictive power of the term structure. Based on the main focus of this study which is detecting whether the term structure of interest rates contains useful information about future inflation rate, the main concentration will be on the literature review that is related to the term structure and its ability to predict the future inflation rate.

According to the empirical literature, the examination of the information contents of the term structure about future inflation rate has been made by employing two main methods. The first method is testing the validity of the Fisher Hypothesis (FH) and the second method is examining whether the slope of the term structure is an optimal predictor of future inflation rate. The following two sub sections cover the findings from the literature review for each method.

2.6.1 THE VALIDITY OF THE FISHER HYPOTHESIS (FH)

The original idea of the relationship between the interest rate and the expected inflation was introduced for the first time by Irving Fisher (1930). The basic idea states that the nominal interest rate equals the (ex anti) real interest rate plus the expected inflation rate. The general form of the Fisher equation is as follows:

$$i_t = r_t + \pi_t^e$$

Where

i_t is the nominal interest rate at time t.

r_t is the (ex anti) real interest rates at time t .

π_t^e is the expected inflation rate at time t.

The main assumptions under FH are: (i) the (ex anti) real interest rate is constant over time (ii) the (ex anti) real interest rates and the expected inflation are independent (iii) the expectations are rational; accordingly FH suggests a one-for-one relationship between the nominal interest rate and the expected inflation rate. Although the real interest rate is assumed to be constant over time under FH, researchers such as Fama and Gibbons (1982), Mishkin (1984a), and Huizinga and Mishkin (1986) believe that this assumption in particular is not robust because the real interest rates may change over time as a result of the changes in the real factors in the economy[17].

The validity of the FH has been examined heavily in the literature mainly because it describes the relationship between the nominal interest rates and the expected inflation. The non rejection of the FH is a clear indication that the nominal interest rate contains useful information about the expected inflation rate. Moreover it may provide evidence that the inflation rate may contain useful information about the future nominal interest rate; i.e. possible feedback may exist.

[17] The main real factors that have an impact on the real interest rates are the productivity of capital and the investor time preference (please see Cooray's (2003) paper: The Fisher Effect: A Survey.

The important implications of FH motivate many economists to examine the existence of Fisher's effect using data not only from developed economies but also from developing economies. Many studies have examined the validity of the FH using data from the USA such as Bonham (1991), Mishkin (1992), Wellace and Warner (1993), Peláez (1995), Crowder and Hoffman (1996) and Fahmy and Kandil (2003). Other studies concentrate on using data from different OCED countries, European countries and Asian countries such as Atkins (1989), MacDonald and Murphy (1989), Woodward (1992), Dutt and Ghosh (1995), Peng (1995), Mishkin and Simon (1995), Olekalns (1996), Hawtrey (1997), Crowder (1997), Booth and Ciner (2001), Granville and Mallich (2004), Satake (2005) and King (2007).

Regarding the studies that concentrate on using data from developing economies, we find that initially most of these studies concentrate on using data from different Latin American countries such as Garcia (1993), Thornton (1996), Carneiro, Divino and Rocha (2002), and Jorgensen and Terra (2003) while few studies concentrate on other developing economies such as Wesso (2000) who uses data from South Africa. However, in recent years, the number of studies have not only increased, but are also covering a wider range of developing economies such as Mitchell-Innes, Aziakpono and Faure (2007) who use data from South Africa, Cooray (2002) who uses data from Sri Lanka, Masih, Ali-Hajji and Umar (2008) who use data from Saudi Arabia, Sathye, Sharma and Liu (2008) who use data from India, Abu Nurudeen and Wafure (2009) who use data from Nigeria, and Elshareif and Tan (2009) who use data from three developing countries, Malaysia, the Philippines and Thailand.

In addition to the above studies, we find that some studies examine the validity of the FH using data from both developed and developing economies such as the study of Al-Khazali (1991) who uses data from nine countries in the Pacific-Basin - Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thialand, the study of Payne and Ewing (1997) who use data from nine lesser developed countries - Argentina, Fiji, India, Malaysia, Nigera, Pakistan, Singapore, Sri Lanka, and Thailand, and the study of Berument and Jelassi (2002) who use data from 26 countries, incorporating a wide range of developed and developing countries - Brazil, Chile, Costa Rica, Egypt, India, Kuwait, Mexico, Morocco, the Philippines, Turkey, Uruguay, Venezuela, Zambia, Greece, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Switzerland, the UK and the USA.

According to the literature, testing the validity of FH particularly at the beginning produces mixed results. The mixed results have shed light on the importance of identifying the real properties of the data and on the importance of using the proper technique that can reflect the real behaviour of the variables under Fisher equation (MacDonald and Murphy 1989, Mishkin 1992, Wellace and Warner 1993).

In his key paper, Mishkin (1992) raises two main issues about the lack of robustness of the Fisher effect; the first one is why the Fisher effect is robust in some periods of time but not in others, and the second one questions whether the lack of the robustness of Fisher effect creates suspicion about the validity of FH. The major contribution of Mishkin’s paper lies in providing clear evidence that by using the recent development in the time series econometrics; i.e. identifying the real properties of the variables, and by using the right econometric techniques, the robustness of Fisher effect will be improved significantly.

Mishkin argues that the previous studies focus on studying the short run Fisher effect which leads to misleading and spurious results; as an alternative, he suggests that the optimal way is to focus on the long run Fisher effect using the cointegration technique as the most appropriate tool for this purpose. Another main contribution in Mishkin's paper is providing strong evidence that the Fisher effect cannot be rejected if the nominal interest rate and the inflation rate exhibit trends for a period of time, while if the variables are not trended together then the Fisher effect will be absent.

The following general form of Fisher equation contains expected values (π_t^e); i.e. the expected value of inflation rate; therefore Fisher equation under this form cannot be estimated:

$$i_t = r_t + \pi_t^e \qquad \text{Eq 2.6.1.1}$$

In order to make Fisher equation empirically testable, Fama in his seminal paper (1975) introduces the idea that the expected inflation equals the sum of the actual inflation at time (t) plus an error term which is assumed to be stationary.

$$\pi_t^e = \pi_t + \varepsilon_t \qquad \text{Eq 2.6.1.2}$$

Accordingly Fisher equation is rewritten in a testable form as follows:

$$i_t = \beta_0 + \beta_1 \pi_t + \mu_t \qquad \text{Eq 2.6.1.3}$$

Where

i_t is the nominal interest rate at time t.

β_0 is the constant (ex anti) real interest rates at time t.

π_t is the actual inflation at time t.

μ_t is the stationary error term (μ_t consists of the inflation expectations errors and the component of shocks to the ex anti real interest rate in period (t) with zero mean).

According to the empirical literature of FH, most of the studies that examine the validity of FH in recent years follow Mishkin (1992) and focus on the long run Fisher effect instead of the short run effect, so they focus first on identifying the properties of the nominal interest rate and the inflation rate, and then on finding out whether there is a long run equilibrium relationship between the two variables using the cointegration analysis. The next step after identifying the cointegrating vector is to identify whether the estimated parameter (β_1) in equation (2.6.1.3) follows the strong form of Fisher effect which is called also "full Fisher effect" through testing the null hypothesis (H_0 : β_1=1) or follows the weak form of Fisher effect where the parameter 0< β_1 <1.

The non rejection of the null hypothesis (H_0 : β_1=1) indicates that the real interest rate is constant and the nominal interest rate moves in a one-to-one relationship with the expected inflation rate, and this means that FH holds and the nominal interest rate contains useful information about future inflation rate; i.e. the nominal interest rate is an optimal predictor of future inflation rate.

2.6.2 *THE MAIN FINDINGS OF THE EMPIRICAL TESTING OF FH AND THE THEORETICAL JUSTIFICATIONS FOR THE DEVIATION OF THE ESTIMATED PARAMETER FROM ITS THEORITICAL VALUE "ONE"*

The findings of most of the studies that examine the validity of the FH indicate that the estimated parameter under FH does not comply with the strong form of Fisher effect; i.e. ($\beta_1 \neq 1$), and it either follows the weak form of Fisher effect where (0< β_1 <1) or it is larger than the theoretical value (β_1 >1).

The deviation of the estimated parameter from its theoretical value has been addressed by many researchers who provide theoretical justifications for this deviation such as Darby (1975) and Feldstein (1976) who introduce the concept of tax effect, Mundell (1963) and Tobin (1965) who introduce the concept of wealth effect, and Carmichael and Stebbing (1983) who introduce the concept of the inverted Fisher effect In addition, the rejection of the Fisher effect is attributed to the fact that the (ex anti) real interest rate is a nonstationary variable.

2.6.2.1 *THE TAX EFFECT*

Darby (1975) addresses the effect of taxes on the estimated parameter under FH. He states that if the nominal interest income is subjected to taxes as in the case of US Treasury Bills, then FH implies that nominal interest will rise in response to the expected inflation by more than the theoretical value; i.e. rise by more than unity, in order to keep the value of the (ex anti) real interest rate unaffected. Darby suggests that the value of the estimated parameter should reflect both the tax effect and the expected inflation effect; therefore the nominal interest rate should rise by this amount $\left(\frac{1}{(1-t)}\right)$.

In addition, Feldstein (1976) declared that the original idea of Fisher (1930) states that nominal interest rate rises when expected inflation rises and this should be a one-for-one relationship under the assumptions that the (ex anti) real interest rate is constant and the income is not subjected to taxes. However, if we are dealing in a world where the income is subjected to taxes, then the relationship between the nominal interest rate and the expected inflation will be different; i.e. the nominal interest rate should rise by more than unity in order to reflect both the expected inflation and the tax effect and to keep the (ex anti) real interest rate unaffected.

The theoretical justifications of Darby and Feldstein motivate other researchers to study the tax effect on the estimated parameter under FH such as Cargill (1977) and Tanzi (1980) who find that the nominal interest rate has not been adjusted enough to reflect both the expected inflation and the tax effect. Because the studies that examine the "tax effect" provide little support for Darby and Feldstein’s explanation, Gandolfi (1982) has modified Darby and Feldstein’s theoretical justification by investigating the effect of the capital gain taxation on the movement of the nominal interest rate and consequently on the estimated parameter.

The main finding of Gandolfi’s study is that the nominal interest rate rises by more than one to reflect both the expected inflation and the tax income but the increase does not comply with Darby and Feldstein’s explanation. The author attributes this phenomenon to the fact that the capital gain is taxed only when it is realised and not when it is accrued; therefore the effective tax on the capital gain will be less than that on real income, and accordingly the value of the changes in nominal interest rate in response to the expected inflation will lie between the theoretical values under the Fisher effect, and Darby and Feldstein's explanation.

Some studies provide evidence in favour of a tax-adjusted Fisher effect such as the studies of Woodward (1992), Croweder and Hoffman (1996), and Croweder and Wohar (1999). Woodward (1992) uses indexed bond data to detect the Fisher effect. The data set consists of monthly series of before and after-tax real and nominal interest rates, along with the expected inflation. The findings provide support to the Fisher effect; i.e. the effect of the expected inflation on before-tax nominal interest rates appears to be more than one for most of the 14 maturities that have been used in the study and the effect on after-tax nominal interest rates is roughly one-for-one in most of the maturities.

Croweder and Hoffman (1996) provide support for a tax-adjusted Fisher equation; i.e. after adjusting for tax effect the results show that Fisher effect is insignificantly different from unity. Croweder and Wohar (1999) use two types of bonds; the taxable bonds and the tax-exempted bonds and their findings support Fisher effect and indicate that the estimated parameters are always larger for taxable bonds relative to tax-exempted bonds.

2.6.2.2 *THE WEALTH EFFECT*

Mundell (1963) and Tobin (1965) argue that nominal interest rate rises by less than the inflation rate and that during inflation the real interest rate falls. They declare that inflation causes the real money balances to decrease and the resulting decline in wealth reduces consumptions and stimulates increased savings and this reduces the real interest rate[18].

In addition, Woodward (1992)[19] provides evidence that for shorter maturities the Fisher effect tends to be close to one in the before-tax version and less than one in the after-tax version. The findings are consistent with Mundell and Tobin's effect and Woodward concludes (p. 319) that: "it is the shorter maturities that are most likely to have the degree of "Moneyness" necessary for real rates to decline in the face of increasing inflation expectations".

2.6.2.3 *THE INVERTED FISHER EFFECT*

Carmichael and Stebbing (1983) introduce an alternative hypothesis to Fisher effect which they call the "Inverted Fisher Hypothesis". They claim that this alternative hypothesis provides an explanation to the Fisher Hypothesis Paradox; i.e. the contradiction between the empirical evidence of FH and Fisher's hypothesis of a constant real interest rate.

[18] Please see Taxation, Inflation and Interest rates, Edited by Tanzi, IMF 1986.

[19] Under Woodward's (1992) study, both the tax effect and the wealth effect were investigated.

The "Inverted Fisher Hypothesis" implies that the after-tax nominal interest rate remains constant over the long term while the after-tax real interest rate moves on a one-to-one basis with the expected inflation. The main assumptions under this alternative hypothesis are; there should be some regulations in the financial market and a relatively high degree of substitutability between the regulated and the non regulated financial assets. Carmichael and Stebbing test the "Inverted Fisher Hypothesis" empirically using data from the USA and Australia and their findings provide support for the hypothesis. Furthermore, Amsler (1986) examines the validity of the "Inverted Fisher Hypothesis" using US data and his findings also provide support for the Inverted Fisher Hypothesis.

However, Graham (1988) who investigates the robustness of the findings of Carmichael and Stebbing (1983) and Amsler (1986) argues that their findings are not convincing because there are some econometric problems in the previous studies such as errors in variables, generated regressors and omitted variables. Graham provides an alternative procedure for testing the "Inverted Fisher Hypothesis" that is not subjected to the above econometric problems, and the new findings show clearly that the "Inverted Fisher Hypothesis" is rejected. In addition, Choudhry (1997) examines the validity of the "Inverted Fisher Hypothesis" using data from Belgium, France and Germany and the findings provide little support for the "Inverted Fisher Hypothesis".

2.6.2.4 *THE NONSTATIONARITY OF THE (EX ANTI) REAL INTEREST RATE*

The rejection of the FH in some cases is attributed to the non stationarity of the (ex anti) real interest rate. Researchers such as Pelaez (1995) and Payne and Ewing (1997) who studied the long run effect of the FH using the cointegration analysis attribute the absence of the cointegration between the nominal interest rate and the expected inflation rate[20] to the fact that the (ex anti) real interest rate is a non stationary variable.

2.6.3 *THE ABILITY OF THE SLOPE OF THE TERM STRUCTURE TO PREDICT INFLATION RATE*

Although Fisher Hypothesis plays a main role in identifying the information contents of the nominal interest rate in levels, many economists are interested in examining the information contents of the entire term structure; hence they focus on the slope of the term structure – this is the term spread which represents the difference between two interest rates of different maturities.

Economists such as Greenspan (2005) and Bernanke (2006) emphasise the importance of the term spread as a leading predictor of economic activity and inflation. Furthermore, a large body of the literature focuses on the term spread and the predictability of future economic activity and inflation such as the studies of Harvey (1989, 1997), Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Kim and Limpaphayom (1997), Smets and Tsatsaronis (1997), Bernard and Gerlach (1998), Hamilton and Kim (2002), Nakaota (2005), Ang et al. (2006), and Diebold et al. (2006). The common feature of all these studies is that they examine whether the term spread

[20] The combination between the nominal interest rate and the expected inflation rate represents the real interest rate and according to the Fisher Hypothesis the real interest rate is assumed to be constant, so the absence of the cointegrating vector means that the real interest rate is not constant.

contains important information about economic activity using data from developed countries such as the US, and OCED countries.

It is believed that the predictive power of the term structure of interest rate is normally identified when the interest rate is determined by the market forces because in this case it reflects the market's expectations about future economic activities. Hence, we find that most of the studies that examine the predictive power of the term structure focus on using data from developed countries because the financial markets in these economies are well developed and the interest rate is normally determined by market forces.

On the other hand, it is known that the interest rate in most of the developing economies is administrated; that is, it is determined directly by the monetary authorities and not by market forces, and the financial markets are undeveloped. That is why we find that the number of studies that examine the predictive power of the term structure in these economies is few. In addition, even with interest rate liberalisation in some of the developing economies, the low quality of economic data remains a huge problem and it may be considered another main reason behind the lack of proper research in this area. For instance the available data may contain many missing values and or the data set covers only the money market interest rates; i.e. the short end of the term structure, since the capital market is still undeveloped.

In spite of these shortcomings, examining the ability of the term structure to predict the macroeconomic variables in developing economies is a very challenging and critical issue because identifying the information contents of the term structure is a very important piece of information for policy makers and for all market players because it may help in the development of the forecasting models in the future. In view of that, we find few studies in the literature that investigate the ability of the term structure to predict macroeconomic variables using data from developing economies, two of these studies are Ghazali and Low (1999) who examine the ability of the term spread to predict the annual output growth in Malaysia and find that the spread contains valuable information about the output growth up to six months ahead, and Kanagasabapathy and Goyal (2002) who study the ability of the term structure to predict the industrial growth in India and find that the spread is a leading indicator of the industrial growth.

The relationship between the term spread and inflation in particular has been examined extensively in the literature. In his seminal paper, Mishken (1990a) introduces the theoretical framework for examining the ability of the term spread to predict the changes in inflation. The theoretical framework[21] is constructed by relying on two main assumptions: the first assumption is related to the Fisher Hypothesis where the difference between the nominal interests (i) and the real interest rate (r) equals the expected inflation rate ($E_t\pi$), so the expected inflation rate can be written in the following form:

$$E_t\pi_t^m = i_t^m - r_t^m \qquad \text{Eq 2.6.3.1}$$

Where

E_t is the expectations at time t.

π_t^m is the inflation rate from time t to time $t+m$.

[21]The theoretical framework of the "Inflation change equation" is borrowed from Mishkin’s papers (1990, 1991).

i_t^m is the m period nominal interest rate at time t.

r_t^m is the m period (ex anti) real interest rate at time t.

The realised inflation rate over the next m periods can be decomposed into two components, the expected inflation rate plus the forecasting error of inflation:

$$\pi_t^m = E_t \pi_t^m + \eta_t^m \qquad \text{Eq 2.6.3.2}$$

Where $\eta_t^m = \pi_t^m - E_t \pi_t^m$ is the forecasting error of inflation.

By substituting Eq (2.6.3.2) in Eq (2.6.3.1), the inflation equation for any financial assets with (m) period to maturity can be written in the following form:

$$\pi_t^m = i_t^m - r_t^m + \eta_t^m \qquad \text{Eq 2.6.3.3}$$

Equation (2.6.3.3) is assumed to hold for any financial assets and for any maturity, so if we have another financial asset with (n) period to maturity, then the inflation equation will take the following form:

$$\pi_t^n = i_t^n - r_t^n + \eta_t^n, \qquad \text{Eq 2.6.3.4}$$

Where (n) period is shorter than (m) period, i.e. $m > n$.

Mishkin (1990a) derived equation (2.6.3.5) which is called the "inflation change equation" from linking equations (2.6.3.3) and (2.6.3.4) together. This represents the second assumption where the term structure of interest rate is linked with Fisher Hypothesis by taking the difference between two interest rates of different maturities along the term structure articulated in terms of the actual inflation rate at time (t).

The derived equation (2.6.3.5) does not include any expected value, so it becomes a testable form:

$$\pi_t^m - \pi_t^n = -(r_t^m - r_t^n) + (i_t^m - i_t^n) + (\eta_t^m - \eta_t^n),$$

$$\pi_t^m - \pi_t^n = \alpha + \beta\ (i_t^m - i_t^n) + \varepsilon_t \qquad \text{Eq 2.6.3.5}$$

Where

$$\alpha = -\ (r_t^m - r_t^n)$$

$$\varepsilon_t = (\eta_t^m - \eta_t^n)$$

The main fact about "inflation change equation" is that it is derived initially from the Fisher equation which is considered by economists to be one of the major theories that explain the relationship between the nominal interest rates and inflation. The parameter (β) represents the slope of the nominal term structure and the predictability of the nominal term structure is identified by testing the significance of the parameter (β).

Mishken (1990a) suggests testing the following two hypotheses; the first hypothesis is to test if β=0 and the second hypothesis is to test if β=1. If the null hypothesis β=0 is rejected then this is an indication that the slope of the nominal term structure ($i_t^m - i_t^n$) contains useful information about the changes of inflation; that is the change in the future inflation at period (m) from the inflation at period (n). In addition the slope of the nominal term structure does not move one-for-one with the slope of the term structure of real interest rates. Moreover, if β=1 is rejected then this suggests that the slope of the term structure of real interest rates (- (r_t^m - r_t^n)) is not constant over time and the nominal term structure of interest rates provides information about the term structure of real interest rates.

Mishken (1990a) examined the ability of the term spread to predict the changes in the inflation using US Treasury bill for maturities up to 12 months and provides evidence that the very short end of the nominal term structure (maturities less than six months) contains no information about future changes in inflation, though it provides useful information about the term structure of real interest rates. Moreover, when longer maturities are used such as the 9 and 12 month, the findings indicate that the nominal term structure begins to contain more information about the changes in inflation and less about the term structure of real interest rates.

Mishken (1990b) extends the investigation about the predictability of the term structure and studied the information in the nominal term structure using US Treasury Bonds with longer maturities from one year to five year. The main findings indicate that the nominal term structure contains useful information about the changes in inflation and less information about the term structure of real interest rates. Mishkin (1991) and Jorion and Mishken (1991) use data from OCED countries and the main findings of their studies are almost the same: that the short end of the term structure of nominal interest rates does not contain useful information about the changes in inflation while if longer maturities of interest rates are included then the predictive power of the term structure improves.

Many researchers follow Mishkin (1990a) and use the "inflation change equation" to examine the relationship between the term spread and inflation such as Frankel and Lown (1994), Gerlach (1997), and Nagayasu (2002). Frankel and Lown (1994) examine the predictive power of the term spread based on different assumptions such as allowing the real interest rate to vary and rather than being restricted to the term spread between two points, they concentrate on the entire length of the yield curve; that is they make use of the points all along the yield curve. They provide strong evidence that the term spread between the five year and the very short interest rate such as the overnight interest rate provides better measurement of the overall steepness of the yield curve and accordingly a better identification of the predictability of the nominal term structure.

Gerlach (1997) examined the information content of the term structure in Germany using the yields on bonds with maturities of 1 year to 10 year. The main purpose behind using a wide range of maturities is to define which segment of the yield curve has the highest predictive power. The main findings indicate that the nominal interest rate spreads contain useful information about the changes in inflation and in particular the spread between the 5 year and 2 year rates which represent the medium term segment of the yield curve. They conclude that the medium and long term yields can play useful roles as indicators of the expected inflation.

Nagayasu (2002) used Japanese data and concentrated on very short term rates (one, two and three month rates) because longer maturities of zero coupons are not available.

The main findings indicate that longer term spread (three month spread) has more information than shorter term spread (two month spread) and the author declares that the findings are unique because in other studies such as that of Mishken (1990a) these maturities contain no information.

In addition, some researchers have extended the literature to examine not only the predictability of the domestic term structure but also the predictability of the foreign term structure based on the fact that in some economies the exchange rate regime is pegged to US dollars, so it is expected that the foreign term structure may contain useful information about domestic inflation such as the study of Mehl (2006) who undertook an in-depth examination of the ability of foreign yield curve to predict the domestic economic variables for many emerging economies such as Brazil, the Czech Republic, Hong Kong, Hungary, India, Korea, Malaysia, Mexico, the Philippines, Poland, Saudi Arabia, Singapore, South Africa and Taiwan, and provides robust evidence that in some emerging economies that have exchange regime pegged to US Dollars, the US yield curve plays a role in predicting the domestic inflation.

Moreover, it is known that the monetary policy stance (i.e. tightening or easing) has an influence on the shape of the term structure of interest rates and accordingly the term spread; hence it is believed that part of the predictive power of the term spread is due to the monetary policy. Economists such as Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Estrella and Mishkin (1997), Dotsey (1998), Ghazali and Low (1999) and Hamilton and Kim (2002) examine whether the term spread contains information that is not explained by monetary policy variables; accordingly, they include additional variables that reflect the monetary policy in their analysis and test if the term spread remains significant even with the inclusion of additional variables.

For example Estralla and Hardouvelis (1991) use the Federal Funds rates as proxy for monetary policy stance, Estrella and Mishkin (1997) use three short term interest rates as proxies for the monetary stance; i.e the central bank rate (CB), the bill rate (Bill) and the real Central Bank rate (RCB), Ghazali and Low (1999) use the monetary aggregates, and Hamilton and Kim (2002) use the federal rate and two monetary aggregates. Most of these studies find that the estimated coefficients of the term spread remain significant even with the inclusion of additional variables which indicates that the term spread contains important information beyond that contained in the monetary policy variables.

2.7 *CONCLUSION*

The importance of the information contents of the term structure is due to the fact that the slope of the term structure normally reflects the market's expectations about future economic activities such as the future movements of short term interest rates, the output growth and inflation.

The Literature Review of the empirical testing of the EH not only shows a large variation in the methodologies and techniques, the countries, the data sets, and the sample periods that have been used for testing but also shows a variation in the findings. In spite of the variation in the findings, the ET continues to be one of the key and most robust theories that explain the predictive power of the term structure. Therefore, when the findings did not provide support to the EH, researchers tended to declare that the rejection of the EH has taken place on statistical grounds and not on economic grounds (Campbell and Shiller 1991, Della Corte et al. 2008).

Investigating the characteristics of the term structure, particularly the predictive power, is an important area of research in economics that continues to flourish. Researchers continue to test the validity of the EH using different approaches and data sets and some of them have worked on extending the literature by suggesting different advanced procedures for testing such as Thornton (2006), and Sarno, Thornton and Valente (2007) who believe that the term structure could be more complex than what the EH suggests.

TESTING THE EXPECTATIONS HYPOTHESIS OF THE TERM STRUCTURE IN THE JORDANIAN MONEY MARKET: THE JORDANIAN DINAR INTERBANK OFFERED RATE (JODIBOR)

3.1 *INTRODUCTION*

Testing the Expectations Hypothesis (EH) for developing countries where the financial markets are either emerging markets or underdeveloped markets is a very interesting case because through testing the EH we may get important information about the efficiency of these markets and the ability of the market players to learn (learning process). This fact motivates us to introduce another case for testing the EH of the term structure for Jordan, and to use a new data set based on one of the financial instruments in the Jordanian money market which is the Jordanian Dinar interbank offered rate (JODIBOR).

Testing the validity of the EH will enable us to test the efficiency of the Jordanian interbank market of different maturities. The key contribution of this study comes not only from testing the validity of the EH for a developing country such as Jordan for the first time, but also from using a new data set that has not been investigated before. To the best of our knowledge, this study is the first attempt at testing the predictive power of the term structure for Jordan through examining the validity of the Pure Expectation Hypothesis (PEH).

This chapter is organised as follows: Section two describes in details the properties of our data set including its' main shortcomings; section three discusses the main three methodologies that have been used for testing the validity of the EH such as the Single Equation Regression, the VAR methodology (Campbell and Shiller 1987, 1991) and the Cointegration analysis using the Johansen techniques; section four describes the unit root test; section five discusses the main empirical results of the unit root test and the three methods; section six describes the Time Varying Parameter test including the methodology and the main empirical results, and section seven presents the conclusion.

3.2 *THE DATA*

The overnight interbank market in Jordan emerged during the nineties. Local banks lend and borrow from each other on an overnight basis and at the end of the working day they provide the Central Bank of Jordan (CBJ) with full information about their daily transactions, particularly the volumes of the interbank transactions in Jordanian Dinar, the overnight lending borrowing rates, and the names of the lenders and borrowers. Based on the daily information provided by the local banks, the CBJ computes the weighted average lending interest rate and publishes this rate which is considered a benchmark rate of all the unsecured overnight transactions[1]. In addition the CBJ

[1]The overnight interbank transactions are unsecured transactions; i.e. no collateral is required. They are cash transactions where the accounts of the lender and the borrower which are held with the Central Bank of Jordan are debited and credited respectively based on the payment orders that are sent to the CBJ via SWIFT network on the day of the transaction. The next working day, the same transaction will be settled; i.e. the accounts of the borrower and lender will be debited and credited respectively based also on new payment orders and the amount of this transaction normally consists of the amount of the loan plus any accrued interest on the loan.

publishes full information about the total volume of the overnight transactions, the total number of transactions, and the highest and lowest lending interest rates via media, CBJ Web page and Reuter.

The main goals from computing and publishing specific information about the overnight interbank transactions are to monitor the market's liquidity needs and to ensure that the level of interest rates in the interbank market complies with the CBJ monetary policy targeting. In addition, providing the market with full information about the liquidity needs and the level of interest rates will enhance the pricing of the next overnight interbank transactions by market players. The main limitation of the interbank market in Jordan is that the majority of the interbank transactions are overnight transactions; i.e. no other maturities are used. Therefore, there was a pressing need to develop the interbank market in Jordan by including other maturities besides the overnight; hence a new benchmark was introduced under the name of JODIBOR; i.e. the Jordanian Dinar interbank offered rate.

The JODIBOR was launched in November 2005 by the licensed commercial banks in cooperation with the Association of Banks in Jordan and the Central bank of Jordan. It is the average offered interest rates of 10 Jordanian commercial banks for lending in Jordanian Dinar, so it is a local interbank benchmark rate. The JODIBOR is provided for six maturities ranging from overnight until one year; i.e. overnight, one week, one month, three month, six month, and one year.

The JODIBOR is similar to the London interbank offered rate (LIBOR). It is the rate of interest at which local banks borrow funds from other local banks in the Jordanian

Dinar. Ten banks submit their rates for the six maturities each day, except Friday and Saturday, between 10:15am and 10:30am. After the submission of the prices, the benchmark rates are computed by excluding the highest and the lowest rate and then calculating the average of the eight remaining interest rates for each maturity. The average offered interest rates are announced at 11:00 am every day.

The main incentives behind the JODIBOR launching can be summarised as follows: to construct a market for the interbank of different maturities, to create a credible benchmark rate in the Jordanian Money market for several maturities, to encourage a more active interbank market for different maturities, to improve the quality and efficiency of interest rates pricing, and to enhance the Jordanian money market's transparency and efficiency.

It is believed that this benchmark will lead local banks to improve the setting of their interest rates and it may assist in using floating interest rate on loans. It is believed also that providing the market with a clear interest rate benchmark on a daily basis for different maturities is critical for transparent pricing and will lead to more growth in the Jordanian financial market. From the monetary authority point of view, the JODIBOR can be considered a clear reflection of interest rates expectations so the Central Bank of Jordan considers the JODIBOR as an additional tool to monitor the market expectations of the interest rates of different maturities.

There are other financial instruments in the Jordanian money market, the yield on which is considered a benchmark for risk free rate such as the Central Bank of Jordan Certificates of Deposits (CDs) and the Jordanian Government securities; i.e. the

Treasury Bills. Given the fact that the secondary market for both instruments is very thin; almost non-existent in fact, market players tend to use the yield that is determined in the primary market as a benchmark, although the main limitation of using this yield is that both instruments are normally issued for a limited range of maturities; for instance the Central Bank of Jordan Certificates of Deposits (CDs) are normally issued for maturities of three and six months and the Treasury Bills for maturities of six month and one year. In addition, the Jordanian Government securities are not issued on a regular basis.

Therefore, the motivation for using the JODIBOR in this study can be described by the following two key points. First the JODIBOR provides us with daily information about the interest rates in the Jordanian money market for six terms of maturities compared with the Central Bank of Jordan Certificates of Deposits (CDs) and the Treasury Bills which have a limited range of maturities. Second, one of the main properties of the JODIBOR is that the interest on the interbank deposits is normally paid at maturity with the face value of the interbank loan, therefore, it becomes in a way similar to the property of the zero coupon bonds yields; i.e. there is no coupon payment[2]. This feature allows us to estimate the perfect foresight spread (PFS) using the same expectations model of the zero coupon bond.

The JODIBOR rate is an annualised rate and the data set is sampled on a daily basis and covers the period from 1 November 2005 (the date of launching the JODIBOR) to 11 November 2007, so the total number of observations is 499 observations. We are aware

[2] The interbank offer rate has been used in several studies such as those of Cuthburtson (1996) who uses the (LIBOR), Konstantinou (2005) who uses the (WIBOR), and Mylonidis and Nikolaidou (2002) who use the (Athibor/Euribor).

that using daily data has advantages and disadvantage; for example the daily data set provides us with a significant large sample that strengthens the accuracy of our estimation, but it may contain excessive noise (Drakos 2002).

3. *THE METHODOLOGY*

In this study, we will follow Hurn, Moody and Muscatelli (1995), Cuthbertson, Hayes and Nitzsche (1996), Lange (1999), Cuthbertson and Bredin (2000), and Mylonidis and Nikolaidou (2002) and test the validity of the PEH using the three main methodologies that have been used extensively in the empirical testing of the EH: these are the single equation regression, the VAR methodology and the cointegration analysis.

The main purpose of this study is to test the predictive power of the term spread through testing the validity of the PEH using the JODIBOR data, so the main focus will be on the short end of the term structure. The empirical testing of the validity of the EH will be implemented in the following order:-

3. .1 *The Single Equation Regression.*

3. .2 *The VAR methodology (Campbell and Shiller, 1987, 1991).*

3. .3 *The Cointegration analysis (Johansen approach).*

3.3.1 *THE SINGLE EQUATION REGRESSION*

Under this method we examine whether the actual spread predicts the changes of the future short term interest rates; i.e. the perfect foresight spread (PFS), in the Jordanian interbank market. Accordingly, we regress the PFS onto constant and actual spread and then test the validity of the PEH by testing first whether the actual spread has any predictive power for the future changes in short term interest rates; i.e. test if the slope coefficient β in the regression is significant which means testing the null hypothesis ($H_0: \beta = 0$).

The next step is to test whether the EH holds and this will be done by testing if the slope coefficient β equals one according to the theory, so we test whether the null hypothesis ($H_0: \beta = 1$) holds. In addition, to examine the validity of the PEH, we test whether the joint null hypothesis ($H_0: \alpha = 0, \beta = 1$) holds, i.e. test whether the term premia (α) equals zero and the slope coefficient (β) equals one.

The following model [3] will be used to test the above null hypotheses:

$$\sum_{i=1}^{k-1} \left(1 - \frac{i}{k}\right) \Delta^m r_{t+im}^m = \alpha + \beta \ (R_t^n - r_t^m) + \varpi_t^m$$

or

$$PFS_t^{(n,m)} = \alpha + \beta S_t^{(n,m)} + \varpi_t^m \qquad \text{Eq 3.3.1.1}$$

[3] The full details about this model are described in the Literature Review section 2.3.

Where

$k \quad = \dfrac{longrate}{shortrate} = \dfrac{n}{m}$.

$\alpha \quad$ = The term premia.

$S_t^{(n,m)}$ = ($R_t^n - r_t^m$) = the actual spread at time (t), where R_t^n is the long term interest rate and r_t^m is the short term interest rate.

$\beta \quad$ = The slope coefficient.

The main assumption under this method is the strong rationality where the market has perfect foresight about future changes of short term interest rates. In this case the perfect foresight spread is the summation of the changes in short term interest rates. In order to employ the single equation regression, two main time series have been constructed using historical data, the PFS and the actual spread. The PFS is constructed according to the following model:

$$\text{PFS} = \sum_{i=1}^{k-1} \left(1 - \frac{i}{k}\right) \Delta^m r_{t+im}^m \qquad \text{Eq 3.3.1.2}$$

While the actual spread is constructed as follows:

$$S_t^{(n,m)} = (R_t^n - r_t^m)$$

By examining figure 3.1 which shows the paths of the JODIBOR six interest rates, it seems that the very short term interest rates such as the overnight, one week, and one month interest rates have similar co-movement, while the longer term interest rates such as the three, six and twelve months have nearly different co-movement. In view of that, before constructing the actual and the perfect foresight spreads we divide the whole sample period into two. The first sample concentrates on the extreme short end of the JODIBOR term structure, so it includes the very short term interest rates such as the overnight, the one week and the one month interest rates and the second sample includes the longer term interest rates such as the one[4], three, six and twelve months' interest rates.

Given that the sample period is very short; that is it covers almost two years, and in order to capture all the available information in the data set, we use the daily quoted interest rates for different maturities as the base for our calculations. Computing the perfect foresight spread using Eq (3.3.1.2) makes us lose some observations at the end of the sample period for each spread and this is one of the major shortcomings of this method. The numbers of the lost observations are shown in details in tables 3.2.1 and 3.2.2.

Under the first sample, we use the very short term interest rates to compute the following two spreads; the first spread is between one week and overnight rates, and the second is between one month and overnight rates. The perfect foresight spread is computed on the basis that the week is seven days and the one month is 28 days[5].

[4]We include the one month interest rate in this sample to examine the predictive power of the spread between one period interest rates; i.e. one month interest rates, and long term interest rates at various maturities; i.e. three, six and twelve months.

[5]As the borrower pays the accrued interest on the interbank loan for the whole week period and not just for the working days, we consider that the week consists of seven days, and accordingly all the other

Regarding the second sample we use the longer term interest rates to calculate the following spreads; the spread between three month and one month rates, the spread between six month and one month rates, the spread between twelve month and one month rates, the spread between six month and three month rates, the spread between twelve month and three month rates and the spread between twelve month and six month rates. The calculations of the eight perfect foresight spreads are mentioned in details in Appendix 1.

3.3.2 *The VAR METHODOLOGY*

Campbell and Shiller (1991) declare that although the single equation regression has great merit in its simplicity, it does however contain major shortcomings such as the existence of overlapping errors. Further it does not provide robust evidence of whether the movements of the actual spread and the theoretical spread are similar[6]. In view of that, they developed the VAR methodology which is considered a difficult method when compared with the single equation regression; although it is more desirable as it does not suffer from overlapping errors. Moreover, the VAR methodology consists of a wide range of statistics that are designed to provide a comprehensive analysis for the validity of the EH. In this study, we will employ the VAR methodology that has been introduced by Campbell and Shiller (1987, 1991) to test the rational expectations hypothesis of the term structure of interest rates (REHTS).

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maturities are calculated using the same base; the week =7days, the one month=28 days, the three month=84 days, the six month=168 days and the twelve month= 336 days.

[6] Please see chapter two section 2.3.2.1 for more details about the single equation regression.

The main important difference between the single equation regression and the VAR methodology is the main assumption underpinning each method. Strong rationality is the main assumption under the single equation regression and strong rationality means that economic agents have perfect foresight about the changes in the future short term interest rates, so they have a full set of information.

On the other hand, weak rationality is the main assumption under the VAR methodology and weak rationality means that economic agents build their decisions and expectations on a limited set of information (Cuthbertson 1996). According to Campbell and Shiller (1991) the actual spread should be one of the main components of this limited set of information because it normally contains embedded information that can help in predicting the future changes in short term interest rates. In addition, this limited set of information consists of past values of interest rates and it may also include any variables that may help in enhancing the analysis[7].

According to the EH the main model that explains the relation between the actual spread and the future changes in short term interest rates is as follows:

$$(R_t^n - r_t^m) = \sum_{i=1}^{k-1} \left(1-\frac{i}{k}\right) E_t (\Delta^m r_{t+im}^m) + Tp_t^m \qquad \text{Eq 3.3.2.1}$$

[7] According to Cuthbertson, Hayes and Nitzsche (1996), the VAR approach requires that both agents and econometricians use the same set of information and if the information set that is used by econometricians is different from the one that is used by economic agents, then the estimated coefficients of the VAR will be biased and accordingly the EH will be rejected. For further details please see the interpretation of Cuthbertson, Hayes and Nitzsche (1996) in chapter two section 2.4.1.5.

The left hand side represents the actual spread ($S_t^{(n,m)}$) between the longer term interest rates for n period (R_t^n) and the shorter term interest rates for m period (r_t^m). The right hand side represents the weighted average of the expected changes in future short term interest rates plus term premia. Since we are testing the PEH then the term premia is assumed to be equal to zero.

In order to explain the VAR methodology and its relation with the above main model of the EH, we will use the following relationship which has been tested extensively in the literature, especially in terms of the validity of the EH at the short end of the term structure[8].

If n =3month and m =1month, so $k = \frac{3}{1}$ =3, the EH identifies this relation as follows:

$$S_t^{(3,1)} = \frac{2}{3} E_t \Delta r_{t+1} + \frac{1}{3} E_t \Delta r_{t+2} \qquad \text{Eq 3.3.2.2}$$

Where,

$S_t^{(3,1)} = (R_t^3 - r_t^1)$

$E_t \Delta r_{t+1} = E_t r_{t+1} - r_t$

$E_t \Delta r_{t+2} = E_t r_{t+2} - E_t r_{t+1}$

In order to test the EH using the VAR, the above two expected changes in future short term interest rates ($E_t \Delta r_{t+1}$ and $E_t \Delta r_{t+2}$) have to be replaced. Based on the main assumption under the VAR method; the weak rationality (dealing with a limited set of

[8] The explanation of the VAR methodology has been borrowed from Cuthbertson and Nitzche (2005).

information), we will replace the terms ($E_t\ \Delta r_{t+1}$ and $E_t\ \Delta r_{t+2}$) by assuming a specific expectations system that reflects market players' expectations using the available information; that is using the actual spread as suggested by Campbell and Shiller (1987,1991) and the past values of interest rates. Therefore, we assume that the two expected changes in short term interest rates ($E_t\ \Delta r_{t+1}$ and $E_t\ \Delta r_{t+2}$) follow a AR(2) process, so for example :

$$E_t\ \Delta r_{t+2} = a_{21}\ E_t S_{t+1}^{(3,1)} + a_{22}\ E_t\ \Delta r_{t+1} + a_{23}\ S_t^{(3,1)} + a_{24}\ \Delta r_t \qquad \text{Eq 3.3.2.3}$$

,and this rule applies as well on $E_t\ \Delta r_{t+1}$ so $E_t\ \Delta r_{t+1}$ can be written as follows:

$$\Delta r_{t+1} = a_{21}\ S_t^{(3,1)} + a_{22}\ \Delta r_t + a_{23}\ S_{t-1}^{(3,1)} + a_{24}\ \Delta r_{t-1} \qquad \text{Eq 3.3.2.4}$$

It is clear that in Eq (3.3.2.3) an additional variable has to be forecasted which is the ($E_t S_{t+1}^{(3,1)}$). Therefore, we use Eq (3.3.2.4) as one of the main components of the limited set of information. Campbell and Shiller (1991) suggest that the spread ($S_{t+1}^{(3,1)}$) should be included as the dependent variable of one of the two VAR equations and that both equations should follow AR (2) process and have the same set of independent variables. Therefore we construct the VAR system of two equations; the dependent variables are ($S_{t+1}^{(3,1)}$ and Δr_{t+1}) and the independent variables that forecast the changes in the future short term interest rates are the same as the variables that forecast the spread. So the constructed VAR system which represents the limited set of information takes the following form:

$$S_{t+1}^{(3,1)} = a_{11} S_t^{(3,1)} + a_{12} \Delta r_t + a_{13} S_{t-1}^{(3,1)} + a_{14} \Delta r_{t-1} + \mu_{1t+1} \qquad \text{Eq 3.3.2.5}$$

$$\Delta r_{t+1} = a_{21} S_t^{(3,1)} + a_{22} \Delta r_t + a_{23} S_{t-1}^{(3,1)} + a_{24} \Delta r_{t-1} + \mu_{2t+1} \qquad \text{Eq 3.3.2.6}$$

The two VAR equations (3.3.2.5 and 3.3.2.6) are used to forecast the changes in the future short term interest rates. The forecasted changes in short term interest rates will replace the $E_t(\Delta^m r_{t+im}^m)$ in Eq (3.3.2.1). To substitute the above two VAR equations into the PEH equation (3.3.2.1), Campbell and Shiller (1987, 1991) rearrange equations (3.3.2.5 and 3.3.2.6) as a first order system. This system is called the companion form.

$$\begin{bmatrix} S_{t+1}^{(3,1)} \\ \Delta r_{t+1} \\ S_t^{(3,1)} \\ \Delta r_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} S_t^{(3,1)} \\ \Delta r_t \\ S_{t-1}^{(3,1)} \\ \Delta r_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1,t+1} \\ u_{2,t+1} \\ 0 \\ 0 \end{bmatrix} \qquad \text{Eq 3.3.2.7}$$

This system is a VAR (2) system (lag=2). It contains a vector (4x1) of dependent variables $z_{t+1}\ [S_{t+1}^{(3,1)}\ \ \Delta r_{t+1}\ \ S_t^{(3,1)}\ \ \Delta r_t]'$, a square (4x4) matrix of estimated coefficients, (A), and a vector (4x1) of independent variables $z_t\ [S_t^{(3,1)}\ \ \Delta r_t\ \ S_{t-1}^{(3,1)}\ \ \Delta r_{t-1}]'$. Matrix (A) should be a square matrix; thus additional selected vectors (2px1) are defined and added to Matrix (A).

$e_1 = [\,1\ \ 0\ \ 0\ \ 0\,]'$, and, $e_2 = [\,0\ \ 1\ \ 0\ \ 0\,]'$

The companion form can be written as follows:

$$z_{t+1} = Az_t + w_{t+1} \qquad \text{Eq 3.3.2.8}$$

To replace the ($E_t\, \Delta r_{t+1}$ and $E_t\, \Delta r_{t+2}$) in the PEH equation (3.3.2.1), the following expressions are derived using the selected additional vectors[9].

$$S_t^{(3,1)} = e_1^{/}\, z_t \text{ , this means } S_t^{(3,1)} = S_t^{(3,1)} \qquad \text{Eq 3.3.2.9}$$

$$\Delta r_t = e_2^{/}\, z_t \text{, this means } \Delta r_t = \Delta r_t \qquad \text{Eq3.3.2.10}$$

$$E_t\, \Delta r_{t+1} = e_2^{/}\, E_t\, z_{t+1} \text{ and since } E_t z_{t+1} = Az_t \text{ , then } E_t\, \Delta r_{t+1} = e_2^{/}\, Az_t \qquad \text{Eq 3.3.2.11}$$

$$E_t\, \Delta r_{t+2} = e_2^{/}\, E_t z_{t+2} \text{ and since } E_t z_{t+2} = AE_t z_{t+1} \rightarrow E_t z_{t+2} = A(A.z_t) = A^2\, z_t \text{ ,then } E_t\, \Delta r_{t+2} = e_2^{/}\, A^2\, z_t \qquad \text{Eq 3.3.2.12}$$

Accordingly, the general form, or the "chain rule of forecasting" using VAR estimates will be as follows:

$$E_t \Delta r_{t+j} = e_2^{/}\, A^j\, z_t \qquad \text{Eq 3.3.2.13}$$

The derived general form in Eq (3.3.2.13) enables us to replace the two expected changes in future short term interest rates ($E_t\, \Delta r_{t+1}$ and $E_t\, \Delta r_{t+2}$) in Eq (3.3.2.1). Following our example the replacement will be as follows:

$$S_t^{(3,1)} = \frac{2}{3}\, E_t\, \Delta r_{t+1} + \frac{1}{3}\, E_t\, \Delta r_{t+2}$$

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9 The reason behind using ($e_2^{/}$), where all entries are zero except the second entry is equal to (one), is to pick up the Δr_t from the z_t vector. In addition the reason behind using ($e_1^{/}$), where all entries are zero except the first entry is equal to (one), is to pick up the $S_t^{(3,1)}$ from the z_t vector.

$e_1^{/} z_t = \frac{2}{3}(e_2^{/} A z_t) + \frac{1}{3}(e_2^{/} A^2 z_t)$, rearrange this equation

$$e_1^{/} z_t = e_2^{/} \left(\frac{2}{3} A + \frac{1}{3} A^2\right) z_t \qquad \text{Eq 3.3.2.14}$$

The left hand side of equation (3.3.2.14) represents the actual spread and the right hand side represents the optimal prediction of the changes in future short term interest rates under the VAR method, i.e. the forecasted spread. The forecasted spread is called the theoretical spread S_t^*. Cuthberston and Bredin (2000) describe the theoretical spread as a complex function of the estimated parameters of the A matrix of the VAR. The VAR methodology says that we replace the expected perfect foresight spread[10] with a theoretical spread that is constructed using a "limited set of information" provided that the actual spread is included in this limited information set because it contains all relevant information of the market. The interpretation of Eq (3.3.2.14) is that if the actual spread and the theoretical spread are equal then the PEH holds.

$$S_t = S_t^* \qquad \text{Eq 3.3.2.15}$$

Equation (3.3.2.15) simply says that the actual spread S_t should equal the constructed theoretical spreads which represent the optimal prediction of future changes in the short term interest rates based on the two VAR equations ($S_{t+1}^{(n,m)}$, Δr_{t+1}).

In order to test the EH under the VAR methodology, Campbell and Shiller derived a set of non-linear restrictions as follows:

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[10] The perfect foresight spread = PFS = $\sum_{i=1}^{k-1}(1-\frac{i}{k})\{\Delta^m r_{t+im}^m\}$

$$F(a) = e_1^{/}\text{-}e_2^{/}\ A\,[I - \left(\frac{m}{n}\right)(I - A^n)(I - A^m)^{-1}](I - A)^{-1} = 0 \qquad \text{Eq3.3.2.16}$$

The restrictions on the parameters of the VAR in Eq (3.3.2.16) are tested by using the Wald test. We can simplify Eq (3.3.2.16) by saying if Eq (3.3.2.14) is true and the PEH holds then the non-linear restriction in Eq (3.3.2.16) must hold as follows[11]:

$$F(a) = e_1^{/}\text{-}e_2^{/}\ (\frac{2}{3}\ A\ +\ \frac{1}{3}\ \ A^2) = 0$$

So the restrictions in equation Eq (3.3.2.16) simply test whether the actual spread equal the constructed spread; that is, test the null hypothesis $H_0 : S_t = S_t^*$.

Campbell and Shiller (1991) who derived the above restrictions declare that testing the restrictions in the form of equation Eq(3.3.2.16) using the Wald test may lead to the rejection of the EH and even if the rejection is statistically significant, it may not mean, from an economic perspective, that there is a major departure from the EH especially if the theoretical spread tracks the actual spread. In view of that, they suggest comparing the behaviour of theoretical spread with the behaviour of actual spread using other tests and procedures such as using the plots of both spreads to compare whether they are moving closely together, and to compute both the correlation coefficient and the standard deviation ratio (SDR) between the two spreads. They claim that if the plots show that both spreads are moving together and if the correlation coefficient and the

[11] Please see Cuthbertson and Bredin (2000), Garganas (2002) and Cuthbertson and Nitzsche (2005).

SDR are equal to one, then both spreads are considered equal and accordingly the EH holds.

The argument of Campbell and Shiller (1991) has been proven in other studies such as those of Cuthbertson, Hayes and Nitzsche (1996), Cuthbertson and Bredin (2000) and Garganas (2002), who use the VAR methodology to test the EH and find that the cross equation restrictions using the Wald test have been strongly rejected[12], which indicates the rejection of the EH, whereas the correlation coefficient and the SDR provide support to the EH.

In this study, we follow Cuthbertson, Hayes and Nitzsche (1996), Cuthbertson and Bredin (2000), and Garganas (2002) and examine the EH by employing different procedures and tests. The following explanation is the order of the procedures that we apply to construct the theoretical spread using the VAR methodology.

We determine first the optimal lag order of the VAR system by using the information criteria such as the Akaike criterion (AIC) and the Schwartz Bayesian criterion (SBIC). The optimal lag is the one that minimises the information criteria and indicates the non existence of serial correlation in the residuals. Second we estimate the two VAR equations using the GMM estimator and the reason for using the GMM estimator instead of the OLS estimator is to obtain a robust system of estimated variance covariance matrix of coefficients to calculate the standard errors of the correlation

[12] The cross equation restrictions of the VAR using Wald test have been rejected in most of the studies. For example, they are rejected in four cases out of eight in Cuthbertson's study (1996) table (8), in four cases out of five in Cuthbertson, Hayes and Nitzsche's study (1996) table (7), and in nine cases out of 10 in Garganas' study (2002) tables 2.5.3a, 2.5.3b and 2.5.3c.

coefficient and standard deviation ratio. Third we use the estimated VAR coefficients, Matrix A, to construct the theoretical spread by applying the general form or the "chain rule of forecasting" equation (3.3.2.13).

After constructing the theoretical spreads, we employ the following test and statistics to test the validity of the EH:

- Plot a graph of the actual spread and the constructed theoretical spread. We expect that the two time series move together (highly positive correlation) if the PEH holds.

-Test the PEH by estimating the following single equation regression

$$S_t^* = \alpha + \beta S_t + \varepsilon_t$$

In this new single equation regression, we regress the theoretical spread onto constant and actual spread and then test the null hypothesis ($H_0 : \beta = 1$) and the joint null hypothesis of the PEH ($H_0 : \alpha = 0, \beta = 1$). The non rejection of the null hypotheses is an indication that the EH holds.

- Employ the Wald test to test the null hypothesis ($H_0: S_t = S_t^*$). Based on the fact that testing the restrictions in the form of Eq (3.3.2.16) using the Wald test leads to the rejection of the EH, although the deviation from the null is very small as shown in most of the studies, hence in this study we use the Wald test to impose linear restriction between the actual spread and the constructed theoretical spread. Our main purpose is simply to test whether the actual spread time series and the theoretical spread time series are equal, regardless of the complex function that has been used to construct the theoretical spread. Therefore, we employ the Wald test to test the following hypothesis ($H_0 : S_t = S_t^*$).

- Calculate the ratio [$s.d.(S_t^*)\ \ s.d.(S_t)$]; we expect that if this ratio approaches one then this is an indication that the PEH holds[13].

- Calculate the correlation coefficient between the actual spread and the theoretical spread Corr (S_t, S_t^*); we expect also that if the correlation coefficient approaches one then this is an indication that the PEH holds[14].

3.3.3 *THE COINTEGRATION ANALYSIS*

Most of the recent studies concentrate on the cointegration approach as an appropriate approach for studying the term structure of interest rates and for testing the validity of the EH. The approaches that have received most attention are those of Johansen (1988) and Johansen and Juselius (1990).

[13] The variance-covariance matrix of coefficients that we obtained will be used to estimate the standard errors for the standard deviation ratio (SDR) and the correlation coefficient between the theoretical spread and the actual spread (Cuthbertson, Hayes and Nitzche 1996). The standard errors (SE) for the standard deviation ratio SDR = [$s.d.(S_t^*)\ \ s.d.(S_t)$] and the Corr (S_t^*, S_t) are non-linear functions of the estimated (A) matrix from the VAR and can be computed as ($f_y(y)^{/}\ \Psi\ f_y(y)$) where $f_y(y)$ is the statistics of interest and Ψ is the (GMM) variance-covariance matrix of parameters (y).

[14] Please see footnote 13.

The main reason that makes this approach more preferable is its ability to identify all the cointegration vectors within a given set of variables. In addition, "it permits direct hypothesis tests on the variables entering the cointegrating regression"[15] (Cooray 2003). The main purpose of the cointegration analysis is to find out whether the term structure of interest rates is driven by one common stochastic trend.

In this study we implement three different types of cointegration tests using the Johansen approach; i.e. the bivariate cointegration test, the trivariate cointegration test and the multivariate cointegration test. We follow Shea's (1992) steps and begin our cointegration testing with the bivariate case because the results of this test will provide us with important information about the structural relationship between different pairs of interest rates.

According to Shea (1992), the main reason behind employing the bivariate test before the multivariate test is to obtain an overview of how well the hypothesis will perform on a part of the yield curve and then proceed to test how the EH will perform in the multivariate system.

The relationship between the term structure and the cointegration test is described by this equation:

$$(R_t^n - r_t^m) = \sum_{i=1}^{k-1} \left(1 - \frac{i}{k}\right) \Delta^m r_{t+im}^m + \varpi_t^m + Tp_t^m \qquad \text{Eq 3.3.3.1}$$

[15] Cooray 2003: 1823.

The right hand side represents the sum of the changes in the future short term rates and this term is assumed to be stationary. The term premia equals zero under the PEH; so this component is also assumed to be stationary. The left hand side is the actual spread and it is assumed to be stationary I(0) with a cointegrating vector (1,-1) if the EH holds.

Under the cointegration analysis, we test the null hypothesis of whether there is a cointegration relationship between interest rates of different maturities. If the cointegration relationship exists, we proceed to directly testing the EH by imposing restrictions on the coefficients of the cointegrating vectors. In this study all the variables that will be included in the cointegration analysis are interest rates of different maturities; therefore we will use Model 2 (i.e. the restricted constant, no trend) because it is the most appropriate model that fit the nature of interest rates series.

The cointegration analysis is normally applied to explain a long term relationship between interest rates of different maturities; accordingly the sample period should be large enough to reflect the behaviour of the interest rates, especially the long term interest rates. We are aware that our data set covers only two years, from 1 November 2005 until 11 November 2007, and since we are dealing with daily data, this makes the number of observations large; i.e. (499) observations. Despite the large number of observations, we still believe that our sample period is somewhat short and it may not permit us to capture the real behaviour of the longer term interest rates in the JODIBOR term structure especially the six month and one year rates. Drakos (2001) declares that using the cointegration techniques in the case where the sample covers a very short period may be doubtful, especially the economic significance of the results. We expect that the results may not be economically significant for the longer term interest rates but at least they will provide us with a powerful piece of information about the market potential.

Before performing the cointegration analysis through VAR system, two primary procedures have to be implemented. The first procedure is to determine the order of integration of interest rates levels and first differences, because the evidence of non stationarity in the levels of interest rates is highly important as it allows us to perform the cointegartion analysis. The second procedure is to determine the optimal lag length of the VAR system and this will be done by using the information criteria such as the Akaike criterion (AIC) and the Schwartz Bayesian criterion (SBIC). The optimal lag order will be the one that minimises the information criteria and indicates that the obtained residuals from VAR system are Gaussian (i.e. the residuals are uncorrelated, normally distributed and homoskedastic).

The first step in the cointegrating analysis after obtaining the optimal lag order is to identify the appropriate rank of the cointegration system. We will use the maximum likelihood estimation approach which was proposed by Johansen and Juselius (1990) to identify the appropriate rank. The model is as follows:-

Let X_t be a vector with dimension (nx1) of interest rates variables which are integrated of order one I(1) with a VAR (Vector Autoregressive) of order (k).

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots\ldots + A_k X_{t-k} + \varepsilon_t \qquad t = 1,2,\ldots\ldots, T.$$

Where

A_i = a (nxn) matrix of parameters.

ε_t = the vector of Gaussian error terms, $\varepsilon_t \sim \mathrm{N}(0, \sigma_\varepsilon^2)$

X_t in this study will be a vector of dimension (6 x 1) as follows:

$$\begin{bmatrix} r_{overnight} \\ r_{oneweek} \\ r_{onemonth} \\ r_{threemonth} \\ r_{sixmonth} \\ r_{oneyear} \end{bmatrix}$$

Reparameterising the above model into the Error Correction Model (ECM) framework, the general representation of the ECM form will be as follows:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \ldots\ldots + \Gamma_{k-1} \Delta X_{t-(k-1)} + \Pi X_{t-1} + \varepsilon_t$$

Where

Γ_i = - (I - A_1 - ….. - A_i), (I = 1,2,…..,k-1), i.e. Γ_i is the parameter vectors.

Π = - (I - A_1 - ….. - A_k); i.e. Π is the product of $\alpha\beta$, where α is the vector of the speeds of adjustment and β is the matrix of the coefficients of the cointegrating vectors.

The Π is a matrix with dimension (nxn) where n is the number of the variables in the cointegration system. The rank of this matrix determines the number of cointegrating relationships among the variables in vector X_t. The rank of the matrix Π is by definition equal to the number of linearly independent stationary combinations of the variables in X_t.

The rank can be zero (r=0) which means there is no cointegration relationship; the rank can be (r=n) which means that all the variables are stationary, or the rank can be a reduced rank (0 < r < n) and in this case Π can be factorised as $\Pi = \alpha\beta'$, where α is a matrix with dimension (n x r) and β' is a matrix with dimension (r x n) where r is the number of cointegrating vectors. To determine the rank of the matrix Π, we will use the two likelihood ratio tests which were proposed by Johansen and Juselius (1990) .

-The first one is the maximal eigenvalue and its statistic is given by this equation:

$\lambda_{\max} = \text{-T} \ln(1-\lambda_{r+1})$,

where λ is the eigenvalues and T is the number of the observations. The null hypothesis under $\lambda_{\max}$ is that there is (at most r) cointegrating vectors against the alternative of (r+1).

-The second test is the Trace test and its statistic is given as follows:

$\lambda_{trace} = \text{-T} \sum \ln(1-\lambda_i)$

where λ is the eigenvalues and T is the number of the observations. The null hypothesis under λ_{trace} is that there are (r) cointegrating vectors against the alternative that there are (r or more) cointegrating vectors.

Determining the rank and identifying the cointegrating vectors if exist is our first null hypothesis testing. The second null hypothesis is to test the validity of the EH by imposing restrictions on the identified cointegrating vectors. The expected cointegrating relationship will be up to (n-1). The restrictions will be set strictly according to the EH which implies that the cointegration space will take the following form:

The theoretical cointegration space =

$$\begin{bmatrix} 1 & 1 & 1 & --- & 1 \\ -1 & 0 & 0 & --- & 0 \\ 0 & -1 & 0 & --- & 0 \\ 0 & 0 & -1 & --- & 0 \\ 0 & 0 & 0 & --- & -1 \end{bmatrix}$$

Testing the EH will be done by imposing the restrictions as follows: Under the bivariate system, we expect to have one unique cointegrating vector. To test the EH; that is the left hand side of equation (3.3.3.1), we will impose restrictions that comply with the theoretical restrictions (1,-1). So we restrict the coefficients of the variables that enter the spread to be (1,-1), or according to the Johansen approach this is called the zero sum restrictions on matrix B. The test whether the restriction is significant or not will be done by using the standard Chi-square χ^2 distribution with a specific significant level (5%). The (degree of freedom) under the χ^2 will be equal to the number of over identifying restrictions.

Whereas under both the trivariate and multivariate systems, we expect to have more than one cointegrating vectors, according to Johansen approach we may have up to (n-1) cointegrating vectors where n equals the number of variables included in the cointegration system. Imposing restrictions on the several cointegration vectors will be similar to the bivariate case except that in each time the numbers of restrictions will be more than one: for example in the trivarite case (the two spreads) we impose two over-identifying restrictions while in the multivariate case (the five spreads) we impose five over-identifying restrictions. In all cases if the restrictions are not significant; i.e. cannot be rejected, we conclude that EH is valid and holds.

Before performing the three methods of testing the EH, a unit root test should be carried out to identify the true order of integration for all JODIBOR interest rates and the two spreads; the actual spread and the PFS.

3.4. *UNIT ROOT TEST*

Determining the order of integration of the JODIBOR interest rates in levels, first differences and the two spreads (univariate series test) is the first and most significant step before implementing any empirical testing. In this study we carry out a unit root test on interest rates in levels and on interest rates first differences, expecting that the order of the integration will be I(1) for the interest rates in levels and I(0) for interest rates first differences. We test the order of integration of interest rates first differences because if the findings show that they are I(0) then this confirms that the order of the integration of the interest rates in levels is I(1).

The evidence of non stationarity of the levels of interest rates is highly important because it allows us to perform the cointegartion analysis. The main idea here is that if the interest rates in levels are I(1) and if the combination between a pair of interest rates; i.e. the spread, is found to be stationary, then this is an indication that the EH may hold. Moreover, we perform a unit root test on the actual spread and the PFS and we expect that any evidence of stationarity for both spreads will be an indication that the EH may hold while any evidence of non stationarity will be an indication that it may not hold.

To identify the order of the integration we employ the Augmented Dickey Fuller (ADF) unit root test (Dickey and Fuller 1979, 1981) and the Phillips-Perron test (PP). The ADF test is implemented under the information criterion (AIC) for the interest rates in levels and first differences and under the information criteria (AIC) and (SIC) for the two spreads. We employ the model with constant as exogenous variables for the JODIBOR interest rates in levels[16] and the two spreads, while for interest rates first differences we employ the model with no constant or trend (i.e. Exogenous=None). The ADF test is based on the following Ordinary Least Square (OLS) estimations:

A-Model (1) : Constant

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-i} + \varepsilon_t$$

[16] We employ the model with constant for the JODIBOR interest rates because it is the most appropriate one that comply with the nature of interest rates series.

B-Model (2): No Constant with No Trend

$\Delta y_t = \beta y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-i} + \varepsilon_t$

Where

Δ is the first difference operator,

$\boldsymbol{y_t}$ is the series tested.

$\boldsymbol{\varepsilon_t}$ is a covariance stationary random error.

The optimal lag length for each model is identified as the one that removes autocorrelation in error terms. The null hypothesis of unit root $|\beta|=1$ is tested against the alternative of stationarity $|\beta|<1$.

To confirm the results of the ADF test, another test is carried out which is the PP test. This test allows for more relaxed assumptions than ADF. For example the main assumption under ADF test is that the residuals should be uncorrelated with each other and their variance should be constant, so normally, to get rid of the serial correlation, extra lags differenced terms must be added, whereas the PP test accounts for the serial correlation in the residuals by making a correction to the t-statistics of the coefficient (ρ) from the AR(1) regression (Asteriou and Hall 2007). The PP model is a AR(1) process:

$$\Delta y_{t-i} = \alpha_0 + \rho y_{t-1} + \varepsilon_t .$$

In order to give an indication about the order of integration of each interest rate, we show in figures 3.2-3.7 each interest rate in level and first difference. It is clear that the order of integration of interest rates in levels can be I(1) and I(0) for the first differences, though the results of the unit root test will confirm the real order of integration for the six rates.

3.5 THE EMPIRICAL RESULTS

3.5.1 THE UNIT ROOT TEST

In table 3.1.1 the results of the ADF (AIC) evidently show that all six interest rates in levels are integrated of order one I(1) as we cannot reject the null hypothesis of non stationarity for the overnight, one week, three month, six month and twelve month rates at all significance levels 1%, 5%, and 10%. Regarding the one month rate, we cannot reject the null hypothesis of non stationarity at significance levels 1% and 5%. The results of the first differences show clearly that we reject the null hypothesis of non stationarity at all significance levels 1%, 5% and 10%.

The PP test results in table 3.1.2 confirm the results of the ADF test that all six rates are I(1) in levels and I(0) in first differences. The results show that we cannot reject the null hypothesis of non stationarity for the overnight rate at significance level 1%, for the one week rate at significance levels 1% and 5%, and for the one month, three month, six month and twelve months rates at all significance levels 1%, 5%, and 10%. Regarding the first differences we reject the null hypothesis of non stationarity at all significance levels 1%, 5% and 10%. Our findings that all six rates are I(1) in levels permit us to include all six interests rates series in the cointegration analysis.

Table 3.1.3 illustrates the results of the unit root test for the actual spread and the PFS and it is clear that four out of eight of the actual spread and three out of eight of the PFS are stationary I(0) which complies with the EH. Most of the spreads that are found to be stationary include the very short term interest rates such as the overnight, one week, and one month rates. The remaining spreads are found to be non stationary I(1), and this does not comply with the EH. This may means that the term structure is not driven by a single common trend but by several non stationary or nearly stationary factors (Christiansen et al. 2002). It is obvious that when the longer term interest rates in the JODIBOR term structure such as the six month and the twelve month rates are part of the spreads, the results of the unit root indicate that we cannot reject the null hypothesis that the spreads are I(1). This may due to the fact that the sample period covers only two years and the longer term interest rates may require more time to reflect their real behaviour.

3.5.2 *THE SINGLE EQUATION METHOD*

Due to the overlapping data[17] and in order to obtain robust results, the single equation was estimated using two estimators, the OLS and the GMM. The OLS is used with a correction based on Newey-West (1987) for a moving average of order (n-m-1) and for conditional heteroskedasticity and the GMM (Generalized Method of Moments) is used because it provides robust standard error in the presence of overlapping errors and it is also robust for heteroskedasticity.

[17]The overlapping data occur because the difference in maturity between the long term rates and the short term rates is longer than the frequency of the data which is daily. According to the data limitations in this study, we cannot solve this problem by lengthen the data frequency to match the maturity of the difference because this will cause many observations to be lost. For further information, please see the literature review chapter two section 2.4.1.1 The estimation problems.

The estimation results of OLS and GMM are shown in tables 3.2.1 and 3.2.2. The regression is done for different pairs of maturities (n and m). The corrected standard errors are the ones that are reported in parentheses in tables 3.2.1 and 3.2.2. In order to examine whether the PEH holds, we use the Wald test to impose the restrictions on the coefficients. The results of the Wald tests are also shown in square brackets in tables 3.2.1 and 3.2.2.

The first hypothesis of interest is to test whether the actual spread has any predictive power for future changes in short term interest rates. The Wald test results under OLS and GMM estimators (column no. 7) indicate clearly that the coefficient of the spread β is significantly different from zero for all pairs of maturities except one pair; i.e. the spread between the twelve month and six month rates, where the (ρ $value$) indicates that we cannot reject the null hypothesis ($H_0 : \beta = 0$),i.e. (ρ $value$) =0.452 under the OLS and 0.439 under the GMM. The main reason for this rejection is because the slope coefficients under both estimators OLS and GMM have negative values; i.e. under OLS the coefficient β= -0.380 and under GMM β= -0.548. The negative values of the slope coefficients indicate clearly that the actual spread between the twelve month and six month rates does not have any predictive power for the changes in the future six month interest rates. Moreover the adjusted R^2 equals (0.003) under the OLS and (0.002) under GMM and both values are very low and confirm the previous conclusion.

Regarding the other seven spreads, the results show that the null hypothesis β=0 is rejected; i.e. the (ρ $value$) =zero, so we accept the alternative null that $\beta \neq 0$. The rejection means that the slope coefficient in each case has a positive value which means that the actual spreads have some predictive power for the changes in the future short term interest rates.

The second hypothesis of interest is to test whether the EH holds and this is done first by testing whether the slope coefficient is equal to one; i.e. $(H_0 : \beta = 1)$, and then testing the joint null hypothesis under the PEH ($H_0 : \alpha$ =0, β= 1). Regarding the null hypothesis ($H_0 : \beta$= 1), the results of the Wald test are not in favour of the EH for all spreads as (ρ *value*) =zero, except for the spread between the six month and three month rates under the GMM estimator, the (ρ *value*) =0.057. Regarding the joint null hypothesis (H_0: α =0, β= 1), the results of the Wald test also are not in favour of the PEH for all spreads. See columns 8 and 9 in tables 3.2.1 and 3.2.2.

In summary, the slope coefficient is not close to the theoretical value one for all pairs of maturities (n and m) except for one case under the GMM estimator as mentioned earlier. In addition the results of the adjusted R^2 are not high and this confirms our findings. The main results suggest that the actual spread between the longer term rates and the shorter term rates have very low predictive power for the changes in the future short term rates.

3.5.3 *THE VAR METHODOLOGY*

In table 3.3.1 we report the results of the optimal lag order selection and the diagnostic tests such as the normality test using Jarque Bera test and the serial correlation test of the residuals using Ljung-Box for each individual equation in the VAR system. We use many lag order selections under the VAR system but the lags that are tabulated under each spread represent the optimal lags that minimise the information criteria and pass the diagnostic test that there is no serial correlation in the residuals.

It is clear that the statistics of the Jarque Bera are very high. The Jarque Berra statistics for both equations; i.e. the spread and the changes in interest rates, are greater than the critical value of the Chi-square distribution with two degrees of freedom $\chi^2(2)$; i.e. greater than 5.991, and this is an indication of non normality. Regarding the statistics of the Ljung-Box (Q-statistic), all the values are less than the critical value of the Chi-square distribution with two degrees of freedom $\chi^2(2)$ and this is an indication that the residuals are not serially correlated.

In table 3.3.2 we report the results of the regression of the theoretical spread on the actual spread. The estimations of the slope coefficient are very close to unity in three cases out of eight; i.e. S(3m -1m) = 0.925, S(m -1m) =1.095 and S(6m – 3m) =1.038. In order to obtain robust results of whether the slope coefficient is close to the theoretical value one, we employ the Wald test to examine the null hypothesis ($H_0 : \beta = 1$) and the joint null hypothesis of the PEH ($H_0 : \alpha = 0, \beta = 1$) and the results indicate the rejection of the EH for all spreads.

By examining the figures from 3.16 to 3.23 which represent the plots between the theoretical spreads and the actual spreads, it seems that in all cases the two time series are moving together and there is a positive correlation between them. However the correlation coefficient and the standard deviation ratio statistics will confirm the power of the correlation between the two spreads.

In table 3.3.3 we report the results of the correlation coefficient, the SDR and the Wald test. The results indicate that the correlation coefficients are close to the theoretical value one in all spreads except the spread between the one week and overnight rates, considering the standard errors are very low. Regarding the standard deviation ratio, two spreads out of eight are close to the theoretical value one such as S(3m-1m) and S(6m-3m), considering also that the standard errors are extremely low for all spreads. Moreover, the Wald test statistics are extremely high for all spreads except for a very few cases and it indicates the rejection of the restrictions for all spreads; i.e. ($\rho - value$= 0).

In summary, although the correlation coefficient and the standard deviation ratio statistics provide some support to the PEH and for very few spreads, the other two tests such as the Wald test and the single equation regression strongly reject the PEH for all the spreads. The rejection under the VAR method is not surprising and complies with the results of the previous method. We may conclude that market players in this market may not use the VAR methodology for forecasting the changes in the future short term interest rates and if they do use the VAR, then their set of information is different from the one that we use in this study. Given that the Jordanian interbank market of different maturities is a relatively new market, we believe that the players in this market are still learning and they may not use all the available information in the most optimum way.

3.5.4 THE COINTEGRATION ANALYSIS

The cointegration analysis using the Johansen approach is performed after all necessary conditions are fulfilled; i.e. all six interest rates are integrated at first order I(1) and an optimal lag order is chosen for the VAR system.

The diagnostic tests for the VAR residuals are as follows: LM statistics indicate that the residuals are not serially correlated, the Jarque Bera test for normality indicates that the residuals are not normally distributed and the VAR residuals heteroskedasticity test indicates that in five bivariate sets out of fifteen, the test supports the assumption of homoskedasticity such as the bivariate systems of ((overnight-one month), (one week – one month), (one week – three month), (one week – six month) and (three month – six month)). The results of the normality and heteroskedasticity tests are against the assumptions but this is normal in financial data.

Regarding the bivariate cointegration tests (the one spread) case, according to the theory we expect to have one cointegrating vector for each bivariate system (r =1). After performing the Johansen approach on 15 bivariate sets, a one cointegrating vector has been identified under just three bivariate systems out of 15; these are the bivariate systems of the overnight and one week rates, the overnight and one month rates and the overnight and three month rates (table no. 3.4).

The first and the second cointegrating vectors are found at 5% level of significance where both the trace and the maximal eigenvalue tests indicate the same number of cointegrating vectors (r = 1). Regarding the third cointegrating vector between the overnight and three month rates, the maximal eigenvalue test indicates that the number of cointegrating vectors is one (r = 1) at 10% level of significance and nothing at 5% level of significance, whereas the trace test indicates that there are no cointegrating vectors (r = 0) at both 5% and 10% levels of significance.

Researchers such as Enders (2003) and Drakos (2002) demonstrate that when there is disagreement between the two maximum likelihood tests, the choice is at the researcher's discretion and normally the results of the maximal eigenvalue test are taken into consideration because the test has a sharper alternative than the trace test. As a result we have chosen the results of the maximal eigenvalue test and consider that we have one cointegrating vector between the overnight and three month rates at 10% level of significance.

Regarding the other 12 bivariate sets, no cointegrating vectors are identified at any level of significance. This means that each of the longer term interest rates (three month, six month and one year rates) is driven by its own stochastic trend. We may conclude that the spreads between different pairs of interest rates that are included in these 12 bivariate sets are non stationary I(1) and this almost complies with the unit root results in table 3.1.3.

The three cointegrating vectors that are identified earlier indicate that the spreads between the interest rates in the very short end of the term structure are stationary. We proceed to test whether the EH holds by imposing a number of restrictions on the elements of the identified cointegarting vectors. For proper identification we impose restrictions that comply with the numbers of cointegrating vectors. Under the bivariate sets, we have one cointegrating vector for each pair of interest rates, so the number of restrictions should equal one. However, as we need to test the EH, we impose the restrictions (1,-1) on the coefficients of each cointegrating vector.

In table 3.4.1 the results indicate that the imposed restrictions cannot be rejected at 5% level of significance. For example when we impose the restrictions (1,-1) on the normalized cointegrating vector between the overnight and one week rates (1,-1.085320), the LR statistic was (3.47) and the probability was (0.062), so the results indicate clearly that we cannot reject the restrictions at 5% level of significance.

Moreover, we impose the restrictions (1,-1) on the second cointegrating vector between the overnight and one month rates (1, -1.469174), and the results of the LR statistics (2.94) and the probability (0.086) indicate also that we cannot reject the restrictions at 5% level of significance. Regarding the third cointegrating vector between the overnight and three month rates (1, -1.062959), the LR statistic was (.0062) and the probability was (0.937) indicating that we cannot reject the restrictions at all levels of significance (5% and 10%).

The results of the bivariate cointegrating relationships provide us with a strong signal that the very short term interest rates have a common trend especially the overnight, one week and one month rates. These results have motivated us to study the trivariate cointegrating relationships so we can use the results as a tool to confirm the findings of the bivariate cases.

In studying the two spreads case; i.e. the trivariate cointegrating relationships, we divide the six interest rates into two trivariate sets. The first set contains the very short term interest rates; the overnight, one week and one month rates, and the second set contains the longer term interest rates; the three month, six month and one year rates. The trivariate results in Table 3.5 show that under the first trivariate set, just one cointegrating vector has been identified and this does not support the bivariate results[18]. Regarding the other trivariate set, no cointegrating vectors were identified and this complies with the results of the bivariate analysis.

After determining the rank of the first trivariate set, we proceed to test if the EH holds. We have chosen the over identification case where we impose more restrictions than the number of the cointegrating relationships which is one in this case. So we impose the restrictions in the form of (1,-1,0) to test the spread between the overnight and one week rates, and in the form of (1,0,-1) to test the spread between the overnight and one month rates.

The results in Table 3.5.1 indicate that we cannot reject the first restrictions (1,-1, 0) at 5% level of significance; i.e. the LR statistics equals (4.76) and the probability equals (0.093), so the result complies with the result of the bivariate set between the overnight and one week rates. However, the second restrictions (1,0,-1) are rejected at all significance levels (5% and 10%) and this contradicts with the result of the bivariate set between overnight and one month rates.

[18] According to the theory the rank of the cointegration space (r) under trivariate test should be up to (n-1) where n equal the number of variables, so in this case we expected to have two cointegrating vectors (3-1=2) but we just got one (r =1).

The last cointegration analysis is the multivariate one where all six rates are included in the cointegration analysis. Studying this case is very important because its results are another important confirmation of the results under the bivariate and trivariate analysis. The results in table 3.6 show that only one cointegrating vector was identified, and this contradicts with the theory; i.e. According to the theory we expect to have five cointegrating relationships.

After determining the rank we proceed to test if the EH holds. Testing this is also performed through imposing a number of restrictions on the elements of the cointegarting vector. We also choose the over identification case and impose the restrictions in the following forms:

- (1,-1,0,0,0,0): test the spread between the overnight and one week rates.
- (1,0,-1,0,0,0): test the spread between the overnight and one month rates.
- (1,0,0,-1,0,0): test the spread between the overnight and three month rate.
- (1,0,0,0,-1,0): test the spread between the overnight and six month rates.
- (1,0,0,0,0,-1): test the spread between the overnight and one year rates.

The results in tables 3.6.1 and 3.6.2 show that the first restrictions (1,-1,0,0,0,0) cannot be rejected at 5% level of significance; i.e. the LR statistic equals (10.43) and the probability equals (0.064). This is the only case where we cannot reject the restrictions and this complies with both the trivariate and bivariate results. The cointegrating vector or the spread between the overnight and one week rates is the only spread that passes all the restrictions under the bivariate, trivariate and multivariate tests. This is an indication that both short term interest rates are driven by one stochastic trend and this is an indication that EH holds for the extreme short end of the JODIBOR term structure.

The results under the cointegration analysis contradict the results of the single equation regression and the VAR methodology. Despite the divergence in the results, we believe that the EH holds for the very short end of the JODIBOR term structure as the cointegration analysis indicates. In addition, by examining the paths of the overnight and one week rates in figure one, it is relatively clear that both rates have the same co-movement. We believe that the difference in the results among the three methods may be due to the fact that under the single equation regression and the VAR methodology we adopt specific assumptions to construct the perfect foresight spread and the theoretical spread which may affect the estimations and then the results. The results of the cointegration analysis are not significant for the longer term interest rates and this complies with our argument earlier that the sample period is short that the real behaviour of longer term interest rates may not be observed yet.

3.6 *TIME VARYING PARAMETERS AND THE LEARNING PROCESS*

The main results of the three econometric techniques show that the EH does not hold except for one case under the cointegration analysis; that is the spread between the overnight and one week rates. The rejection of the EH and the fact that we are using the term structure of interest rates in the Jordanian interbank market which is considered a relatively new market have led us to believe that the parameters that have been estimated in the classical way may not be stable; that is, they are time varying, which indicates that the market is learning.

It is known that at the beginning of any new market the trading volume normally tends to be thin; however it may increase overtime depending on many factors such as the awareness of market players and the existence of a formal regulatory framework. It is believed that in the early age of any new market, the market players may not act efficiently (Hall and Urga 2002) and they may take time to learn how to build their expectations rationally especially if the market is thin. However, when the trading increases and the market becomes more active, market players become more competent to construct good predictions and to price their financial instruments rationally and efficiently.

Studying the market efficiency at the beginning of any new market may not be a rational thing to do because if the market is still young we know that it needs more time to be developed. Nevertheless, we can concentrate on the evolution of the market players' behaviour because it is one of the main issues that lead to the development of any market and studying the evolution of the market players' behaviour is usually done through studying the market players' ability to learn (Hall and Urga 2002).

The learning process as defined by many researchers is the process where we have the weak form of the rational expectations. Under this form, we assume that market players may make many errors in their predictions and pricing during the learning process, but this only happens in the short run while in the long run it is believed that these errors will be ruled out (Cuthbertson 1988, Hall and Garratt 1992, Koekemoer 2001). As the market is learning, it is strongly believed that the targeted parameters will not be stable, and this encourages us to examine whether the parameters in our study are time varying; i.e. not stable.

Our main aim is to get an idea whether the market players in the JODIBOR market are learning from their errors and whether they use the available information more efficiently and adjust their predictions accordingly. We expect that the estimated time varying parameters will provide us with important information about the learning process and whether the market players are going to move toward rational expectations and become capable of reaching the true value of the parameters, which is according to the EH close to the theoretical parameter one.

3.6.1 TIME VARYING PARAMETER METHODOLOGY

The Kalman filter is one of the most important mechanisms that have been used to estimate linear regression models with time varying parameters. We will use the state space models to estimate the time varying parameters and identify the learning process. There are two main components under the state space models; the measurement equation and the transition equations which are also called the state equations. According to Bhar (1996, pp 4-5):

"The transition equation describes the evolution of the state variables (i.e. the parameters) and the measurement equation describes how the observations are actually generated from the state variables".

The state space model contains the following equations:

1- The measurement equation:

$PFS^{(n,m)} = \alpha_t + \beta_t \, SPD^{(n,m)} + \varepsilon_t$ Eq 3.6.1.1

where $\varepsilon_t \sim N(0, \sigma^2_{\varepsilon})$

2- The transition equations

The time varying parameters vector (α_t and β_t), represents the state variables or the unobservable variables. According to the "Systematically time varying parameter" (Cuthbertson, Hall and Taylor, 1992), the process of the constant (α_t) and the slope coefficient (β_t), evolution is assumed to follow a random walk .

$\alpha_t = \alpha_{t-1} + \omega_{1t}$ where $\omega_{1t} \sim N(0, \sigma^2_{\omega 1t})$ Eq 3.6.1.2

$\beta_t = \beta_{t-1} + \omega_{2t}$ where $\omega_{2t} \sim N(0, \sigma^2_{\omega 2t})$ Eq 3.6.1.3

The main assumptions under this model:

- The error term in the measurement equation (ε_t) is a white noise N (0, σ^2_{ε}).

- There is no correlation between the error term of the measurement equation and the error terms in the transition equations:

  $E(\omega_{1t}, \varepsilon_t)=0$ and $E(\omega_{2t}, \varepsilon_t)=0$ or in general form $E(\omega_i, \varepsilon_j) = 0 \quad \forall$ I,..,j,

- There is no correlation between the error terms of the measurement and the transition equations and the regressors:

E (α_t, ε_t)=0, E (β_t, ε_t)=0, E($\alpha_{t-1}, \omega_{1t}$)=0 and E($\beta_{t-1}, \omega_{2t}$)=0.

- The covariance matrix of the error terms (Q) under the transition equations is assumed to be fixed and diagonal:

$$Q = \begin{bmatrix} \sigma^2_{\omega 1t} & 0 \\ 0 & \sigma^2_{\omega 2t} \end{bmatrix}$$

The Kalman filter estimations of the parameters are computed by using maximum likelihood. The maximum likelihood estimation will begin by estimating the variances of the error terms in the transition equations that are related to the unobservable variables α_t and β_t; i.e. $\sigma^2_{\omega 1t}$ and $\sigma^2_{\omega 2t}$. These variances are called hyper-parameters and they are very important because they play an important role in determining the speed of the market's learning (Hall 1998).

The main use of the estimated hyper-parameters is to calculate the " signal to noise " ratio which is considered an important tool in determining how rapidly the coefficients adjust in the Kalman filter algorithm or, in other words, to determine the speed of learning of the market players (Garratt and Hall 1997, Hall 1998b). The noise ratio is calculated by dividing the volume of the hyper-parameter or the variances of the error terms in the transition equations ($\sigma^2_{\omega 1t}$ and $\sigma^2_{\omega 2t}$) by the variance of the error term of the measurement equation (σ^2_{ε}). In order to make the calculation meaningful and easier to interpret, the (σ^2_{ε}) is normalized to be equal one (Garganas 2002).

3.6.2 *THE EMPIRICAL RESULTS OF THE TIME VARYING PARAMETER METHODOLOGY*

The results of the Maximum Likelihood estimation are reported in table 3.7. The two hyper-parameters which represent the variances of the error terms in the transition equations ($\sigma^2_{\omega 1t}$ and $\sigma^2_{\omega 2t}$) are reported in the 2nd and 3rd columns. The final observation of the estimated time varying parameters (α_t and β_t) at time T is reported in columns 4 and 5. In column 6 we report the average value of the time varying parameter (β_t) and this value is an important indicator because it provides us with an idea of whether, on average, (β_t) was close to the theoretical value one.

The results of the (signal to noise) ratio indicate that the estimated (β_t) is adjusted rapidly mainly in the cases of the following spreads (PFS $^{(w,n)}$ PFS $^{(m,n)}$, and PFS $^{(3m,1m)}$). These findings give an indication that the interbank market for the very short maturities is an active market. As known to all, the trading volume is a major indicator about the activity of the market; therefore we report in table 3.8 the trading volumes of the Jordanian interbank market for all maturities during the period from January 2000 until March 2008.

The trading transactions in the interbank market before 1 November 2005; i.e. the date of the JODIBOR launching, are mainly overnight transactions and even after November 2005 the interbank trading volumes for longer maturities such as the three and six months remain not large comparing with shorter maturities; the overnight, one week and one month. Regarding the interbank trading volume for one year maturity, the information in table 3.8 shows clearly that there is no trading under this maturity.

The information in table 3.8 indicates clearly that the interbank market of overnight, one week and one month is an active market. This fact confirms our findings that the speed of learning is faster in this part of the market while in the other part of the market where the trading volume is small or where there is no trading, the speed of learning is very slow or there is no signal about learning at all.

The time path of the estimated time varying parameter (β_t) for different spreads is an important reflection of the evolution of the market players and their ability to learn. The time path of the estimated (β_t) for the spread PFS$^{(w,n)}$ is plotted in figure 3.24. It is positive and ranges between the values of (0.29) and (1.8) so it is unstable. It is obvious that (β_t) fluctuates below and above the theoretical value one and on many occasions it approaches one. Moreover, the average value of the estimated β_t is (1.116) and this value is close to the theoretical value one.

The time path of the estimated time varying parameter (β_t) for the spread PFS$^{(m,n)}$ is plotted in figure 3.25; it begins with negative value (-0.14) and then increases gradually to become positive. It ranges between the values of (-0.14) and (1.3) so it is unstable. The average value of the estimated β_t is (1.093) and this value is very close to the theoretical value one. Moreover, by examining figure 3.25 it is noticeable that the estimated β_t approaches one more often.

The time path of the estimated (β_t) for the spread PFS$^{(3m,1m)}$ is plotted in figure 3.26. It is unstable and it did not reach the theoretical value of the parameter; i.e. one, not even once. The average value of the estimated β_t is (0.605) and this value is a long way from the theoretical value one. Estimating the time varying parameter in this part of the market is an important step because it allows us to identify the trend of the estimated parameter. It is clear that the trend is upward and this upward trending may continue until the time varying parameter approaches the theoretical value one at one point of time in the future. Moreover, the time path of the estimated β_t for the spread PFS $^{(6m,1m)}$ is plotted in figure 3.27. It is very much similar to the case of PFS $^{(3m,1m)}$; that is, it is unstable and it did not reach the theoretical value of the parameter, one, not even once. The average value of the estimated β_t is (0.723) so it is far away from the theoretical value one.

The time paths of the estimated time varying parameter (β_t) for the spreads PFS $^{(12m,1m)}$, PFS $^{(6m,3m)}$ PFS $^{(12m,3m)}$ and PFS $^{(12m,6m)}$ are shown in figures 3.28, 3.29, 3.30, and 3.31 respectively. It is clear that the time varying parameters are almost stable and far away from the theoretical value one; i.e. the averages of the estimated β_t are 0.472, 0.287, 0.333 and 0.485 respectively. The stability of the parameters as shown in figures 3.28, 3.29, 3.30, and 3.31 and the fact that the averages of the estimated β_t are very low and very far away from the theoretical value one confirm strongly that this part of the market; i.e. the longer maturities, is still not active at all. The trading volume adds additional support for our conclusion; i.e. the trading volumes for the three and six month maturities are very low comparing with shorter maturities and there is no trading for the twelve month maturity (table 3.8).

The results of the time varying parameter test indicate clearly that the parameter is not stable, so the assumption under the OLS that the parameter is stable may not be valid. In addition, we notice that there is a significant relationship between the learning process and the fact that the market is active. The results show clearly that the time varying parameters are moving in the right direction in the active interbank market, and although the estimated parameters did not fully converge to the theoretical value one, there is a clear signal that they approach one for the spreads that include short term interest rates such as the spreads between the overnight and one week rates and between the overnight and one month rates.

The findings indicate that market players behave rationally in the active part of the interbank market; that is, they learn from their past mistakes and adjust their predictions and pricing accordingly. We are aware that the sample period is short and it may not be feasible to divide it into sub periods in order to test the validity of the EH, but if we follow this market in the future, the EH may not be rejected for some sub period especially for the spreads that include short term interest rates.

The information content of the term structure is important for all market participants particularly market traders and monetary authorities. The validation of the EH implies that the term structure contains information about future short term rates. Market traders rely on the information of the term structure because it assists in the valuation of the market financial instruments, whereas the monetary authorities concentrate on the information of the term structure, particularly the slope of the term structure because it is a better indicator for the monetary policy stance. The validation of the EH is an indication that short and long term interest rates are perfect substitutes for each other;

and accordingly the monetary policy could affect the slope of the term structure considering the extent to which short and long term rates are related.

The rejection of the EH for the entire JODIBOR term structure, except for the extreme short term interest rates, is an indication that long and short term interest rates are not perfect substitutes for each other. Accordingly the monetary policy action which is affecting the long term rates by influencing the current short term rates and altering the market's expectations of the future short term rates may not be effective as the long and short term rates are not related. In view of that, the Jordanian interbank market of different maturities cannot be considered an efficient vehicle for monetary policy implementation. Moreover, the rejection of the EH indicates that the market traders are not capable of utilising all the received information into the interbank pricing and they may over or under react to the received information; i.e. they may act irrationally particularly for longer term maturities.

3.7 *CONCLUSION AND FURTHER REMARKS*

The main finding from this study is that the spread may have some predictive power of the changes in the future short term interest rates. The results of the single equation regression show clearly that we reject the null hypothesis ($\mathrm{H}_0 : \beta = 0$) for all spreads except for the spread between the twelve month and six month rates. Regarding the null hypotheses that are related directly to the EH, ($H_0 : \beta = 1$) and the joint null hypothesis of the PEH ($H_0 : \alpha_t = 0,\ \beta = 1$), the results indicate the rejection of both null hypotheses and this means that the EH does not hold.

The results of the VAR methodology indicate that the correlation coefficient and the standard deviation ratio statistics provide some support to the PEH, while the other tests such as the Wald test and the single equation regression strongly reject the PEH for all spreads. However, the findings of the cointegration analysis disagree with the above results especially for the spreads that include very short term interest rates. We found that we cannot reject the restrictions that we imposed on the cointegrating vector that includes the overnight and one week rates under the bivariate, trivariate and multivariate tests. In addition we cannot reject the restrictions that are imposed on the cointegrating vector that includes the overnight and one month rates under the bivariate test.

In this study we will adopt the results of the cointegration analysis because we believe that this technique is a very powerful tool and it does not have major shortcomings as the other methods do. Moreover, our strong belief about the findings of cointegration analysis is supported by the evidence that is obtained from studying the time varying parameter (TVP). The results indicate that the estimated time varying parameters approach the theoretical value one for the spreads that include short term interest rates such as the spreads between the overnight and one week rates and between the overnight and one month rates. So the results of the time varying parameter test confirm strongly that market players' expectations are moving toward rationality, at least for the very short term interest rates. We expect that through the learning process the parameter may converge toward the theoretical value one at some point in the future.

Regarding the longer term interest rates in the JODIBOR term structure, the results indicate that there is a potential for the interbank market of the three and six month maturities to develop, especially if we take into consideration the upward trending of the estimated time varying parameters, whereas all the signals indicate that the interbank market of twelve month maturity; i.e. the longest term in the JODIBOR term structure, does not exist yet. For example the results of the learning process support the fact that the interbank market of twelve month maturity does not exist because no signal of learning is shown; i.e. the hyper-parameter $\sigma^2_{\omega 2t}$ of β_t equation in the 3rd columns equals zero for some of the spreads that include the twelve month rate. The pricing of the twelve month maturity is not efficient and we can see this clearly by the wide spread between the twelve month rate and shorter term rates. The large spread prevents trading; as a result this part of the interbank market does not exist yet. We believe that the Jordanian interbank market for longer maturities will stay undeveloped until all market players recognize that this part of the market is overpriced.

In conclusion, the main purpose of examining the validity of the EH is to provide evidence on the relationship between the short and long term interest rates in the Jordanian money market. We are aware that the Jordanian interbank market of different maturities is still not well developed and not efficient particularly for longer term maturities, and accordingly we expect that the EH may not hold for some parts of the market, so the rejection of the EH in this study is not a surprising result. The rejection confirms the fact that the spread at the current time may not have higher information content for predicting the changes in the future short term rates in the Jordanian interbank market.

3.7.1 FURTHER REMARKS

This study is the first attempt at understanding the relationship between interest rates of different maturities in the Jordanian money market. We believe that we have drawn attention to some important facts about the term structure of interest rates in the Jordanian interbank market. The non rejection of the EH in the extreme short end of the JODIBOR term structure is evidence of the potential of the Jordanian Interbank Market. We believe that further research will be valuable especially if more data become available which may reflect the real behaviour of longer term interest rates.

Figure 3.1: ***The JODIBOR Interest Rates (Levels)***

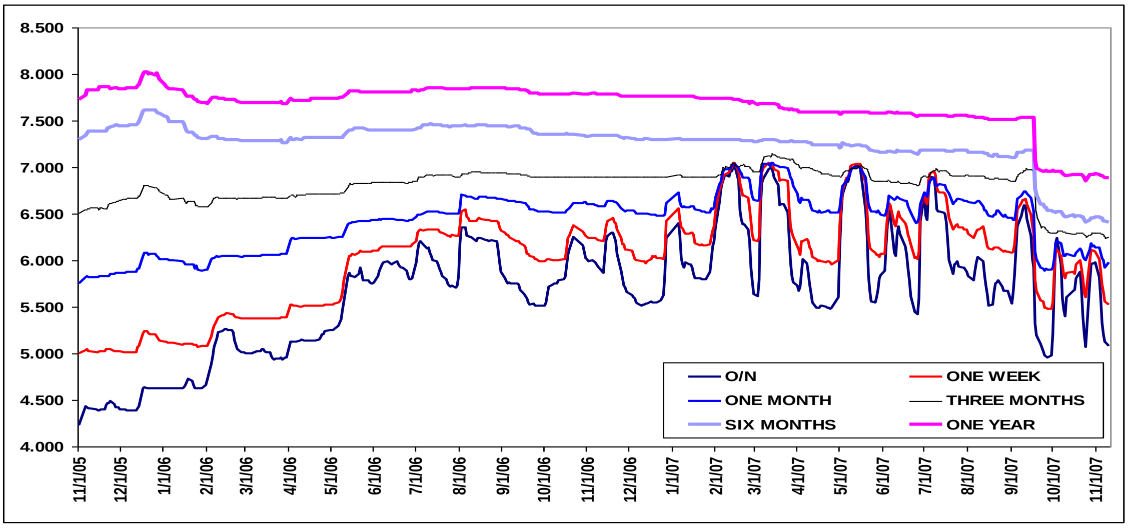

Figure 3.2: ***Overnight Rate (Level And First Difference)***

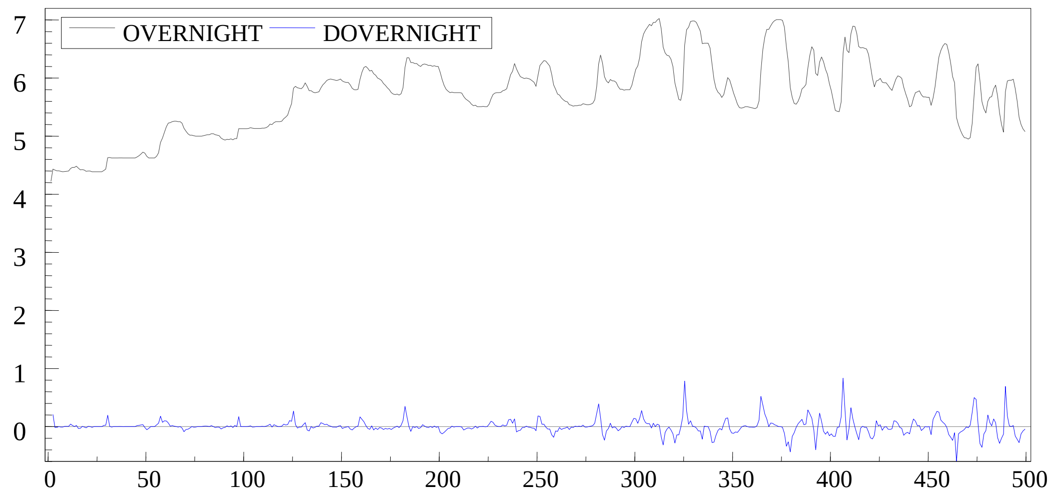

Figure 3.3: ***One Week Rate (Level And First Difference)***

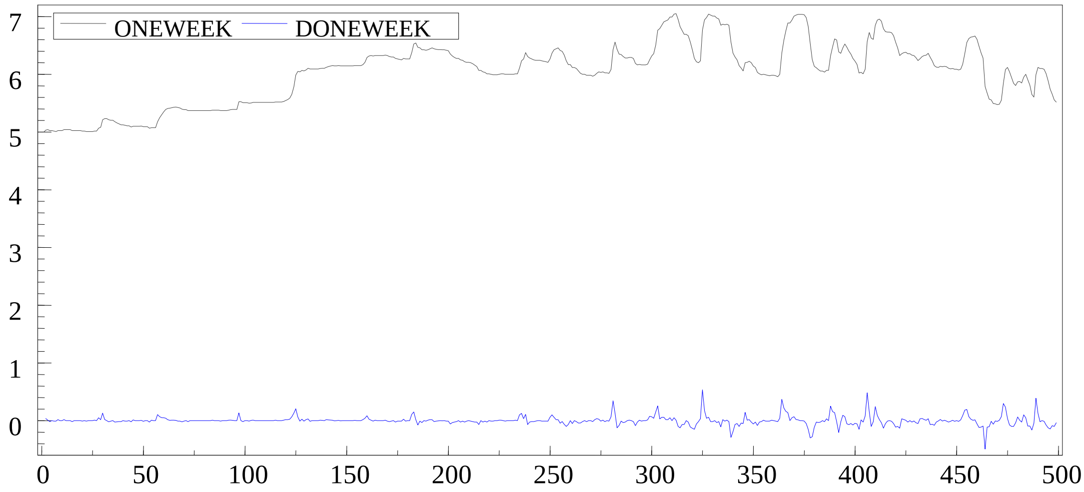

Figure 3.4: ***One Month Rate (Level And First Difference)***

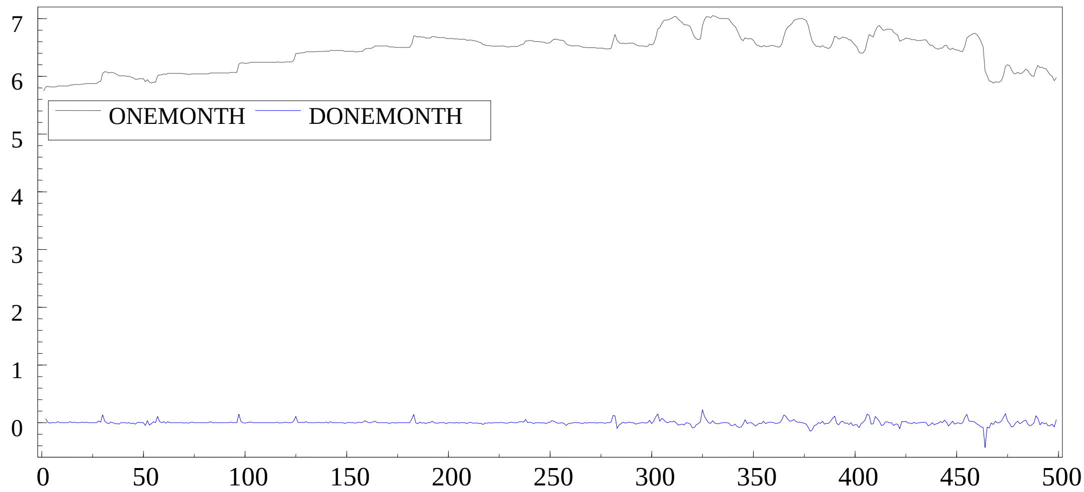

Figure 3.5: ***Three Month Rate (Level And First Difference)***

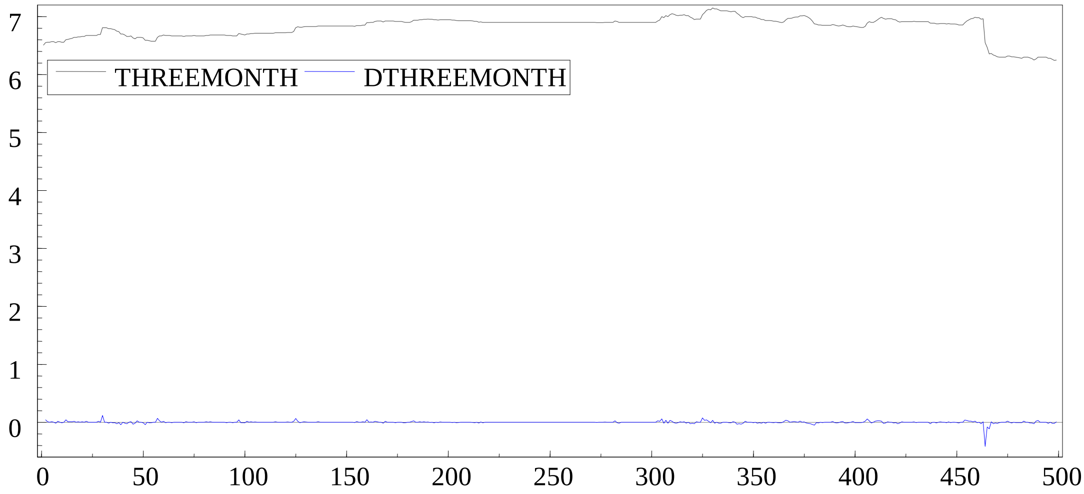

Figure 3.6: ***Six Month Rate (Level And First Difference)***

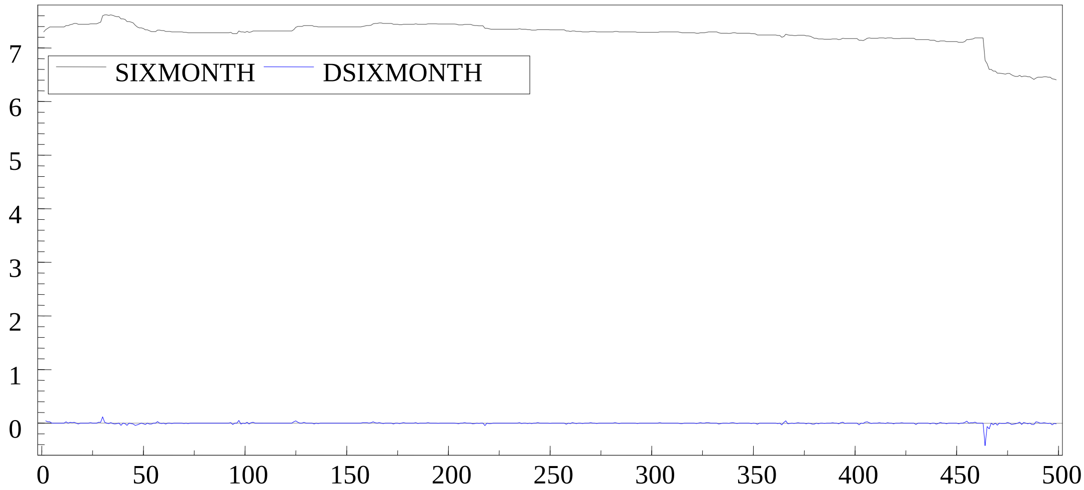

Figure 3.7: ***One Year Rate (Level And First Difference)***

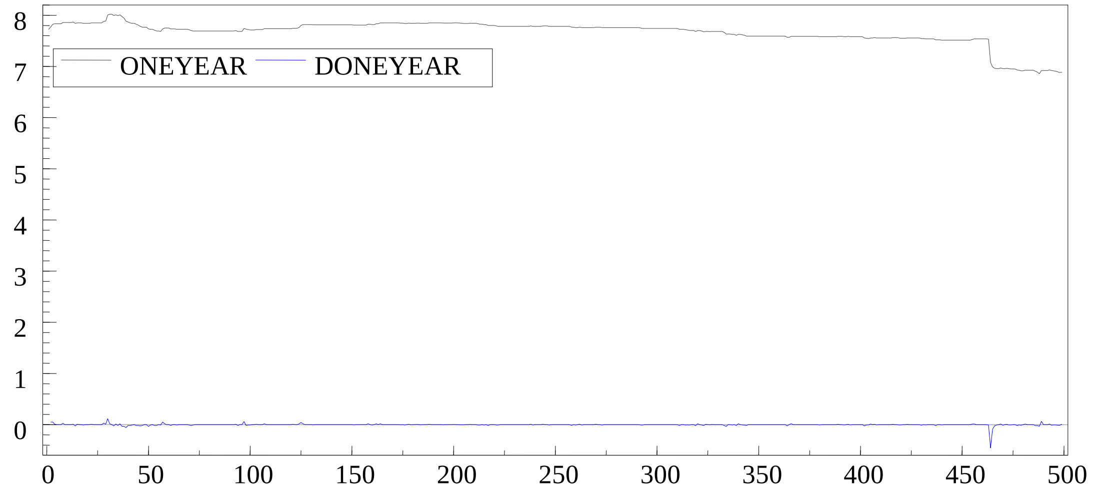

Figure 3.8: ***Actual Spread And Perfect Foresight Spread (1W-1N)***

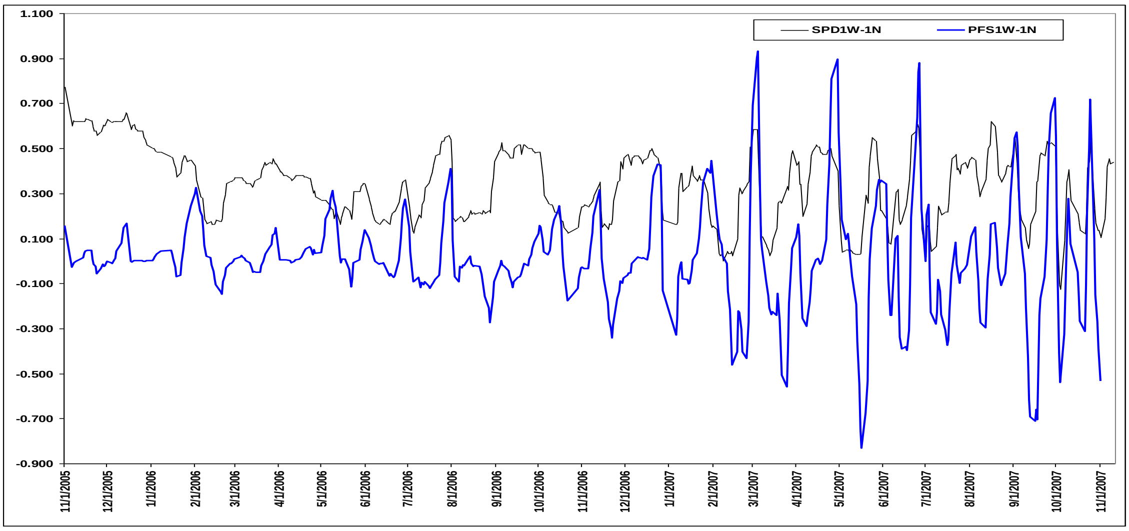

Figure 3.9: ***Actual Spread And Perfect Foresight Spread (1M-1N)***

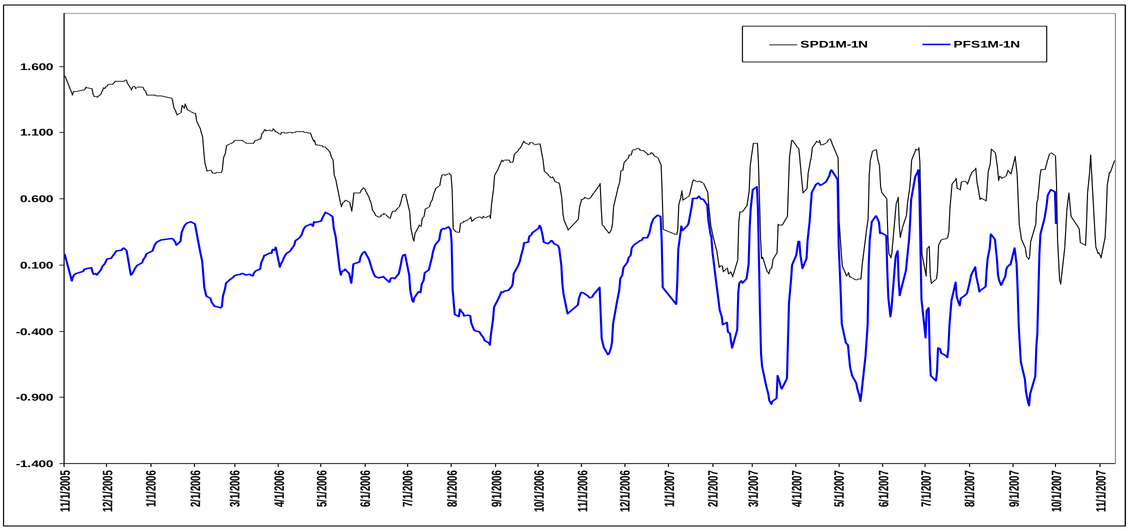

Figure 3.10: ***Actual Spread And Perfect Foresight Spread (3M-1M)***

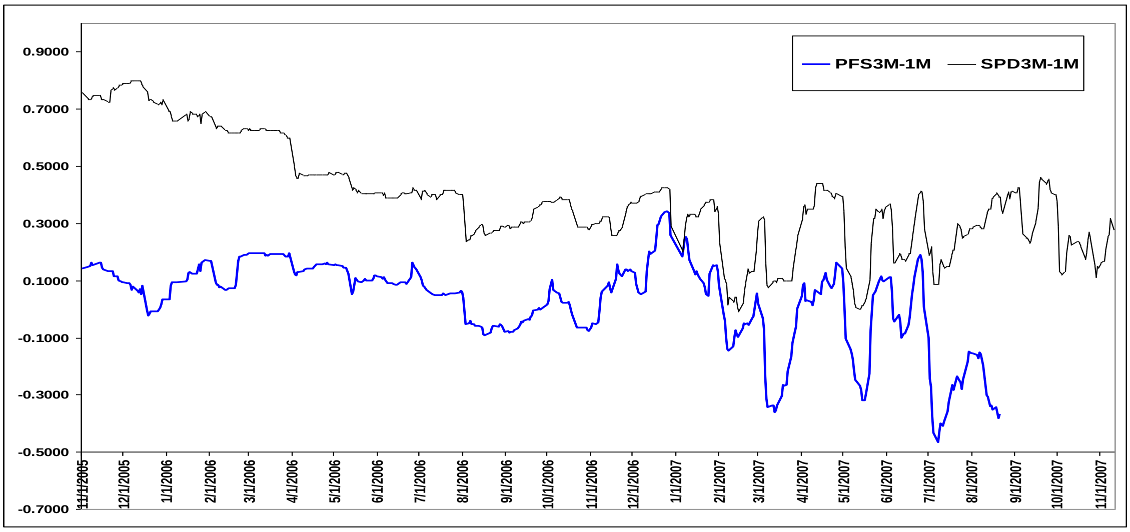

Figure 3.11: ***Actual Spread And Perfect Foresight Spread (6M-1M)***

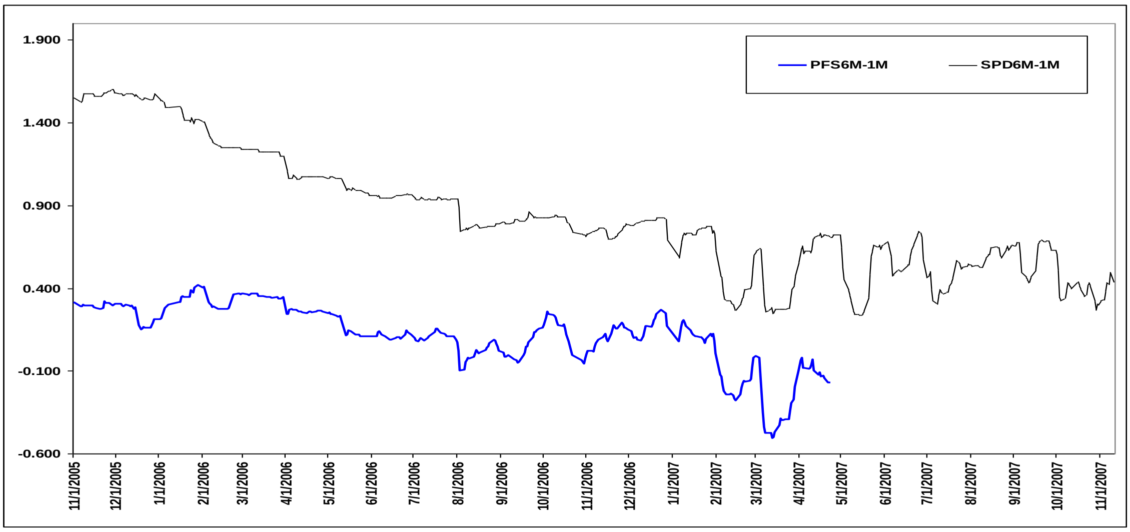

Figure 3.12: ***Actual Spread And Perfect Foresight Spread (12M-1M)***

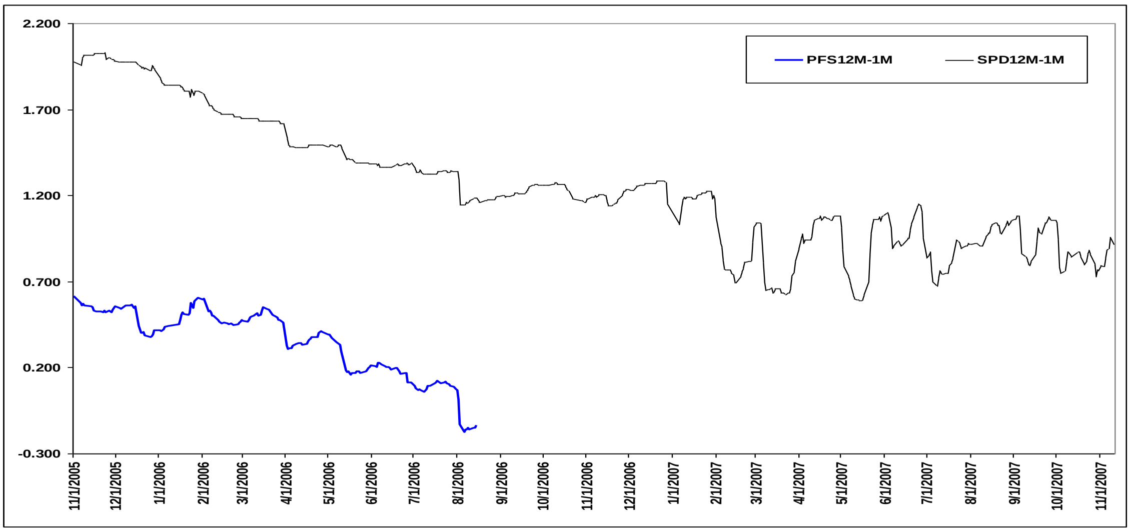

Figure 3.13: ***Actual Spread And Perfect Foresight Spread (6M-3M)***

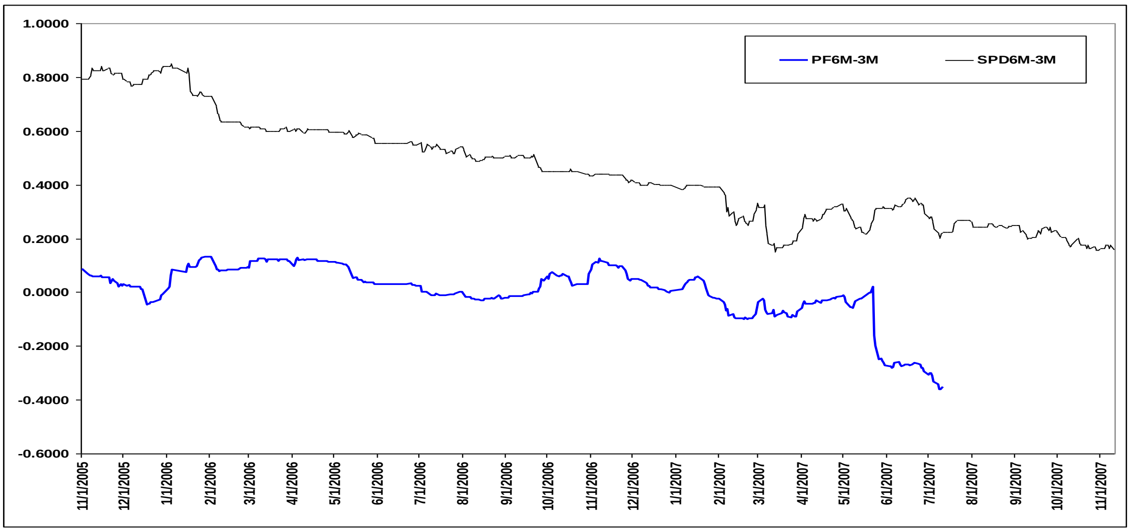

Figure 3.14: ***Actual Spread And Perfect Foresight Spread (12M-3M)***

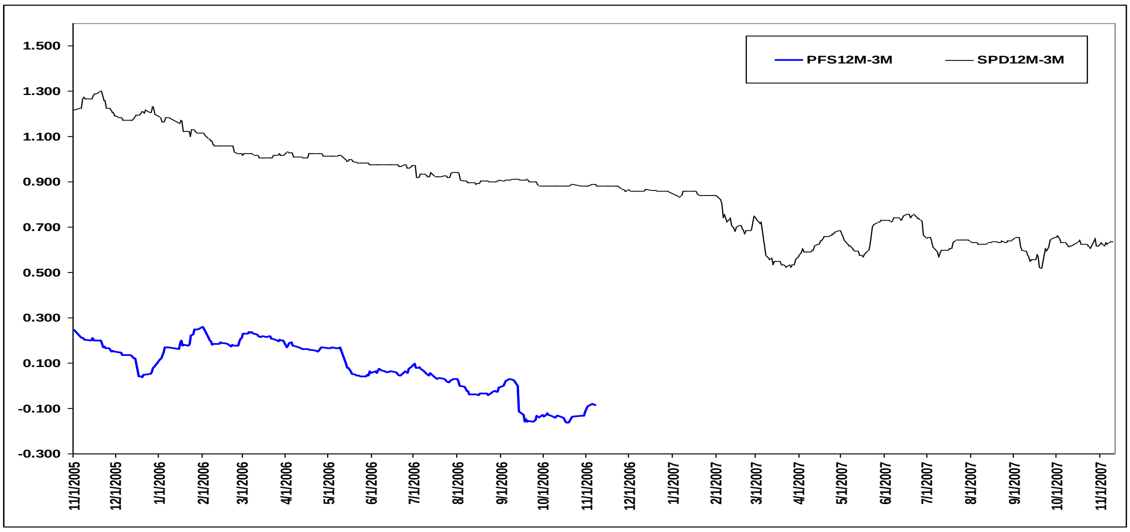

Figure 3.15: ***Actual Spread And Perfect Foresight Spread (12M-6M)***

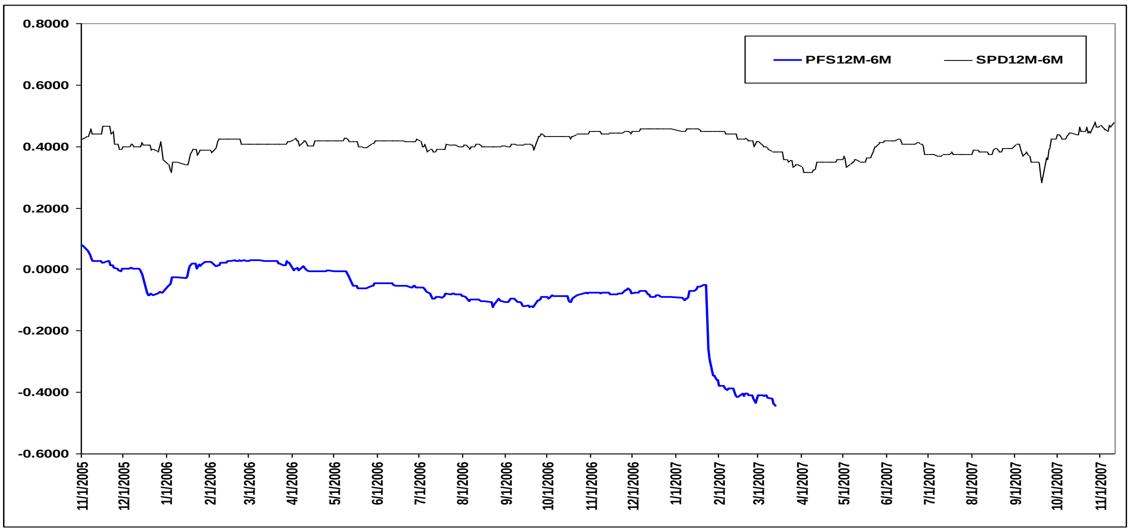

Figure 3.16: ***Actual Spread And Theoretical Spread (1W-1N)***

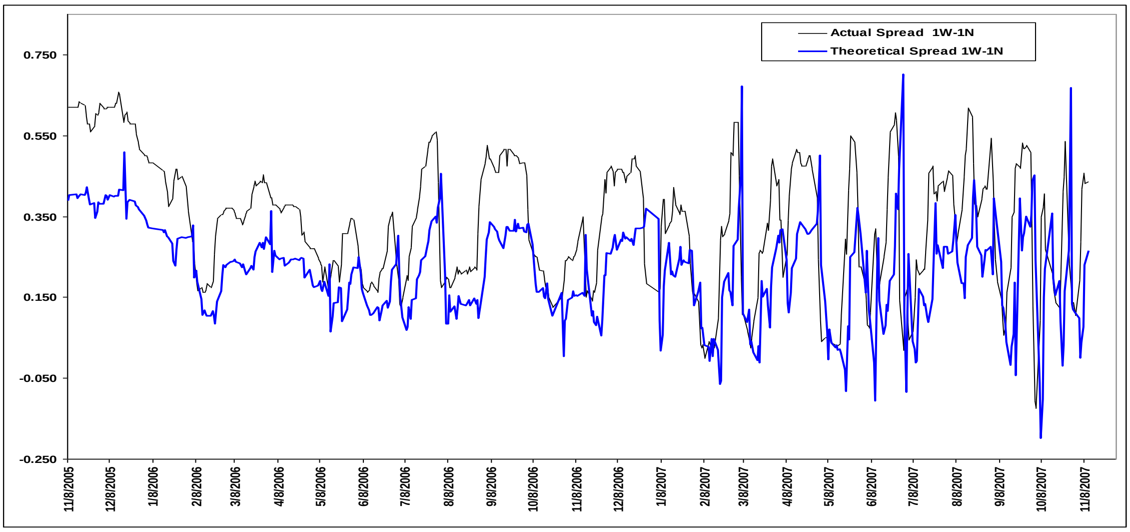

Figure 3.17: ***Actual Spread And Theoretical Spread (1M-1N)***

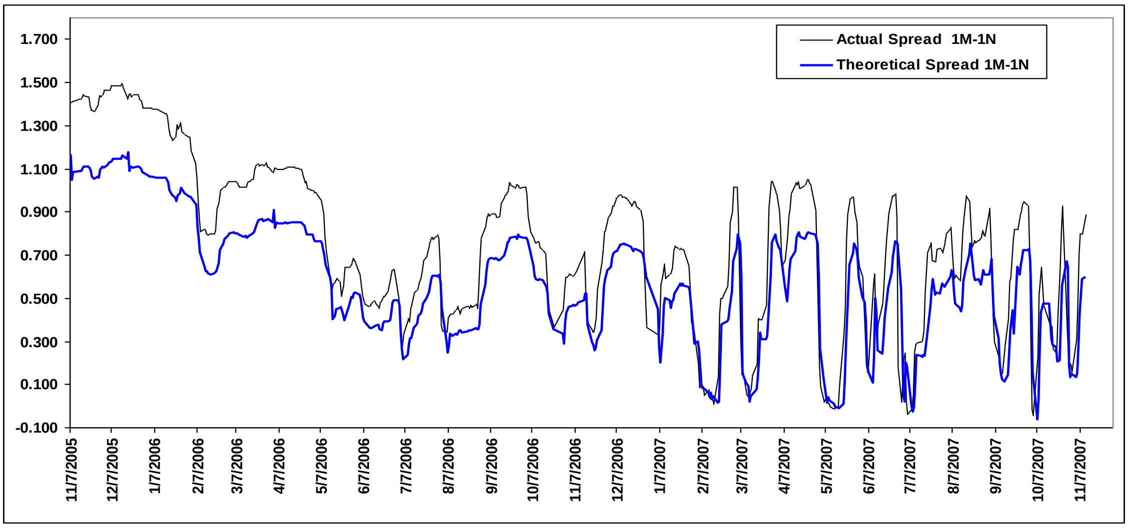

Figure 3.18: ***Actual Spread And Theoretical Spread (3M-1M)***

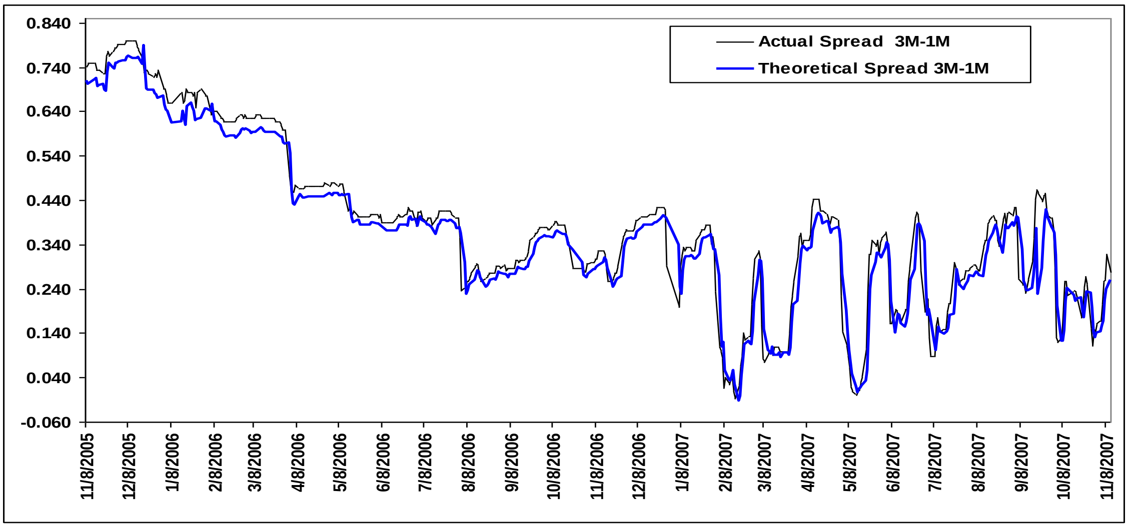

Figure 3.19: Actual Spread And Theoretical Spread (6M-1M)

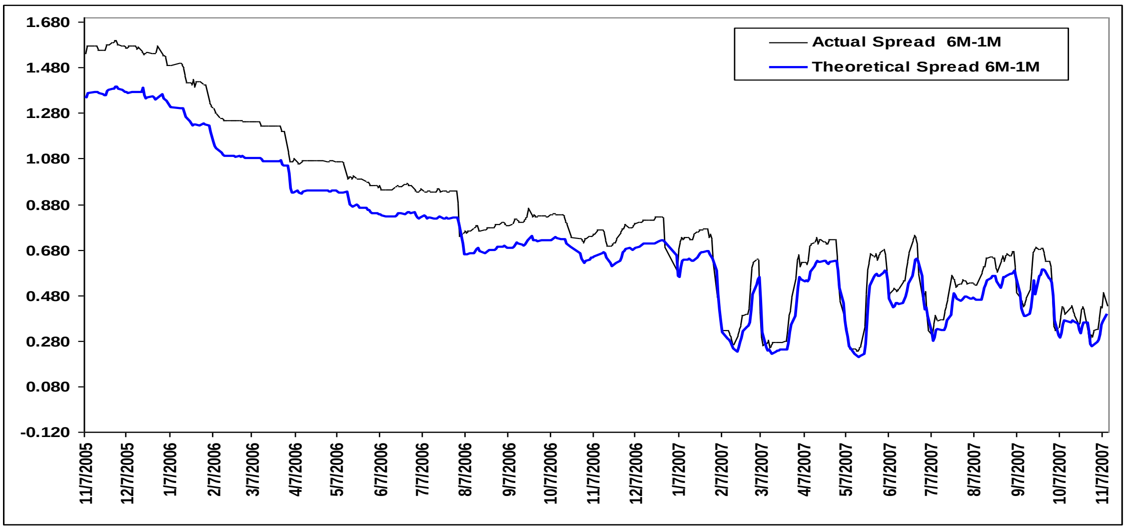

Figure 3.20: ***Actual Spread And Theoretical Spread (12M-1M)***

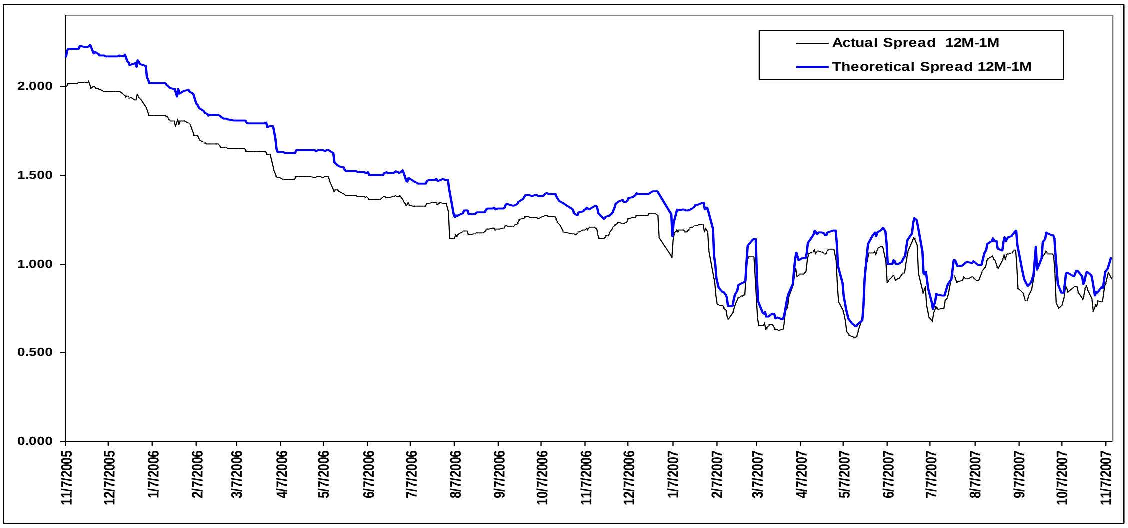

Figure 3.21: ***Actual Spread And Theoretical Spread (6M-3M)***

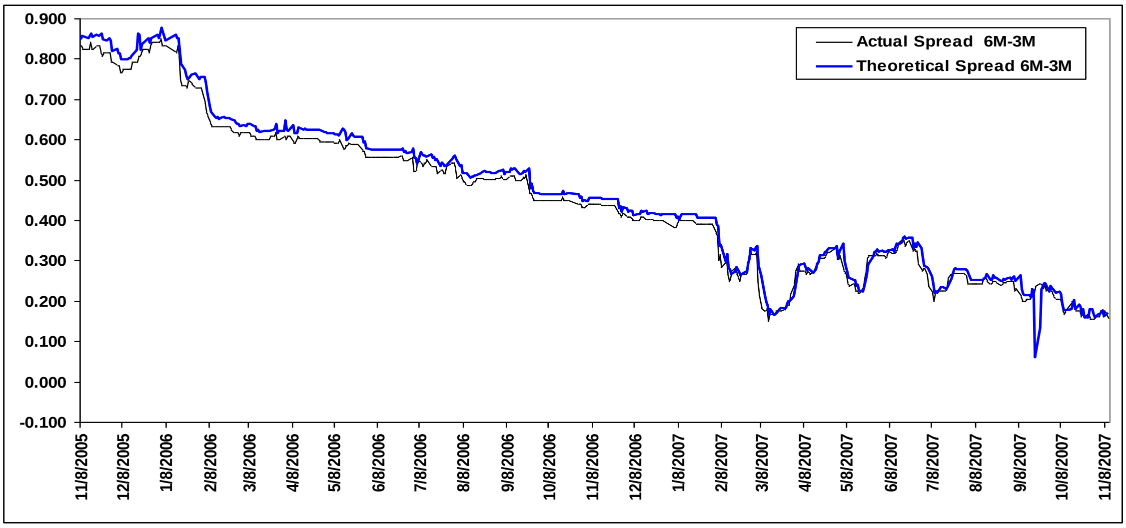

Figure 3.22: ***Actual Spread And Theoretical Spread (12M-3M)***

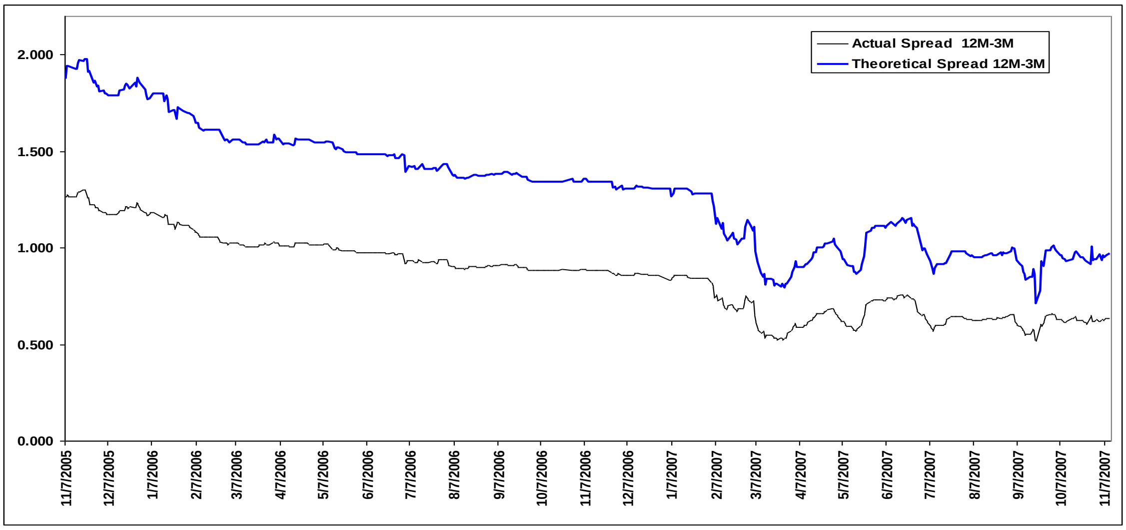

Figure 3.23: ***Actual Spread And Theoretical Spread (12M-6M)***

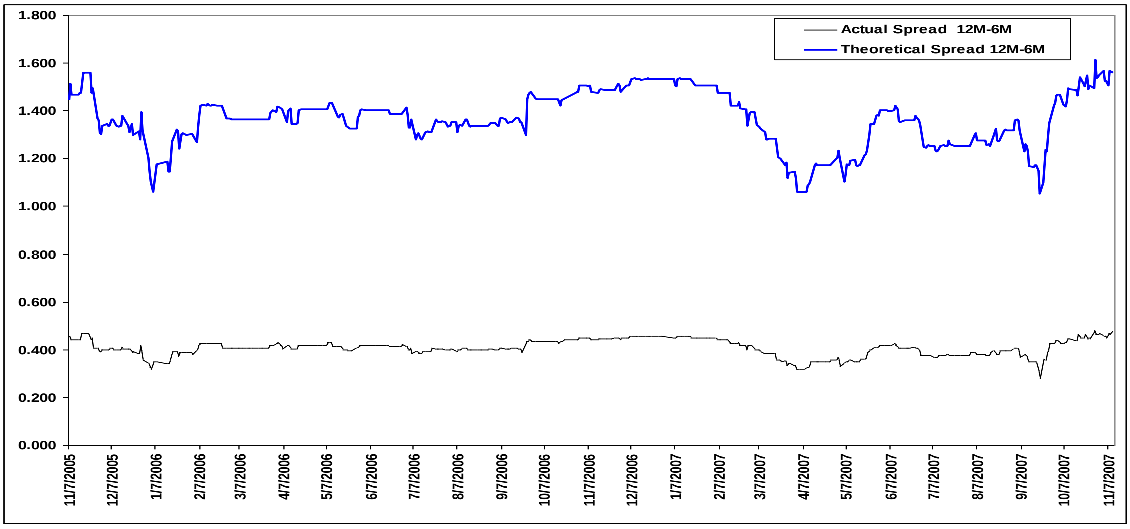

Figure 3.24: ***Time Varying Parameter Of The*** $PFS^{(W,N)}$***, Kalman Filter***

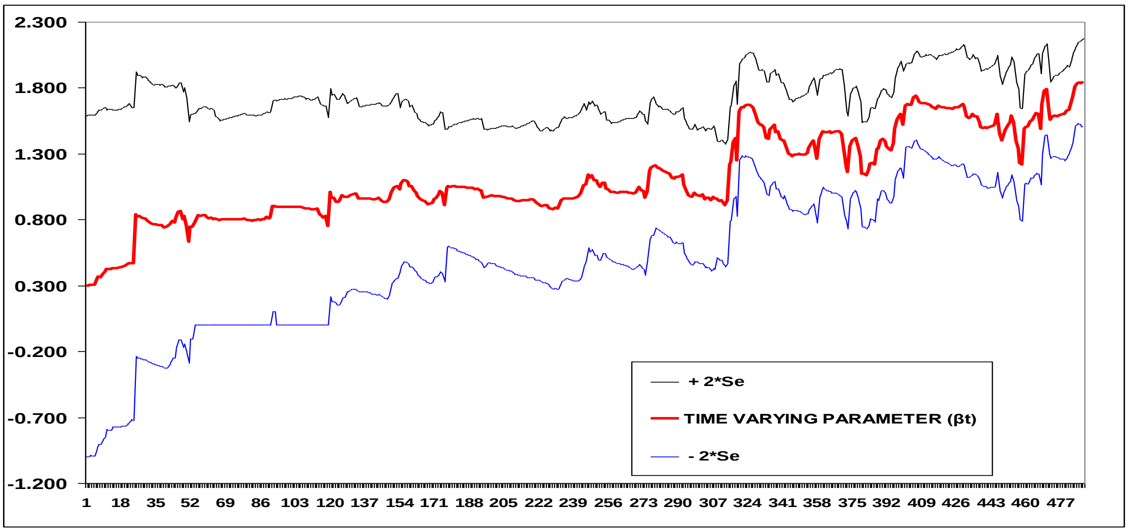

Figure 3.25: ***Time Varying Parameter Of The*** $PFS^{(M,N)}$***, Kalman Filter***

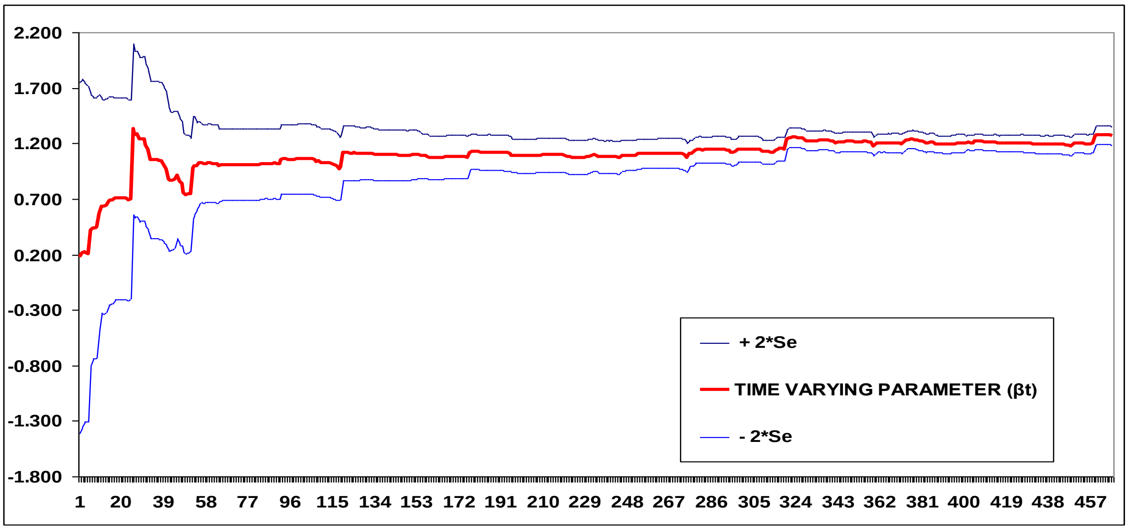

Figure 3.26: ***Time Varying Parameter Of The*** $PFS^{(3M,1M)}$***, Kalman Filter***

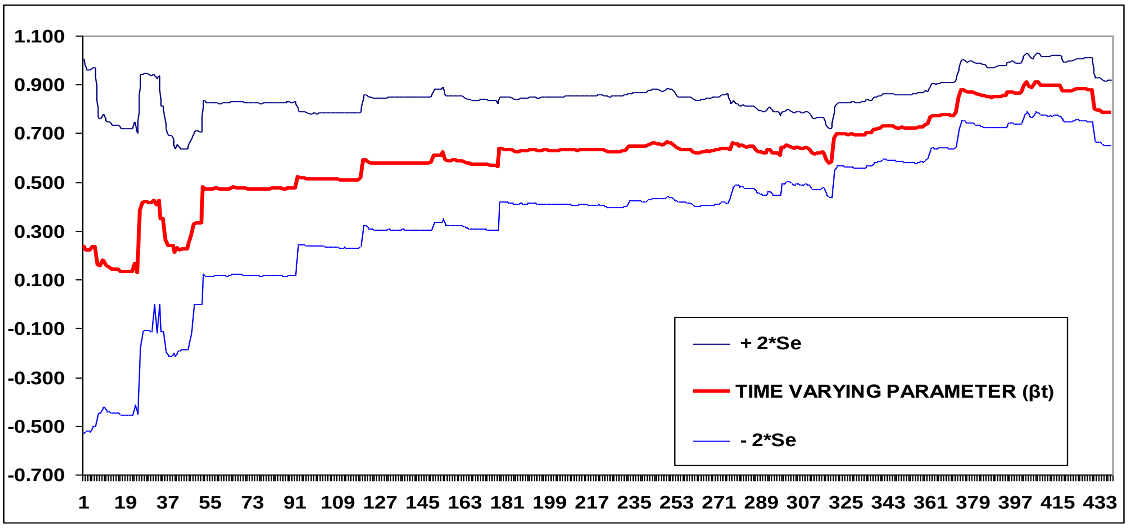

Figure 3.27: ***Time Varying Parameter Of The*** $PFS^{(6M,1M)}$***, Kalman Filter***

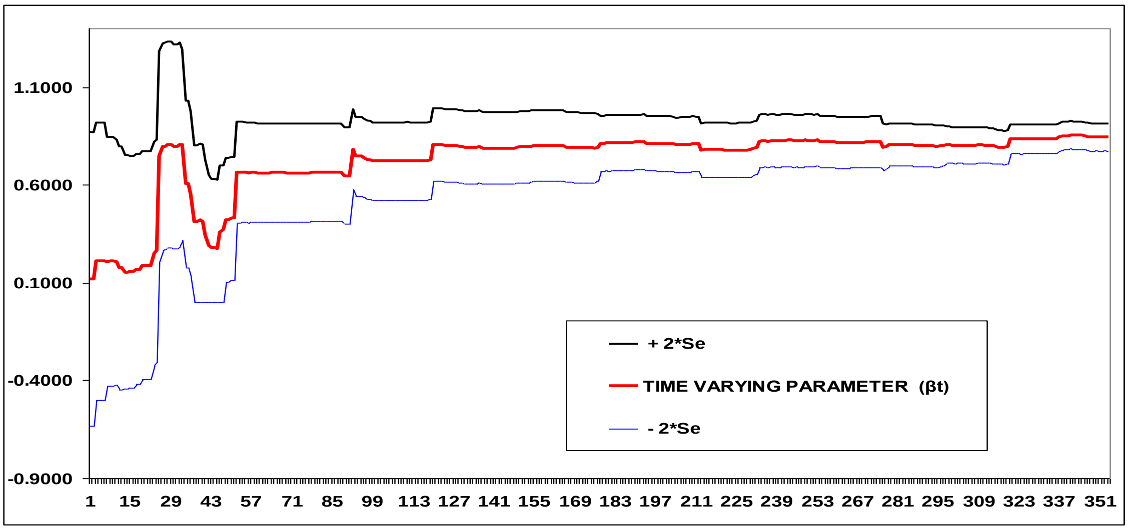

Figure 3.28: ***Time Varying Parameter Of The*** $PFS^{(12M,1M)}$***, Kalman Filter***

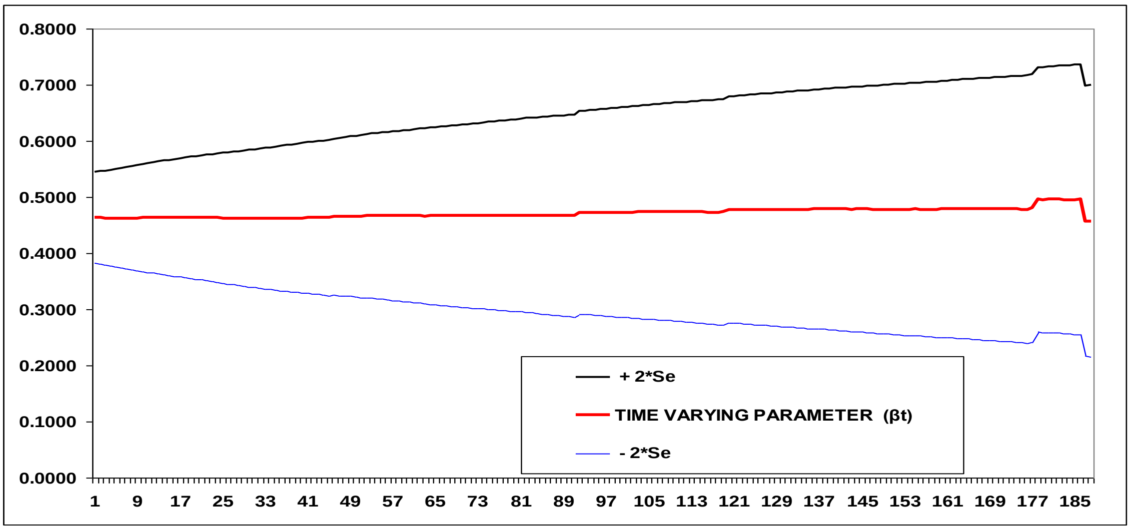

Figure 3.29: ***Time Varying Parameter Of The*** $PFS^{(6M,3M)}$***, Kalman Filter***

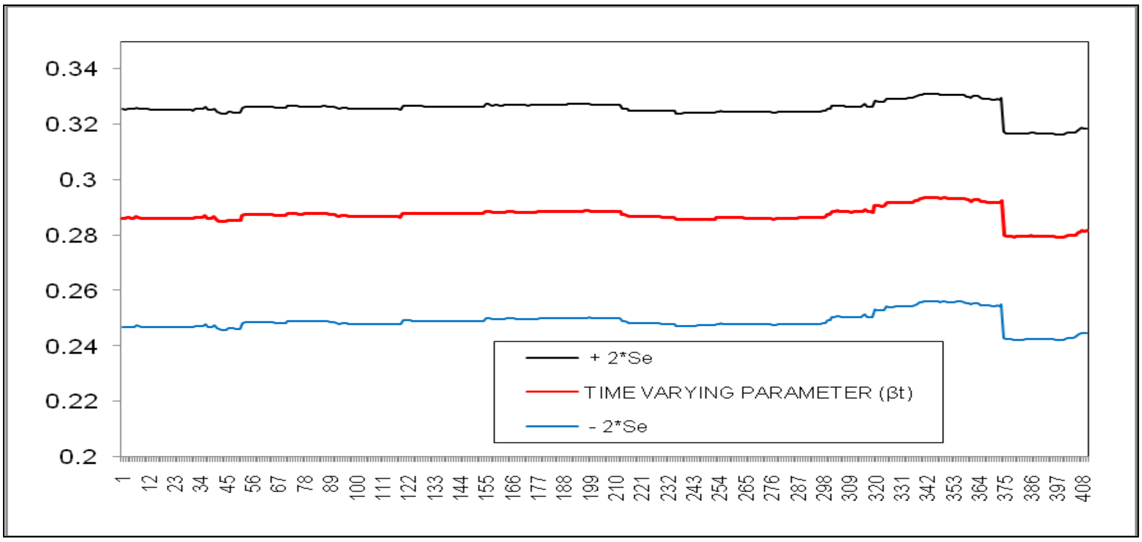

Figure 3.30: ***Time Varying Parameter Of The*** $PFS^{(12M,3M)}$***, Kalman Filter***

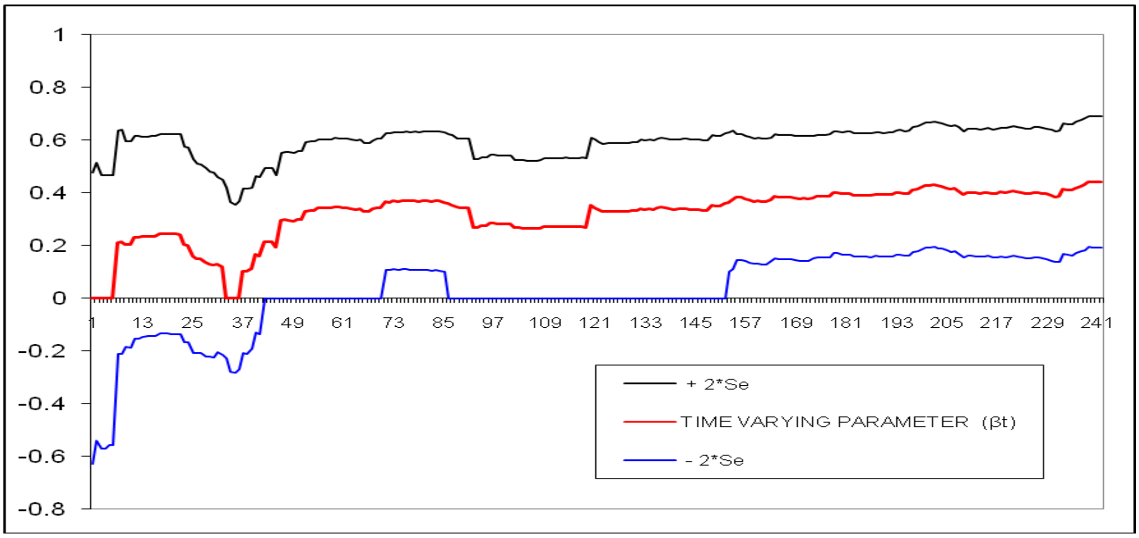

Figure 3.31: ***Time Varying Parameter Of The*** $PFS^{(12M,6M)}$, ***Kalman Filter***

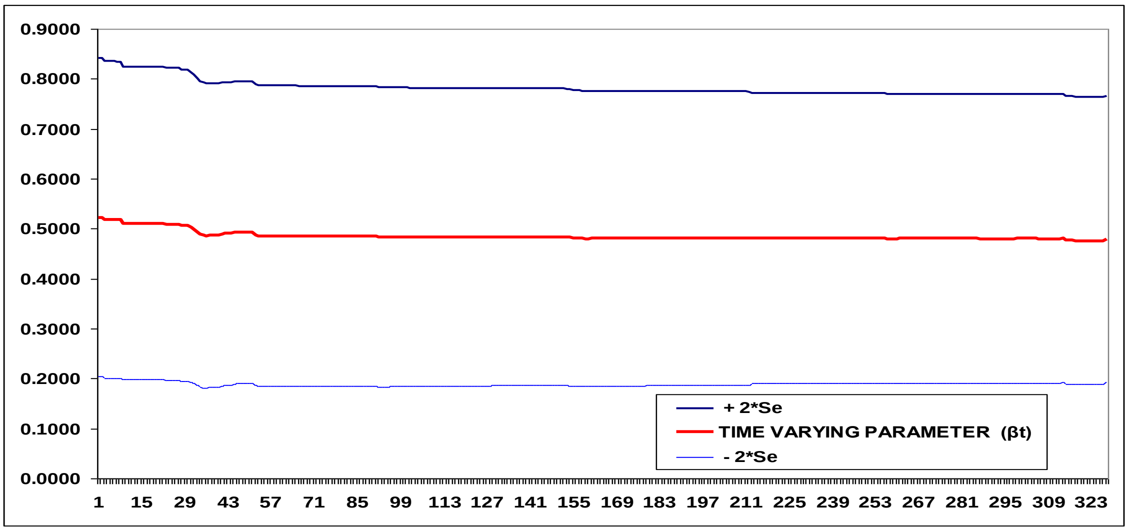

Table 3. .1: ***Unit Root Test For The JODIBOR Interest Rates ADF***

Test Of The Order Of Integration Using (ADF) Test Under AIC		
Variables	**I(1)** **t-Statistics** **(No. Of Lags)**	**I(0)** **t-Statistics** **(No. Of Lags)**
Levels		
Overnight Rate	**-2.438573* (15)**	
One Week Rate	**-2.114928* (15)**	
One Month Rate	**-2.614178** (1)**	
Three Month Rate	**-1.254498* (3)**	
Six Month Rate	**0.621190* (2)**	
One Year Rate	**0.618083* (1)**	
First Difference		
Δ Overnight Rate		**-8.587144*** (14)**
Δ One Week Rate		**-8.039328*** (14)**
Δ One Month Rate		**-13.71964*** (0)**
Δ Three Month Rate		**-10.68928*** (2)**
Δ Six Month Rate		**-11.79747*** (1)**
Δ One Year Rate		**-18.19234*** (0)**

Notes:
-The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 5.0, (2004).
- Levels
*** Denote that the null hypothesis of non-stationarity can't be rejected at (1%, 5%,10%) significance levels.**
****Denote that the null hypothesis of non-stationarity can't be rejected at (1%, 5%) significance levels.**
-First differences
***** Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

Table 3. .2: ***Unit Root Test For The JODIBOR Interest Rates PP***

Test Of The Order Of Integration Using (PP) Test		
Variables	**I(1)** **t-Statistics**	**I(0)** **t-Statistics**
Levels		
Overnight Rate	**-3.374890*** **	
One Week Rate	**-2.775943** **	
One Month Rate	**-2.491895***	
Three Month Rate	**-1.177991***	
Six Month Rate	**1.037737***	
One Year Rate	**0.840608***	
First Difference		
Δ Overnight Rate		**-10.19653******
Δ One Week Rate		**-12.19170******
Δ One Month Rate		**-13.74323******
Δ Three Month Rate		**-18.44699******
Δ Six Month Rate		**-19.11354******
Δ One Year Rate		**-18.16680******

Notes:
-The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 5.0, (2004).
- Levels
*** Denote that the null hypothesis of non-stationarity can't be rejected at (1%,5%,10%) significance levels.**
****Denote that the null hypothesis of non-stationarity can't be rejected at (1% and 5%) significance levels.**
***** Denote that the null hypothesis of non-stationarity can't be rejected at (1%) significance level.**
-First difference
****** Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

Table 3. .3: ***Unit Root Test For The Perfect Foresight Spread (PFS) And The Actual Spread (SPD)***

	ADF				PP
	SIC t-Statistics	**Lags**	**AIC t-Statistics**	**Lags**	**t-Statistics**
Panel (A):Unit Root Test For The Actual Spreads					
SPD (One Week-Overnight)	***-6.698195**	**1**	***-3.861307**	**14**	***-5.310551**
SPD (One Month-Overnight)	***-4.564083**	**2**	*****-2.68274**	**14**	***-4.184374**
SPD (Three Month-One Month)	****-3.047504**	**1**	****-2.921343**	**4**	*****-2.796392**
SPD (Six Month-One Month)	**-2.039457**	**1**	**-1.820909**	**12**	**-1.984223**
SPD (Twelve Month-One Month)	**-2.19343**	**1**	**-2.067012**	**12**	**-2.078717**
SPD (Six Month-Three Month)	**-1.30971**	**2**	**-1.30971**	**2**	**-1.1509**
SPD (Twelve month-Three	**-1.588388**	**1**	**-1.925809**	**2**	**-1.54406**
SPD (Twelve month-Six Month)	*****-2.743701**	**0**	**-2.040161**	**14**	*****-2.652551**
Panel (B):Unit Root Test For The Perfect Foresight Spreads					
PFS (7days-1day)	***-11.34286**	**1**	***-6.515516**	**15**	***-3.984253**
PFS (28days-1day)	***-6.793437**	**1**	***-4.656897**	**16**	***-5.12591**
PFS (84days-28days)	***-3.466371**	**1**	***-3.466371**	**1**	*****-2.840518**
PFS (168days-28days)	**-2.217519**	**1**	**-2.217519**	**1**	**-1.902047**
PFS (336days-28days)	**-0.041901**	**1**	**-0.041901**	**1**	**-0.11281**
PFS (168days-84days)	**-0.404564**	**2**	**-0.06217**	**3**	**0.074621**
PFS (336days-84days)	**-1.158283**	**2**	**-1.158283**	**2**	**-1.240234**
PFS (336days-168days)	**-0.081431**	**2**	**-0.081431**	**2**	**0.104356**

Notes:
-The actual and the perfect foresight spreads are constructed as follows: the first two spreads under panels (A) and (B) represent the interest rates in the extreme short end of the JODIBOR term structure such as the overnight, one week, and one month interest rates. The remaining spreads include the longer term interest rates such as the one, three, six and twelve months' interest rates. We construct the spreads in this way because the very short term interest rates have similar co-movement while the longer term interest rates have nearly different co-movement.
-The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 5.0, (2004).
- Levels
*** I(0) at all significant levels (1%, 5%, 10%).**
**** I(0) at (5% and 10%) significant levels.**
*****I(0) at (10%) significant level.**

Table 3.2.1: ***Does The Actual Spread Predict The Future Changes In Short Term Interest Rates (OLS):*** $PFS_t^{(n,m)} = \alpha + \beta S_t^{(n,m)} + \varpi_t^m$

	Adjust. R^2	Estimated Coefficients Using Robust Standard Error*				Wald Tests			No. of Obs.	No. of Obs. Lost
		α	SE(α)	β	SE(β)	$H_0: \beta = 0$ [$\rho - value$]	$H_0: \beta = 1$ [$\rho - value$]	$H_0: \alpha = 0, \beta = 1$ [$\rho - value$]		
Panel (A): First Sample										
SPD (7days-1day)	**0.120**	**-0.168**	**(0.044)**	**0.520**	**(0.111)**	**[0.000]**	**[0.000]**	**[0.000]**	**493**	**6**
SPD (28days-1day)	**0.408**	**-0.438**	**(0.072)**	**0.631**	**(0.087)**	**[0.000]**	**[0.000]**	**[0.000]**	**472**	**27**
Panel (B):Second Sample										
SPD (84days-28days)	**0.375**	**-0.169**	**(0.034)**	**0.492**	**(0.073)**	**[0.000]**	**[0.000]**	**[0.000]**	**443**	**56**
SPD(168days-28days)	**0.699**	**-0.322**	**(0.052)**	**0.462**	**(0.051)**	**[0.000]**	**[0.000]**	**[0.000]**	**359**	**140**
SPD(336days-28days)	**0.753**	**-0.753**	**(0.110)**	**0.683**	**(0.068)**	**[0.000]**	**[0.000]**	**[0.000]**	**191**	**308**
SPD(168days-84days)	**0.333**	**-0.170**	**(0.036)**	**0.348**	**(0.064)**	**[0.000]**	**[0.000]**	**[0.000]**	**415**	**84**
SPD(336days-84days)	**0.466**	**-0.632**	**(0.110)**	**0.699**	**(0.108)**	**[0.000]**	**[0.005]**	**[0.000]**	**247**	**252**
SPD(336days-168days)	**0.003**	**0.075**	**(0.211)**	**-0.380**	**(0.504)**	**[0.452]**	**[0.006]**	**[0.000]**	**331**	**168**

***The estimation method is the Least Squares. For robust standard errors, the spread equations were estimated using Newey-West HAC Standard Errors & Covariance**

Table 3.2.2: ***Does The Actual Spread Predict The Future Changes In Short Term Interest Rates (GMM):***
$PFS_t^{(n,m)} = \alpha + \beta S_t^{(n,m)} + \varpi_t^m$

	Adjust. R^2	Estimated Coefficients Using GMM As Estimation Method*				Wald Tests			No. of Obs. **	No. of Obs. Lost
		α	SE(α)	β	SE(β)	$H_0: \beta = 0$ [$\rho - value$]	$H_0: \beta = 1$ [$\rho - value$]	$H_0: \alpha = 0, \beta = 1$ [$\rho - value$]		
Panel (A): First Sample										
SPD (7days-1day)	**0.103**	**-0.233**	**(0.057)**	**0.715**	**(0.157)**	**[0.000]**	**[0.000]**	**[0.000]**	**492**	**6**
SPD (28days-1day)	**0.409**	**-0.459**	**(0.101)**	**0.659**	**(0.128)**	**[0.000]**	**[0.000]**	**[0.000]**	**471**	**27**
Panel (B):Second Sample										
SPD (84days-28days)	**0.375**	**-0.170**	**(0.048)**	**0.495**	**(0.106)**	**[0.000]**	**[0.000]**	**[0.000]**	**442**	**56**
SPD(168days-28days)	**0.698**	**-0.321**	**(0.074)**	**0.462**	**(0.074)**	**[0.000]**	**[0.000]**	**[0.000]**	**358**	**140**
SPD(336days-28days)	**0.751**	**-0.750**	**(0.149)**	**0.680**	**(0.092)**	**[0.000]**	**[0.000]**	**[0.000]**	**190**	**308**
SPD(168days-84days)	**0.332**	**-0.170**	**(0.051)**	**0.348**	**(0.091)**	**[0.000]**	**[0.000]**	**[0.000]**	**414**	**84**
SPD(336days-84days)	**0.462**	**-0.633**	**(0.160)**	**0.700**	**(0.158)**	**[0.000]**	**[0.057]**	**[0.000]**	**246**	**252**
SPD(336days-168days)	**0.002**	**0.145**	**(0.294)**	**-0.548**	**(0.708)**	**[0.439]**	**[0.029]**	**[0.000]**	**330**	**168**

***The estimation method is the GMM with a correction for Heteroscedasticity and moving-average errors of order (n-m-1) using Newey-West.**
**** An instrumental variables of one lag of the actual spread has been used and consequently the number of the observations has been reduced by one.**

Table 3.3.1: VAR Optimal Lags Selection And Diagnostics Tests

Spreads Optimal VAR Lag Orders	**AIC (VAR System)**	**SBIC (VAR System)**	**Jarque-Bera***		**Ljung-Box (2 Lags)****	
			Eq.1	**Eq. 2**	**Eq.1**	**Eq. 2**
			Spread	**Changes In Interest Rates**	**Spread**	**Changes In Interest Rates**
SPD (1w-1n) 3	**-6.05**	**-5.93**	**713.27**	**5223.72**	**0.046**	**0.054**
SPD (1m-1n) 2	**-6.25**	**-6.17**	**5648.11**	**6230.66**	**0.044**	**0.004**
SPD (3m-1m) 3	**-9.13**	**-9.01**	**689.6**	**14759.26**	**0.019**	**0.066**
SPD (6m-1m) 2	**-8.96**	**-8.88**	**1766.47**	**15797.80**	**0.227**	**0.066**
SPD (12m-1m) 2	**-8.84**	**-8.75**	**1856.551**	**16350.07**	**1.362**	**0.065**
SPD (6m-3m) 3	**-10.98**	**-10.86**	**1224.86**	**824339.40**	**0.029**	**0.009**
SPD (12m-3m) 2	**-10.76**	**-10.67**	**832.75**	**842155.70**	**0.178**	**0.376**
SPD (12m-6m) 2	**-11.48**	**-11.40**	**645.66**	**1507258.00**	**0.576**	**0.005**

***The critical value for a Chi square with 2 degree of freedom (Jarque-Bera) is 5.991.**
**** The critical value for a Chi square with 2 degree of freedom (Ljung-Box) is 5.991.**

Table 3.3.2: ***The Regression Of The Theoretical Spread (S_t^*) On The Actual Spread (S_t) Using (OLS) : $S_t^* = \alpha + \beta S_t + \varepsilon_t$***

	Adjust. R^2	Estimated Coefficients Using Robust Standard Error*				Wald Tests		
		α	SE(α)	β	SE(β)	$H_0: \beta = 0$ [$\rho - value$]	$H_0: \beta = 1$ [$\rho - value$]	$H_0: \alpha = 0, \beta = 1$ [$\rho - value$]
S^* (One Week –Overnight)	**0.260**	**0.084**	**(0.019)**	**0.393**	**(0.049)**	**[0.000]**	**[0.000]**	**[0.000]**
S^* (One Month –Overnight)	**0.848**	**0.043**	**(0.020)**	**0.712**	**(0.020)**	**[0.000]**	**[0.000]**	**[0.000]**
S^* (Three Month – One Month)	**0.943**	**0.010**	**(0.008)**	**0.925**	**(0.016)**	**[0.000]**	**[0.000]**	**[0.000]**
S^* (Six Month – One Month)	**0.984**	**0.005**	**(0.009)**	**0.869**	**(0.008)**	**[0.000]**	**[0.000]**	**[0.000]**
S^* (Twelve Month – One Month)	**0.989**	**0.004**	**(0.012)**	**1.095**	**(0.008)**	**[0.000]**	**[0.000]**	**[0.000]**
S^* (Six Month – Three Month)	**0.992**	**-0.001**	**(0.004)**	**1.038**	**(0.007)**	**[0.000]**	**[0.000]**	**[0.000]**
S^* (Twelve Month – Three Month)	**0.995**	**-0.001**	**(0.006)**	**1.524**	**(0.006)**	**[0.000]**	**[0.000]**	**[0.000]**
S^* (Twelve Month – Six Month)	**0.933**	**0.069**	**(0.022)**	**3.173**	**(0.052)**	**[0.000]**	**[0.000]**	**[0.000]**

***The estimation method is the Least Squares. For robust standard errors, the spread equations were estimated using Newey-West HAC Standard Errors & Covariance.**

Table 3.3.3: ***VAR Tests - Theoretical Spread (S_t^*) And Actual Spread (S_t)***

JODIBOR Theoretical Spreads	**Corr(S_t, S_t^*) (SE)**	$s.d.(S_t^*)/s.d.(S_t)$ **(SE)**	**Wald Test $H_0: S_t = S_t^*$ [$\rho - value$]**
S^* (One Week -Overnight)	***0.511 (0.0170)**	***0.769 (0.0012)**	**33.26 [0.0000]**
S^* (One Month -Overnight)	***0.921 (0.0029)**	***0.773 (0.0001)**	**497.76 [0.0000]**
S^* (Three Month – One Month)	***0.971 (0.0068)**	***0.953 (0.0002)**	**64.19 [0.0000]**
S^* (Six Month – One Month)	***0.992 (0.0015)**	***0.876 (0.00001)**	**2587.81 [0.0000]**
S^* (Twelve Month – One Month)	***0.994 (0.0009)**	***1.101 (0.000005)**	**4118.05 [0.0000]**
S^* (Six Month – Three Month)	**0.996 (0.0026)**	***1.042 (0.0002)**	**485.13 [0.0000]**
S^* (Twelve Month – Three Month)	**0.998 (0.0012)**	***1.527 (0.000003)**	**639014.1 [0.0000]**
S^* (Twelve Month – Six Month)	***0.966 (0.0004)**	***3.285 (0.00003)**	**7975864 [0.0000]**

***Significant at 5% level.**

Table 3.4: Bivariate Cointegration Tests

Interest Rates (Bivariate Cointegration)	No Of Lags	λ Max		t-Statistic	Critical Value	λ Trace		t-Statistic	Critical Value	The Cointegrating Vector
		Null	Alt.			Null	Alt.			
(O/N , One Week)	**4**	**r = 0**	**r = 1**	**39.75**	**15.89**	**r = 0**	**r ≥ 1**	**44.13**	**20.26**	**(1,-1.085320)***
(O/N , One Month)	**3**	**r = 0**	**r = 1**	**22.10**	**15.89**	**r = 0**	**r ≥ 1**	**26.03**	**20.26**	**(1,-1.469174)***
(O/N , Three Month)	**3**	**r = 0**	**r = 1**	**15.00**	**15.89**	**r = 0**	**r ≥ 1**	**15.76**	**20.26**	**(1,-1.062959)****
(O/N , Six Month)	**3**	**r = 0**	**r = 1**	**13.80**	**15.89**	**r = 0**	**r ≥ 1**	**17.52**	**20.26**	**No Coint*****
(O/N , Twelve Month)	**3**	**r = 0**	**r = 1**	**13.30**	**15.89**	**r = 0**	**r ≥ 1**	**16.56**	**20.26**	**No Coint*****
(One Week, One Month)	**3**	**r = 0**	**r = 1**	**11.71**	**15.89**	**r = 0**	**r ≥ 1**	**15.90**	**20.26**	**No Coint*****
(One Week, Three Month)	**3**	**r = 0**	**r = 1**	**10.29**	**15.89**	**r = 0**	**r ≥ 1**	**11.05**	**20.26**	**No Coint*****
(One Week, Six Month)	**3**	**r = 0**	**r = 1**	**9.55**	**15.89**	**r = 0**	**r ≥ 1**	**13.49**	**20.26**	**No Coint*****
(One Week, Twelve Month)	**3**	**r = 0**	**r = 1**	**9.36**	**15.89**	**r = 0**	**r ≥ 1**	**12.77**	**20.26**	**No Coint*****
(One Month, Three Month)	**3**	**r = 0**	**r = 1**	**9.07**	**15.89**	**r = 0**	**r ≥ 1**	**9.84**	**20.26**	**No Coint*****
(One Month, Six Month)	**3**	**r = 0**	**r = 1**	**9.19**	**15.89**	**r = 0**	**r ≥ 1**	**13.11**	**20.26**	**No Coint*****
(One Month, Twelve Month)	**2**	**r = 0**	**r = 1**	**7.85**	**15.89**	**r = 0**	**r ≥ 1**	**11.63**	**20.26**	**No Coint*****
(Three Month, Six Month)	**4**	**r = 0**	**r = 1**	**8.06**	**15.89**	**r = 0**	**r ≥ 1**	**12.22**	**20.26**	**No Coint*****
(Three Month, Twelve Month)	**4**	**r = 0**	**r = 1**	**6.44**	**15.89**	**r = 0**	**r ≥ 1**	**11.55**	**20.26**	**No Coint*****
(Six Month, Twelve Month)	**3**	**r = 0**	**r = 1**	**15.84**	**15.89**	**r = 0**	**r ≥ 1**	**17.90**	**20.26**	**No Coint*****

***The cointegrating vector is identified under both the maximum eigen value and the trace test at 5% level of significance.**

****The cointegrating vector is identified under the maximum Eigen value at 10% level of significance where the t-statistic equals 14.99882 and the critical value equals 13.90590, whereas no cointegrating vector was identified under the trace Test.**

*****No cointegrating vector is identified either at 5% or 10% levels of significance.**

-Diagnostic test for the VAR residuals: LM statistics indicate that the residuals are not serially correlated, the Jarque Bera test for normality indicates that the residuals are not normally distributed, and the VAR residuals heteroskedasticity test indicates that in five bivariate cases out of 15 the test support the assumption of homoskedasticity ; i.e. (overnight , one month), (one week, one month), (one week, three month), (one week, six month) and (three month, six month).

Table 3.4.1: ***Imposing Restrictions On The Bivariate Cointegrating Vectors (Testing The Expectations Hypothesis)***

Interest Rates (Bivariate Cointegration)	**The Cointegrating Vector (Normalized)**	**LR Statistics After Imposing Restrictions That The Coeffecients Equal (1,-1)**	**Probability**
(O/N , One Week)	**(1,-1.085320)**	**3.47**	**0.062***
(O/N , One Month)	**(1,-1.469174)**	**2.94**	**0.086***
(O/N , Three Month)	**(1,-1.062959)**	**.0062**	**.937****
(O/N , Six Month)	**No Coint**	**_**	**_**
(O/N , Twelve Month)	**No Coint**	**_**	**_**
(One Week, One Month)	**No Coint**	**_**	**_**
(One Week, Three Month)	**No Coint**	**_**	**_**
(One Week, Six Month)	**No Coint**	**_**	**_**
(One Week, Twelve Month)	**No Coint**	**_**	**_**
(One Month, Three Month)	**No Coint**	**_**	**_**
(One Month, Six Month)	**No Coint**	**_**	**_**
(One Month, Twelve Month)	**No Coint**	**_**	**_**
(Three Month, Six Month)	**No Coint**	**_**	**_**
(Three Month, Twelve Month)	**No Coint**	**_**	**_**
(Six Month, Twelve Month)	**No Coint**	**_**	**_**

***The restrictions cannot be rejected at 5% level of significance.**
****The restrictions cannot be rejected at all levels of significance (5% and 10%).**

Table 3.5: ***Trivariate Cointegration Tests (Two Spreads Test)***

Interest Rates (Trivariate Cointegration)	No Of Lags	λ Max		t Statistic	Critical Value At 5%	λ Trace		t Statistic	Critical Value At 5%	The Cointegrating Vector (Normalized)
		Null	Alt.			Null	Alt.			
(Overnight , One Week, One Month)	5	r = 0	r = 1	43.95	22.30	r= 0	r ≥ 1	53.08	35.19	(1, -1.218308,0.234404)
		r ≤ 1	r = 2	6.81	15.89	r ≤ 1	r ≥ 2	9.13	20.26	_
		r ≤ 2	r = 3	2.31	9.16	r ≤ 2	r = 3	2.31	9.16	_
(Three Month, Six Month, Twelve Month)	4	r = 0	r = 1	13.93	22.30	r = 0	r ≥ 1	27.68	35.19	NO COINT*
		r ≤ 1	r = 2	9.37	15.89	r ≤ 1	r ≥ 2	13.74	20.26	_
		r ≤ 2	r = 3	4.37	9.16	r ≤ 2	r = 3	4.37	9.16	_

*** In addition, no cointegrating vector is identified at 10% level of significance.**

Table 3.5.1: ***Imposing Restrictions On The Trivariate Cointegrating Vectors (Testing the Expectations Hypothesis-The Two Spreads)***

Interest Rates (Trivariate Cointegration)	**The Cointegration Vector (Normalized)**	**LR Statistics After Imposing Restrictions (1,-1,0)**	**Prob.**	**LR Statistics After Imposing Restrictions (1,0,-1)**	**Prob.**
(O/N,One Week,One Month)	**(1,-1.218308,0.234404)**		**0.093***		**0.000****
(Three Month,Six Month, Twelve month)	**No Cointegration**	-	-	-	-

***The restrictions cannot be rejected at 5% level of significance.**

**** The restrictions are rejected at all levels of significance (5% and 10%),**

Table 3.6: ***Multivariate Cointegration Tests (Five Spreads Test).***

Interest Rates (Multivariate Cointegration)	No Of Lags	λ Max		t Statistic	Critical Value At 5%	λ Trace		t Statistic	Critical Value At 5%	The Cointegrating Vector (Normalized)
		Null	Alt.			Null	Alt.			
(Overnight , One Week, One Month, Three Month, Six Month, Twelve month)	3	r = 0	r = 1	51.29	40.96	r = 0	r ≥ 1	121.62	103.85	(1,-0.808735, -0.763037, 0.593255, 0.343314, -0.333214)
		r ≤ 1	r = 2	22.95	34.81	r ≤ 1	r ≥ 2	70.33	76.97	_
		r ≤ 2	r = 3	18.99	28.59	r ≤ 2	r ≥ 3	47.38	54.08	_
		r ≤ 3	r = 4	16.13	22.30	r ≤ 3	r ≥ 4	28.39	35.19	_
		r ≤ 4	r = 5	7.49	15.89	r ≤ 4	r ≥ 5	12.25	20.26	_
		r ≤ 5	r = 6	4.76	9.16	r ≤ 5	r = 6	4.76	9.16	_

Tables (3.6.1 And 3.6.2:)

Tables 3.6.1 ***Imposing Restrictions On The Multivariate Cointegrating Vectors (Testing The Expectations Hypothesis – The Five Spreads)***

Interest Rates (Multivariate Cointegration)	**The Cointegrating Vector (Normalized)**	**LR Statistics After Imposing Rest.**	**Prob.**	**LR Statistics After Imposing Rest.**	**Prob.**
		(1,-1,0,0,0,0)		**(1,0,-1,0,0,0)**	
(Overnight, One Week, One Month, Three Month, Six Month, Twelve month)	**(1, -0.808735,-0.763037, 0.593255, 0.343314, -0.333214)**	**10.43**	**0.064***	**28.76**	**0.000****

***The restrictions cannot be rejected at 5% level of significance.**
****The restrictions are rejected at all levels of significance (5% and 10%).**

Tables 3.6.2 ***Imposing Restrictions On The Multivariate Cointegrating Vectors (Testing The Expectations Hypothesis – The Five Spreads)***

Interest Rates (Multivariate Cointegration)	**LR Statistics After Imposing Rest.**	**Prob.**	**LR Statistics After Imposing Rest.**	**Prob.**	**LR Statistics After Imposing Rest.**	**Prob.**
	(1,0,0,-1,0,0)		**(1,0,0,0,-1,0)**		**(1,0,0,0,0,-1)**	
(Overnight , One Week, One Month, Three Month, Six Month, Twelve month)	**34.32**	**0.000****	**38.89**	**0.000****	**38.65**	**0.000****

**** The restrictions are rejected at all levels of significance (5% and 10%).**

Table 3.7 : ***The time varying parameter Model****

Spreads	Hyper-Parameters (Variances)		Time Varying Constant (α_t)*** Last Observation At Time T	Time Varying Slope (β_t) Last Observation At Time T [SE]	The Average Of The Time Varying Slope (β_t)	Forecast Errors: Jarque Bera	Forecast Errors: Ljung-Box (16 Lags)	Log Likelihood
	$\sigma^2_{\omega 1t}$ " α_t Equation" [SE]** (t-Statistic)	$\sigma^2_{\omega 2t}$ " β_t Equation" [SE]** (t-Statistic)						
Panel (A): First Sample								
PFS (7days-1day)	**10426 [0.55284E-04] (0.18859E+09)**	**2818.3 [2556.8] (1.1023)**	**-0.73**	**1.8 [2.180]**	**1.116**	**75.20**	**561.73**	**1228.6**
PFS (28days-1day)	**754.76 [781.65] (0.96560)**	**9.6299 [16.480] (0.58433)**	**-0.49**	**1.3 [1.354]**	**1.093**	**5204.49**	**258.15**	**1467.6**
Panel (B):Second Sample								
PFS (84days-28days)	**2041.6 [2771.8] (0.73657)**	**230.10 [424.86] (0.54158)**	**-0.68**	**0.79 [0.921]**	**0.605**	**2430.77**	**155.44**	**1663.5**
PFS (168days-28days)	**271.91 [253.98] (1.0706)**	**1.9435 [18.167] (0.10698)**	**-0.77**	**0.84 [0.9147]**	**0.723**	**590.40**	**170.25**	**1420.5**
PFS (336days-28days)	**0.40239E+07 [0.35418E-06] (0.11361E+14)**	**31690 [0.53362E-05] (0.59386E+10)**	**0.63**	**0.46 [0.6992]**	**0.472**	**220781.82**	**1.37**	**437.0**
PFS (168days-84days)	**0.28899E+06 [0.64267E-05] (0.44967E+11)**	**0.19588E-06 [0.000] (0.000)**	**-0.42**	**0.28 [0.3187]**	**0.287**	**219417.47**	**53.66**	**1783.4**
PFS (336days-84days)	**138.36 [223.54] (0.61895)**	**148.55 [228.34] (0.65058)**	**-0.48**	**0.44 [0.6900]**	**0.333**	**10500.658**	**64.30**	**1046.1**
PFS (336days-168days)	**76254 [0.44006E-05] (0.17328E+11)**	**0.54733E-07 [0.000] (0.000)**	**0.19**	**0.48 [0.7658]**	**0.485**	**996018.29**	**0.59**	**996.66**

The Kalman Filter: The time varying parameter model is estimated by REG-X program, Hall Stephen G. (1998b). **The Standard errors are not corrected for serial correlation; so there is serial correlation in the errors. No standard errors are provided in the Reg-X software output for the time varying constant (α_t).**

Table 3.8: The Interbank Volumes For Different Maturities In (JD MIO) During The Period From January 2000 Until March 2008.

Interbank Maturities	**Volume (JD MIO)**
Overnight	
One Week	**233.70**
One Month	**215.49**
Three Month	**47.20**
Six Month	**27.20**
Twelve Month	**-**

THE TERM STRUCTURE OF INTEREST RATES IN THE JORDANIAN PRIMARY MARKET: EMPIRICAL EVIDENCE FOR THE EXPECTATIONS HYPOTHESIS

4.1 *INTRODUCTION*

The existence of a long run relationship between different maturities of interest rates is an indication that the interest rates are bound together by a common trend. This implies that the term structure of interest rates is driven by one common stochastic trend, and this piece of information is very important for all market players like market practitioners and monetary authorities. This simply means that if there is a deviation in one of the interest rates from the long run equilibrium, eventually the deviated interest rates will be forced back into the long run equilibrium (Masih and Masih, 1996).

In order to identify the long run equilibrium relationship, many economists use cointegration analysis as the most appropriate tool[1]. The evidence of cointegration between variables rules out the possibility that the estimated relationship is "spurious" and implies that Granger Causality must exist between these variables in at least one direction (Granger Representation Theorem: see Engle and Granger, 1987 and Granger, 1988). The cointegration approach not only has the ability to identify the cointegrating

[1]Many researchers use only the cointegration analysis for testing the EH such as` Hall, Anderson and Granger (1992), Shea (1992), Cuthbertson, Hayes and Nitzsche (1998), Bremnes, Gjerde and Saettem (2001), Drakos (2002), Ghazali and Low (2002), Cooray (2003), Shivam and Jayadev (2004) and Musti and D'Ecclesia (2008).

vectors within a set of interest rates but also allows for direct hypothesis testing on the variables entering the cointegrating vector.

In this chapter we test the Expectations Hypothesis (EH) for Jordan using another money market instrument, and because the secondary market is very thin we focus instead on the primary market. Due to the absence of regular issues of Government securities in the Jordanian Financial market[2], the Central Bank of Jordan issued its own notes under the name of Certificates of Deposits (CDs). The CDs are a monetary policy instrument and they are mainly used for liquidity management by the Central Bank of Jordan, although, for licensed banks, they are considered a short term investment in risk-free securities. The CDs have existed in the market for approximately ten years and they are considered by all market players to be a risk-free benchmark instrument. We choose the CDs because they are the most convenient instrument that provides us with information about the market's expectations of interest rates almost every two weeks.

The main purpose of this chapter is to explain the behaviour of the CDs' term structure of interest rates and to examine whether the two main maturities of the CDs' interest rates (i.e. the three and six months) are related in the long run. Therefore, the empirical testing in this chapter is another attempt to test the predictive power of the term structure for Jordan using another money market instrument besides the JODIBOR.

We will test the validity of the EH and the dynamic causal relationship between the two interest rates using the cointegration analysis and the Error Correction Model (ECM).

[2] Please see chapter three section 3.2

The approaches followed here are those adopted by many researchers such as Masih and Masih (1996), Ghazali and Low (2002), Ang and McHibbin (2007), and Musti and D'Ecclesia (2008).

The main contribution from this chapter is to establish whether the EH holds for the term structure of interest rates in the Jordanian primary market; i.e. the short end of the term structure. We believe that the findings will have major implications for all market players, especially the policy designers, because they imply important information, such as identifying the predictive power of the term structure and the efficiency of the market. In addition, identifying the direction of causality between the two interest rates; i.e. unidirectional or bidirectional, will have an important empirical application - that is, the forecasting application.

This chapter is organised as follows: Section two describes in detail the properties of our data set including its main shortcomings; section three discusses the unit root test, the main methodology that has been used for testing the long run relationship between the CDs interest rates of different maturities which is the cointegration analysis using the Johansen approach and the Granger causality analysis using the Error Correction Model (ECM); section four discusses the main empirical results of the unit root test, the cointegration analysis and the Granger causality test; section five discusses the robustness test that has been employed to assess the influence of the Spline smoothing function on the causality direction such as employing forward recursive cointegration analysis; section six describes the investigation that is carried out to justify the absence of the cointegration in some recursive periods such as investigating the influence of the learning process and the existence of structural breaks; section seven describes the impulse response function, and section eight presents the conclusion.

4.2 *THE DATA*

The Central Bank of Jordan (CBJ) adopted the indirect monetary policy approach in 1993 and the operating target was to influence the short term interest rates. The large structural excess liquidity position of the banking system, the absence of sufficient regular Government debt instruments, the weakly developed market for Government securities (mainly the secondary market), and the thin Interbank market each plays a role as a motivator for the Central Bank of Jordan to implement its monetary policy via a set of monetary instruments. These instruments allow for an effective steering of short term interest rates and in this paper we will focus on one of the main monetary instruments, which is the Central Bank of Jordan Certificates of Deposits (CDs).

The CDs are issued in the primary market through auction mechanisms. They enable the CBJ to affect banks' reserves[3] by absorbing or injecting reserves into the system on a regular basis and consequently allow for an effective steering of short term interest rates. The CDs are auctioned on a bi-weekly basis and their maturities are designed to range between one month, three month, six month and twelve month; however the main emphasis is on the three and six months maturities.

[3] Injecting reserves occurs when the volume of matured CDs is greater than the volume of auctioned CDs and absorbing reserves occurs when the volume of matured CDs is less than the volume of auctioned CDs .

The volume of the CDs auctions which are determined by the CBJ reflects the monetary policy stance. The Central Bank of Jordan decides on CDs' auctions volumes[4] with the outlook of achieving the CDs' target interest rates. The volume of the excess reserves left within the banking system conveys an important monetary policy signal. For example, if the objective is to tighten the monetary policy then the decision will be to decrease the volume of the excess liquidity left in the market, and this is done by increasing the CBJ demand; i.e. increasing the volume of the auctioned CDs, and vice versa if the objective is to relax the stance of monetary policy.

The CDs become the main monetary instrument that affects the excess liquidity in the system and accordingly the short term interest rates. The interest rates of the auctioned CDs are affected directly by the volumes of the auctions. So the large volume of the auction; i.e. the CBJ demand, is big, is relative to the excess liquidity left in the market and provides a clear signal for the market participants to increase their bidding interest rates which are reflected later by a high weighted average interest rate on the auction.

In order to provide the market with clear and transparent information about CBJ monetary policy stance; i.e. for better communication with licensed banks, the CBJ not only announces the volume of the auction but also the total volume of excess liquidity in the system, the volume of matured CDs and any transactions that may affect the volume of the total excess liquidity.

[4] It is the same as saying "The volume of excess reserves to be left with the banking system".

The main property of the CDs auction is that the licensed banks compete on the quantities and prices through the offers they submit. Therefore, the interest rate on the auction is a market-determined rate and it plays an important role as a benchmark in the money market. The CDs are considered as risk-free securities since they are issued by the Central Bank of Jordan. In addition the accrued interest is paid at maturity with the face value of the CDs; thus the CDs become in a way similar to the property of the zero coupon bonds; i.e. no coupon payment.

The data set covers the period from 21 June 1997 to 31 December 2007. The date of 21 June 1997 represents the beginning of the period where the CBJ adopts market force pricing of CDs through the auction mechanism instead of the fixed pricing mechanism which was employed by the Central Bank during the period from 1993 to May 1997. The frequency of the data is bi-weekly so the total number of observations is 274.

The main shortcoming of the CDs is that CBJ concentrates mainly on two maturities, three and six months, with almost no concentration on the one month and twelve month maturities. Figure 4.1 illustrates all the CDs' maturities. As a result of the nature and the availability of the data, our concentration in this study will be only on the three and six months' interest rates.

In figure 4.2 we plot the three and six months' interest rates for the period from 21 June 1997 to 31 December 2007. By examining figure 4.2, we notice that the CBJ in some periods reduced its reliance on the six month maturity; that is the six month CDs are not regularly issued like the three month ones; therefore we have many missing values in the six month interest rate series. The missing values are estimated by the Spline smoothing function[5], and in figure 4.3 we plot the estimated six month interest rate and the three month interest rate.

4.3 THE METHODOLOGY

4.3.1 UNIT ROOT TEST

In this chapter we carry out a unit root test on interest rates levels and first differences. We employ the Augmented Dickey Fuller (ADF) unit root test (Dickey and Fuller 1979, 1981) and the Phillips-Perron test (PP). Furthermore, we employ two models for testing the order of integration of interest rates levels: first we use the model with constant and second we use the model with constant and trend as exogenous variables. Both models comply with the nature of interest rates series. For the first differences we use the model with no constant or trend; i.e. exogenous=none[6].

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[5] The missing values are estimated by the Spline smoothing method in OxMetrics Software (PcGive program). For more details, please see section 4.5.1.

[6] For full description of the ADF and PP models, please see chapter three section 3.4. Moreover in this chapter we use additional model; i.e. the model with constant and trend and the framework of this model is as follows:

$$\Delta y_t = \alpha + \eta T + \beta y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-i} + \varepsilon_t$$

4.3.2 *THE COINTEGRATION ANALYSIS*

In order to identify the long run relationship between different maturities of interest rates and to validate the EH, we perform a cointegration analysis and then derive an Error Correction Model (ECM) framework on a pair of interest rates[7]. The existence of the cointegrating vector is a clear indication that this pair of interest rates is subjected to a long run relationship; i.e. is subjected to a common attractor. The ECM Framework is used to test the causality effect and to identify which of the interest rates plays the role of the attractor or whether both rates are adjusting towards each other (Musti and D'Ecclesia, 2008).

In this chapter we use Johansen (1988) and Johansen and Juselius (1990) procedures as the main tool to identify the cointegrating vector between our two Interest rates; i.e. the one spread case. The main reason behind using the Johansen approach is due to the fact that we are interested in implementing the weak exogeneity[8] test and the Johansen approach offers a convenient procedure for testing; i.e. via imposing restrictions on the speed of adjustment (Budina et al, 2006). In addition we can test the validity of the EH directly via imposing restrictions on the coefficients of the cointegrating vector.

[7] Please see chapter three section 3.3.3 for full details about the cointegration analysis. The full details include the procedures and tests that are applied before performing the cointegration analysis, the full description of the framework of the unrestricted VAR model, the derived error correction model (ECM) and the two likelihood ratio tests that are proposed by Johansen and Juselius (1990) to determine the number of cointegrating relationships among the variables.

[8] The weak exogeneity test identifies the long run causality and the direction of causality.

We apply a bivariate cointegration test given that we are dealing with two interest rates time series; i.e. the three and six months. It is expected that the bivariate cointegration test will provide us with important information about the structural relationship between this pair of interest rates[9].

Since we are dealing with a bivariate case, we expect to have just one unique cointegrating vector, and to test whether the EH holds or not we need to impose a restriction that complies with the theoretical restrictions (1,-1). So we restrict the coefficients of the variables that enter the spread by (1,-1). The standard Chi-square χ^2 distribution with a significant level of 5% will indicate whether the restrictions are significant or not. The degree of freedom will be equal to the number of over-identifying restrictions which is one in our case.

4.3.3 *GRANGER CAUSALITY TEST AND THE ERROR CORRECTION MODEL (ECM)*

The Granger Causality test has been used extensively in the empirical literature. In recent literature economists have focused on the advanced test of Granger Causality following Granger (1986) and Engle and Granger (1987). The advanced Granger Causality test is applied using cointegration analysis and the ECM (Islam and Ahmad, 1999; Hondroyiannis and Papapetrou, 2000).

[9] See Shea (1992): the bivariate cointegration test provides an overview of how the EH performs on a part of the yield curve.

According to Granger (1986, 1988), the existence of cointegration between two variables indicates that there is a long run relationship between them; i.e. they share a common trend, and as a result the causality must exist at least in one direction. Detecting Granger causality can be done by using the ECM which is derived from the cointegration analysis**.**

The ECM representation shows that the changes of the dependent variables are a function of two key parts: the first part is the sum of the lagged explanatory variables and the sum of the lagged dependent variable, although for short run causality testing we consider just the sum of the lagged explanatory variables; and the second part is the Error Correction Term (ECT). It is agreed by analysts that the ECT adds another dimension for testing the causality; i.e. the long run causality. Accordingly the ECM framework allows analysts to test for short run and for long run causality effects.

Testing the short run causality is usually done through imposing restrictions on the sum of the lagged explanatory dynamic variables, while testing for the long run is done through imposing restrictions on the coefficient of ECT which is called the speed of adjustment. According to Islam and Ahmed (1999:100): "The value of the speed of adjustment parameter is expected to be less than one in absolute terms for stability of the system and for variables in the regression to be cointegrated". The sign and the magnitude of the coefficient of the ECT are used as indication of the direction of causality (Masih and Masih, 1996; Islam and Ahmed, 1999). In general, the long run causality test leads to the identification of the direction of Granger causality; i.e. unidirectional or bidirectional, which is considered important for economists and policy designers.

The causality test follows the cointegration test; we test for causality assuming we have cointegration between the targeted variables[10]. So the assumption that we have cointegration is a prerequisite to employ the causality test (Ang and McHibbin, 2007). We perform the same causality tests that have been employed in recent literature using the following ECM form:

$$D(CD3M)_t = \sum_{i=1}^{k-1} a_i \; D(CD3M)_{t-i} + \sum_{i=1}^{k-1} \mathrm{B}_i \; D(CD6M)_{t-i} + \alpha_{cd3m} \, \mathrm{ECT}_{t-1} + \mu_{1t} \qquad \text{Eq. 4.3.3.1}$$

$$D(CD6M)_t = \sum_{i=1}^{k-1} \mathrm{A}_i \; D(CD3M)_{t-i} + \sum_{i=1}^{k-1} b_i \; D(CD6M)_{t-i} + \alpha_{cd6m} \, \mathrm{ECT}_{t-1} + \mu_{2t} \qquad \text{Eq. 4.3.3.2}$$

Where

CD3M = the three month CDs Interest rate.

CD6M = the six month CDs Interest rate.

D = the difference operators.

ECT_{t-1} = the Error Correction Term = (CD3M + (β_{21} β_{11})CD6M + π)

where π is the constant in the cointegrating vector.

α_{cd3m} = the speed of adjustment in the D(CD3m) equation.

α_{cd6m} = the speed of adjustment in the D(CD6m) equation.

[10] See Mosconi and Giannine (1992).

μ_{1t} and μ_{2t} = the error terms that are assumed to satisfy the Gaussian assumption.

We use the ECM to perform the following three causality tests following the approach that was employed by Masih and Masih (1996), Asafu-adjaye (2000), Hondroyiannis and Papapetrou (2000), Hondroyiannis, Lolos and Papapetrou (2005) and Ang. and McKibbin (2007):

-Weak Exogeneity: Testing the weak exogeneity is the same as saying testing the long run noncausality effect. This test can be implemented either by using the restricted ECM that is derived from the Johansen cointegration analysis which is based on the likelihood ratio test and follows a Chi-square distribution (Asafu-adjaye, 2000) or by using the Wald F-test. We test the significance of the speed of adjustment α by testing the null hypothesis H_0: α_{cd3m}=0 for the first equation and the null hypothesis H_0: α_{cd6m}=0 for the second equation.

-The short run noncausality effect: Testing the short run effect is the same as saying testing the significance of the lagged dynamic terms. We test the significance of the sum of the lagged explanatory variables in each equation and this can be done by using the joint Wald F-test.

-Strong Exogeneity: We impose stronger restrictions by testing the joint Wald F-test of both the coefficient of ECT and the explanatory variables; i.e. the lagged dynamic terms. This test does not distinguish between the short and long run causality effects. It is more restrictive and indicates the overall causality in the system. The non significance of all explanatory variables including ECT indicates the absence of Granger causality (Ang. and McKibbin, 2007). According to Hondroyiannis, Lolos and Papapetrou, 2005: 179, “A variable is defined as strongly exogenous when it is weakly exogenous and it is not affected by any of the endogenous variables in the system".

4.4 *THE EMPIRICAL RESULTS*

4.4.1 *THE UNIT ROOT TEST*

The results of the ADF (AIC and SIC) tests under the two models, with constant and with constant and trend, which are reported in tables 4.1.1 and 4.1.2 evidently show that we cannot reject the null hypothesis of non stationarity at all significance levels (1%, 5%, and 10%), so the three and six months' interest rates in levels are integrated of order one I(1).

Moreover the results of the first differences show clearly that we reject the null hypothesis of non stationarity at all significance levels (1%, 5% and 10%), so the three and six months’ interest rates in first differences are integrated of order I(0). The results of the PP unit root test are shown in Table 4.2 and they confirm the ADF results; we cannot reject the null hypothesis of non stationarity for both the three and six months’ interest rates in levels at all significance levels (1%, 5%, 10%). Regarding the first differences we reject the null hypothesis of non stationarity at all significance levels (1%, 5% and 10%). The unit root findings permit us to include both interest rates in the cointegration analysis.

4.4.2 THE COINTEGRATION ANALYSIS

The cointegration analysis using the Johansen approach is performed for the whole sample period after all necessary conditions are fulfilled; i.e. the two interest rates are integrated of first order I(1) and an optimal lag order is chosen for the VAR system. The diagnostic tests for the VAR residuals indicate that the residuals are not serially correlated according to LM statistics, the residuals are not normally distributed according to the Jarque Bera test which indicates the rejection of the null hypothesis: residuals are multivariate normal at 5% level of significance, and the residuals are heteroskedastic according to the VAR residuals heteroskedasticity test which indicates that the null hypothesis of no heteroskedasticity is rejected at 5%[11].

We use the bivariate cointegration test (the one spread case) so we expect to have one cointegrated vector (r =1). After performing the Johansen approach, we found one cointegrating relationship at 5% level of significance. The trace and the maximal eigenvalue tests indicate the same number of cointegrating vectors (r = 1). The identified cointegrating vector indicates that the spread between the three and six month interest rates is stationary (Table 4.3, Panel A).

We proceed to test whether the EH holds by imposing a number of restrictions on the elements of the cointegrating vector. For proper identification we impose restrictions that comply with the numbers of cointegrating vectors. In this bivariate case we have

[11] The results of the normality and heteroskedasticity tests are not complying with the assumptions of the residuals (i.e. Gaussian conditions) but this is normal in financial data.

one cointegrating vector, so the number of overidentifying restrictions equals one. We impose restrictions that the coefficients equals (1,-1) on the normalised cointegrating vector (1, -0.999885).

In Table 4.3 (Panel B) the LR statistics and the probability results show that the imposed restrictions cannot be rejected at 5% level of significance (i.e. LR statistics=1.76E-05 and the $\rho - value$=0.997). These results are a strong signal that the three and six month interest rates have a long run relationship and they share a common trend which eventually means that the EH holds.

Following the cointegration analysis and the EH testing, we derive the ECM from the Johansen framework. In Table 4.3 (Panel C) we show in details the components of each equation. The left hand side of the first and the second equations; i.e. the dependent variables, are the changes in the three month CDs' interest rate D(CD3M) and the changes in the six month CDs' interest rate D(CD6M) respectively whereas the right hand side contains the two main parts which are the Error Correction Terms (ECT) coefficients; i.e. the speeds of adjustment, (α_{cd3m}) for the first equation and (α_{cd6m}) for the second equation, and the coefficients of the lagged dynamic terms. The R^2 and adjusted R^2 are also displayed.

4.4.3 THE ERROR CORRECTION MODEL (ECM) AND CAUSALITY TEST

Our main concern is to test the short and long run causality effects. We begin our testing by using "the available test within Johansen framework" (Hall and Milne, 1994) in which we test the significance of the speeds of adjustment (α). The results in Table 4.3 (Panel C) reveal that (α_{cd3m}= -0.199010) has the right sign (negative) and it is significant according to the SE and t-statistic (SE=0.05066 and t-statistic=-3.92819) while (α_{cd6m} = -0.06541) has the wrong sign (i.e. negative instead of positive) and it is not significant according to the SE and t-statistics (SE= 0.04296 and t-statistic= -1.52246).

In order to confirm the significance of the speeds of adjustment and to test for the weak exogeneity, we impose restrictions on both (α) and test the two null hypotheses H_0:α_{cd3m}=0 and H_0:α_{cd6m}=0. The results confirm the significance of (α_{cd3m}) at level 5% (LR statistic=12.861 and $\rho-value$=0.000), and the non-significance of (α_{cd6m}) at level 5% (LR statistic=1.987 and $\rho-value$=0.159).

For weak exogeneity testing, it is enough to use the ECM that is derived from the Johansen framework. However the other two causality tests such as the short run causality effect and the strong exogeneity are implemented by using the Wald F-test. Accordingly we construct the same ECM[12] and re-estimate it using the OLS estimator and in order to obtain robust standard errors (SE) for all the coefficients of the constructed ECM[13] we use the Newey West HAC standard errors and covariance method (Table 4.4). We test the three types of the Granger causality applying the Wald

[12] We use the cointegrating vector from the Johansen test outcome to construct the error correction term (ECT) and then we build the Error Correction Model (ECM) using both the constructed (ECT) and the appropriate lags of each explanatory variables.

[13] According to the diagnostic test of the VAR residuals, we find that the null hypothesis of no heteroskedasticity is rejected at 5% significance level. Please see section 4.4.2.

test on the estimated coefficients of the constructed ECM. The results of the Wald test are shown in Table 4.5 and the following is a summary of the main results:

-Weak Exogeneity: We repeat the test of the significance of the speeds of adjustment using the Wald test. We impose restrictions on the two coefficients of the ECT (α_{cd3m}=0 and α_{cd6m}=0). The F-statistic and the probability results in Table 4.5 indicate the significance of α_{cd3m} at level 5% (F-statistic =17.439 and $\rho-value$=0.0000) and the non significance of α_{cd6m} at level 5% (F-statistic =2.548 and $\rho-value$=0.1117). The results of the Wald test and the weak exogeneity test under the Johansen framework confirm the same fact which is that the six month interest rate is weakly exogenous and the direction of the causality is unidirectional; i.e. the six month interest rate causes the three month interest rate while the reverse is not correct.

-The short-run effect: Regarding the first equation, we impose restrictions on the sum of the lagged explanatory variables (i.e. $B_1 = B_2 = B_3 = 0$). The joint Wald F-statistic and the probability indicate the significance at level 5% (i.e. F-statistic =3.205 and $\rho-value$=0.0238). Regarding the second equation, we impose restrictions on the sum of the lagged explanatory variables (i.e.$A_1 = A_2 = A_3 = 0$) and the joint Wald F-statistic and the probability indicate the non significance at 5% (i.e. F-statistic =2.255 and $\rho-value$=0.0824).

-Strong Exogeneity: We use the joint Wald F-statistic to test the significance of the combination of the coefficient of the ECT and the sum of the lagged explanatory variables. We impose the restrictions **(α_{cd3m}= $B_1 = B_2 = B_3 = 0$)** in the first equation, and the joint Wald F-statistic and the probability indicate the significance at level 5% (i.e. F-statistic =9.726 and $\rho - value$ = 0.0000). Under the second equation, we impose the restrictions ($\alpha_{cd6m} = A_1 = A_2 = A_3 = 0$), the joint Wald F-statistic and the probability indicate the non significance at level 5% (i.e. F-statistic =1.715 and $\rho - value$=0.1469). The strong exogeneity test indicates that six month interest rates are strongly exogenous. So this is an additional confirmation that we have unidirectional causality where the six month interest rate causes the three month interest rate while the reverse is not correct; i.e. we may conclude that no feedback relationship is observed.

The empirical results indicate that we have unidirectional causality effects[14] where long term interest rate causes short term interest rate, and although they comply with many findings in the literature, they do not comply with our expectations. We expect that we either have unidirectional causality which complies with the general belief of the EH; i.e. short term interest rate causes long term interest rate, or bidirectional causality which is considered a significant support for the EH.

In order to verify the robustness of the causality results, particularly the direction of causality, we investigate whether the Spline smoothing function, which has been used to estimate many missing values under the six month interest rate series, has any influence on the results of Granger causality and the direction of causality. The following section discusses the method that is employed to verify the robustness of the causality results.

[14] According to Granger (1988), if we have cointegration between specific variables then at least we should have causality in one direction (i.e. unidirectional).

4.5 TESTING THE ROBUSTNESS OF THE CAUSALITY RESULTS

4.5.1 FORWARD RECURSIVE COINTEGRATION ANALYSIS

The original six month interest rate series contains many missing values. The missing values represent the times when the Central Bank of Jordan did not issue this specific maturity and only issued the three month maturity. The missing values have been interpolated using the natural cubic Spline function[15].

The Spline function is defined over the full time interval; accordingly all the available data points are utilised to interpolate the missing values, so the missing values can be defined as a function of the future and past existing values. As a result, if a causal relationship exists between two variables then this relationship may be affected by the Spline's way of fitting the missing values.

The natural cubic Spline model minimises the following objective function:-

$$\text{Min } \sum_{t=1}^{T}(y_t - g(x_{(t)}))^2 + \alpha\int_a^b (g''(x))^2\, dx,$$

[15] The missing values are estimated by the Spline smoothing method in OxMetrics Software (PcGive program). OxMetrics uses a natural cubic Spline and for more details, please see OxMetrics reference 9.10.2 and 10.4.4.2.

The process of minimising the objective function is about finding the optimal trade-off between the first term [$\sum_{t=1}^{T}(y_t - g(x_{(t)}))^2$]; i.e. the sum of squares of deviation between (y_t) and (g(x_t)), which measures the "goodness of fit", and the second term [$\alpha\int_a^b (g^{''}(x))^2 dx$] which measures the "smoothness" (Oda, 1996; Waggoner, 1997).

Under the objective function, g(x) represents the Spline function, the integral interval {a,b} represents the interval of function g(x), and the parameter (α) is a smoothing parameter; its main role is to control the trade-off process between the goodness of fit and the smoothness. Our main purpose is to retain the properties of the original data; therefore we force the Spline function to track all the existing values and interpolate the missing values by choosing the right value of parameter (α). The right choice of parameter (α) leads to an optimal trade-off between the goodness of fit and the smoothness; so we end up with estimated values exactly equal to the existing values and with an optimal interpolation of the missing values. Having an accurate estimation of the actual existing values is an indication that the nature of our original data set stays the same.

In order to verify that the Spline function has no effect on the causal relationship, we employ a forward recursive cointegration analysis. The main purpose from employing the forward recursive analysis is because at the beginning of the sample period the two maturities of the CDs were issued together more often and this makes the number of missing values small relative to the existing values. Accordingly, we believe that the Spline function in this case has minimal influence and the real causality relationship between the two interest rates may be reflected more clearly. Under this method, we rearrange the data set into nine recursive periods and then we perform the Johansen cointegration test, the validity of the EH test and the weak exogeneity test which indicates the direction of causality for each recursive period.

4.5.1.1 *THE EMPIRICAL RESULTS FOR THE FORWARD RECURSIVE COINTEGRATION ANALYSIS*

4.5.1.1.1: *The Cointegration Analysis*

In Table 4.6.1, the results reveal the absence of cointegrating vector in the first three recursive periods (June 1997-December 1999, June 1997-December 2000, and June 1997-December 2001). For the following two recursive periods, the cointegrating vector has been identified at a 10% level of significance for the period June 1997-December 2002, and at 5% for the period June 1997-December 2003, but only under the maximum eigenvalue statistics. Regarding the last four recursive periods the cointegrating vectors have been identified at 5% level of significance under both the trace and the maximum eigenvalue statistics.

4.5.1.1.2: *The Expectations Hypothesis (EH)*

The results of the validity of the EH for each recursive period are reported in Table 4.6.2. The likelihood ratio (LR) statistics and the probability indicate that the EH holds for the recursive periods that have cointegrating vectors.

4.5.1.1.3: *The Granger Causality*

Following the cointegration and the EH tests, we continue to test for long run Granger causality; i.e. the weak exogeneity. This test has been done by imposing the restrictions on the two speeds of adjustment for each recursive period using the standard test within the Johansen Framework.

The results of the weak exogeneity test (table 4.6.3) comply with the original results of the whole sample. The LR statistics and the probability clearly indicate the significance of the speeds of adjustment that are related to the D(CD3M) equations at 5% level of significance while the LR statistics and the probability for the speeds of adjustment that are related to the D(CD6M) equations indicate non significance at level 5%. The results confirm that we have unidirectional causality where six month interest rate causes three month interest rate.

To conclude, the results of the forward recursive cointegration analysis confirm the robustness of the original results; i.e. we have unidirectional causality under each recursive period. However, the absence of the cointegration in the first three recursive periods; i.e. June 1997-December 1999, June 1997-December 2000 and June 1997-December 2001, opens the door for further investigation in order to clarify the main reasons behind this fact.

4.6 *ABSENCE OF COINTEGRATION - FURTHER RESEARCH*

In this section, we consider two main assumptions that may cause the absence of cointegration; first, the effect of the learning process at the beginning of the sample period and second, the existence of structural breaks.

4.6.1 *THE LEARNING PROCESS AND TIME VARYING PARAMETERS*

The main reason behind investigating the learning process is because in the early age of any new markets, market players may not act efficiently and they may take time to learn how to build their expectations rationally (Hall and Urga, 2002). The learning process as defined by many researchers is the process where we have the weak form of the rational expectations, so under this form market players may make many errors in their predictions and pricing during the learning process. In view of that, we assume that the absence of the cointegration in the first three recursive periods; i.e. the beginning of the sample period, may occur because market players are learning. We focus on studying whether the market players use the available information more efficiently and adjust their prediction accordingly.

We use Time Varying Parameter (TVP) as the tool to explore the learning process. The purpose is to recognise the evolution of the market players' behaviour through time and particularly at the beginning of the sample period. We expect that the learning process will be slow at the beginning or there may be no strong evidence of learning. Our expectations are based on the fact that at the beginning market players are still adapting to the new monetary policy implementation.

4.6.1.1 *TIME VARYING PARAMETER METHODOLOGY*

We use the Kalman filter to estimate linear regression models with time varying parameters. We use the state space models to estimate the time varying parameters and identify the learning process[16]. The state space model contains the following equations:

1-The measurement equation:

$$CD3M = \alpha_t + \beta_t (CD6M) + \varepsilon_t \quad \text{where } \varepsilon_t \sim N(0, \sigma_{\varepsilon}^2) \qquad \text{Eq. 4.6.1.1.1}$$

2- The transition equations

$$\alpha_t = \alpha_{t-1} + \omega_{1t} \quad \text{where } \omega_{1t} \sim N(0, \sigma_{\omega 1t}^2)$$

$$\beta_t = \beta_{t-1} + \omega_{2t} \quad \text{where } \omega_{2t} \sim N(0, \sigma_{\omega 2t}^2)$$

4.6.1.2 *THE EMPIRICAL RESULTS OF THE TIME VARYING PARAMETER METHODOLOGY*

The results of the Maximum Likelihood estimation are reported in Table 4.7. The two hyper-parameters which are reported in the second and third columns represent the variances of the error terms in the transition equations ($\sigma_{\omega 1t}^2$ and $\sigma_{\omega 2t}^2$). The final observation of the estimated TVP (α_t and β_t) at time T is reported in columns 4 and 5 respectively. In column 6 we report the average value of the TVP (β_t) and this average

[16] For more details about the Kalman filter, the state space model and its main assumptions, please see chapter three section 3.6.1

is an important indicator because it provides us with an idea of whether, on average, the TVP (β_t) is close to the theoretical value one.

The results of the "signal to noise" ratio indicate that the estimated Time Varying parameter (β_t) is adjusted rapidly for the whole period. This complies with the fact that we have cointegrating vector for the whole sample period and that the EH holds (see Table 4.3). Moreover the time path of the estimated (β_t) for the whole sample period is an important reflection of the evolution of market players and their abilities to learn. The time path of the estimated (β_t) is plotted in Figure 4.4; it is positive and ranges between the values of (0.87) and (0.90). Although the parameter did not fully converge to the theoretical value one, the trend of the estimated (β_t) is upward particularly at the end of the sample period which can be considered a clear sign that it may approach the theoretical value one at some point in the future.

In order to investigate how the market players behave at the beginning of the sample period, we implement the same TVP estimation on the first three recursive periods; June 1997-December 1999, June 1997-December 2000 and June 1997-December 2001.

The results of the "signal to noise" ratio indicate that the estimated TVP (β_t) is not adjusted quickly; i.e. the hyper-parameter of (β_t) is almost zero which indicates that there is no sign of learning at the beginning. The time paths of the estimated TVP (β_t) which are shown in figures 4.5, 4.6 and 4.7 strongly confirm this fact. We may conclude that the market did not show any strong signs of learning at the beginning of the sample period, so we may not be able to decisively conclude that the learning process causes the absence of the cointegration.

4.6.2 *THE STRUCTURAL BREAKS*

The fact that the two CDs' interest rates are cointegrated for the whole sample period is a clear indication that even if we have some structural breaks through the whole sample period, their effect was not strong enough to prevent the two interest rates from being cointegrated. In the empirical literature, the absence of cointegration is normally attributed to the existence of structural breaks. So the absence of the cointegration in the first three recursive periods may have occurred as a result of structural breaks.

The sample period is long and the Central Bank of Jordan has adapted different monetary policy stances through the whole period. Accordingly it is rational to investigate whether some of these changes have an effect on the CDs' interest rates, mainly at the beginning. We believe that there are two structural breaks that may cause the absence of cointegration especially in 1998; i.e. at the beginning of the sample period[17]. For the empirical testing we use the dummy variables to account for the two structural breaks.

[17] We suspect that we may have another two structural breaks in 2005; accordingly we include them as exogenous variables in the VAR system besides the two structural breaks in 1998; i.e. we include four dummy variables in each equation, and repeat the entire tests. The results of the cointegration analysis, the test of the validity of the EH and the causality test did not change. Since their effect was not significant we exclude them and consider just the two structural breaks in 1998.

The first dummy variable is assigned to the day of 28 February 1998. Figure 4.1 illustrates that the CDs' interest rates have increased dramatically for both the three and six months' rates on that day. The reason behind this increase is due to the fact that the CBJ implemented a tightening monetary policy. The CBJ's operational target was to increase the interest rates on the local currency (i.e. The Jordanian Dinar (JD)) so the spread between the JD and US dollars increases in favour of the JD. The ultimate target at that time was to retain the volume of the foreign reserves. The increase in CDs' interest rates was a reaction to the signals that have been sent to the market by the CBJ such as absorbing most of the excess liquidity from the market by increasing the volumes of the CDs' auctions.

The second dummy variable is assigned to the day of 15 August 1998. On this day the CBJ implemented another very tightening monetary policy; not only did the CBJ send out signals by increasing the volumes of the CDs' auctions but also raised its key interest rates. It is clear that both dates occur in 1998 which is the beginning period of the CDs' issuance process by auctions. Hence, it is understandable that market players are still adapting to the new implementation of the monetary policy, especially the CDs' auctions mechanism and they may overreact to the CBJ signals. In order to test the influence of the two structural breaks, we repeat the Johansen cointegration test, the validity of the EH test, and the causality test for all recursive periods using the same models but including two dummy variables as explanatory variables.

The framework of the VAR (Vector Autoregressive) of order (k) model including dummy variables is as follows: Let Xt be a vector with dimension (2x1) of interest rates variables which are integrated of order one I(1)

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots\ldots + A_k X_{t-k} + \psi D_t + \varepsilon_t \qquad t = 1,2,\ldots\ldots, T.$$

Where

A_i = a (nxn) matrix of parameters.

ε_t = the vector of gaussian error terms, $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$

D_t = a vector of dummy variables (exogenous variables), and ψ is a matrix of coefficients.

Reparameterising the above model into the Error Correction Model (ECM) framework and the representation of the ECM including dummy variables is as follows:-

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \ldots\ldots + \Gamma_{k-1} \Delta X_{t-(k-1)} + \Pi X_{t-1} + \psi D_t + \varepsilon_t$$

Where

Γ_i = - (I - A_1 - ….. - A_i), (i = 1,2,…..,k-1), i.e. Γ_i is the parameter vectors.

Π = - (I - A_1 - ….. - A_k); i.e. Π is the product of $\alpha\beta$, where α is the vector of the speeds of adjustment and β is the matrix of the coefficients of the cointegrating vectors.

4.6.2.1 *THE EMPIRICAL RESULTS - STRUCTURAL BREAKS*

4.6.2.1.1 THE COINTEGARTION ANALYSIS

The results of the cointegration test are reported In Table 4.8.1 and show that the cointegrating vectors are identified for all recursive periods[18] at level 5% except for the first period (June 1997 to December 1999), where the cointegrating vector is identified at 10% level of significance. By accounting for the two structural breaks, the results of the cointegration analysis have been changed dramatically for the first three recursive periods. The new results are an apparent verification that the absence of the cointegration is caused by not accounting previously for structural breaks.

4.6.2.1.2 *THE VALIDITY OF THE EXPECTATIONS HYPOTHESIS*

The results of testing whether the EH holds or not are shown in Table 4.8.2. The EH holds for all periods at 5% level of significance except for the period June 1997 to December 2006, it holds at 1% level of significance.

[18] After accounting for the two structural breaks; i.e. including two dummy variables as exogenous variables into the VAR system, and performing the Johansen cointegration test, the output of the Eviews displays the following warning: Critical values assume no exogenous series. Accordingly, both the Trace and the Max-Eigen statistics indicate that we may have two cointegrating vectors under each recursive period. Given that we are dealing with one spread case, one cointegrating vector should be identified. Therefore we decide to take the first choice; that is the Hypothesized No. of CE(s): None, in which the Trace and the Max-Eigen statistics are substantially larger than the critical values.

4.6.2.1.3 *THE ERROR CORRECTION METHOD (ECM) WITH DUMMY VARIABLES AND THE CAUSALITY TEST*

Following the cointegration tests, we estimate the following ECM where we include the two dummy variables as explanatory variables:

$$D(CD3M)_t = \sum_{i=1}^{k-1} a_i \; D(CD3M)_{t-i} + \sum_{i=1}^{k-1} \mathrm{B}_i \; D(CD6M)_{t-i} + \alpha_{cd3m}\,\mathrm{ECT}_{t-1} + \psi_1 \mathcal{D}_1 + \psi_2 \mathcal{D}_2 + \mu_{1t}$$

Eq.4.6.2.1.3.1

$$D(CD6M)_t = \sum_{i=1}^{k-1} \mathrm{A}_i \; D(CD3M)_{t-i} + \sum_{i=1}^{k-1} b_i \; D(CD6M)_{t-i} + \alpha_{cd6m}\,\mathrm{ECT}_{t-1} + \gamma_1 \mathcal{D}_1 + \gamma_2 \mathcal{D}_2 + \mu_{2t}$$

Eq.4.6.2.1.3.2

Where

CD3M = the three month CDs Interest rate.

CD6M = the six month CDs Interest rate.

D = the difference operators.

ECT_{t-1} = the Error Correction Term= (CD3M + (β_{21} β_{11})CD6M + π)

where π is the constant in the cointegrating vector

α_{cd3m} = the speed of adjustment in the D(CD3m) equation.

α_{cd6m} = the speed of adjustment in the D(CD6m) equation.

$\mu_{1t} and \mu_{2t}$ = the error terms that are assumed to satisfy the Gaussian condition.

D_1 = the issue date Feb. 28, 1998, we assign 1 for this date and zero elsewhere.

D_2 = the issue date Aug.15, 1998, we assign 1 for this date and zero elsewhere.

We test for long run causality, i.e. the weak exogeneity, for each recursive period using the derived ECM with dummy variables. We impose restrictions on the two speeds of adjustment ($\alpha_{cd3m}=0$ and $\alpha_{cd6m}=0$) using the standard test under the Johansen framework.

The results in Table 4.8.3 indicate clearly that by considering the dummy variables, the results regarding the significance of α_{cd3m} and α_{cd6m} have been changed. Both the LR statistics and the probability not only indicate the significance of the speed of adjustment (α_{cd3m}) at level 5%, but also indicate that the speed of adjustment (α_{cd6m}) becomes significant at level 5% for all recursive periods except for the following recursive periods (i.e. June 1997-December 1999, June 1997-December 2000, and June 1997-December 2001) is significant at level 10%. Nevertheless α_{cd6m} still has the wrong sign (i.e. negative) under all recursive periods.

In Table 4.9 (panels A, B, and C) we report the results of the cointegration analysis, the EH test and the derived ECM for the whole sample period after including the dummy variables. The results indicate that we have cointegrating vector and the EH holds at 5% level of significance (LR statistic = 3.46 and $\rho-value$ = 0.063). The dummy variables are found to be statistically significant except for one dummy under the six month interest rate equation; i.e. the coefficient = 0.230137, SE=0.1342 and t-statistic=1.714949.

To check the robustness of the above results we construct the ECM including the dummy variables. After that we re-estimate the ECM using OLS estimator with the

Newey West HAC standard errors and covariance method to obtain robust standard errors (SE). The results in Table 4.10 are robust and reveal clearly the significance of all dummy variables.

Furthermore, we proceed to test the three types of the Granger causality applying the Wald test on the estimated coefficients of the constructed ECM (Table 4.10). The results are reported in Table 4.11 and illustrate that the causality test results for the second equation where D(CD6M) is the dependent variable have been changed significantly. The details of the causality results are as follows:

-Weak Exogeneity: We use the Wald test to impose restrictions on the two coefficients of the ECT; i.e. the speeds of adjustments α_{cd3m} and α_{cd6m} . The F-statistic and the probability results in Table 4.11 indicate the significance of α_{cd3m} and α_{cd6m} at 5%. The results confirm that the three and six months' interest rates are not weakly exogenous. So we conclude that the direction of causality becomes bidirectional instead of unidirectional, although the speed of adjustment (α_{cd6m}) still has the wrong sign.

-The short-run effect: Regarding the first equation, we impose the following restrictions on the sum of the lagged explanatory variables, ($B_1 = B_2 = B_3 = 0$). The joint Wald F-statistic and the probability indicate the non significance of the sum of lagged variables at 5% level (i.e. F-statistic =1.940 and $\rho - value$=0.1234), whereas in the second equation the joint Wald F-statistic and the probability indicate the significance of the sum of the lagged variables $(A_1 = A_2 = A_3 = 0)$ at 5% (i.e. F-statistic=7.756 and $\rho - value$=0.0001).

-Strong Exogeneity: We test the significance of the combination of the coefficient of the ECT and the sum of the lagged explanatory variables using the Joint Wald F-statistic. Regarding the first equation we impose the restrictions ($\alpha_{cd3m} = B_1 = B_2 = B_3 = 0$), where the joint Wald F-statistic and the probability indicate the significance at 5% (i.e. F-statistic =8.128 and $\rho - value$=0.0000). Regarding the second equation we impose the restrictions ($\alpha_{cd6m} = A_1 = A_2 = A_3 = 0$), where the joint Wald F-statistic and the probability also indicate the significance at 5% (i.e. F-statistic =6.206 and $\rho - value$=0.0001). The strong exogeneity test takes into consideration the overall causality effect and its results show strongly that both interest rates, the three and the six months, are not strongly exogenous. This result is an additional confirmation that we have bidirectional causality in spite of the fact that (α_{cd6m}) still has the wrong sign; that is negative.

In order to obtain a deeper insight about the influence of the negative sign of the speed of adjustment (α_{cd6m}), we implement the Impulse Response Function (IRF). Our expectations are that the IRF will provide us with a clear view about the influence of the negative sign of (α_{cd6m}) and convey information about the stability of the VAR/VECM Systems (Klasra, 2006).

4.7 *IMPULSE RESPONSE FUNCTION (IRF)*

"The Impulse Response Function essentially maps out the dynamic response path of a variable due to a one-period standard deviation shock to another variable" (Masih and Masih, 1996: 414). The IRF has been implemented by imposing a shock on one of the interest rates so we can observe the dynamic behaviour of the other interest rate. We implement the IRF on the VAR/VECM systems with and without dummy variables.

The VAR/VECM Systems are considered steady-stable systems when the IRF gradually declines and dies out to a steady state. The steady state means that the Impulse response coefficients converge to value zero in the case of the VAR system or to a constant value in the case of the VECM system; i.e. the first difference VAR Model. Figures 4.8 and 4.9 illustrate the IRF on the VAR system for 274 periods' horizons using both the Cholesky and the Generalised method.

In response to a one standard deviation disturbance in six month interest rate (CD6M), the three month interest rate (CD3M) deviates from the equilibrium but the speed of adjustment causes the response to die out quickly and decline until it converges to zero. Also in response to a one standard deviation disturbance in CD3M rate, the CD6M rate deviates far away from the equilibrium; i.e. the reflection of the negative sign of α_{cd6m}, but eventually it converges to zero after some periods. The IRF reflects the stability of the estimated model.

Moreover, the response of the variables in the VECM systems indicates that the systems are stable because the impulse response of the CD3M rate to one standard deviation disturbance in CD6M rate and the impulse response of the CD6M rate to one standard deviation disturbance in CD3M rate decline quickly to a steady state; i.e. they converge to a constant value. Figures 4.10 to 4.13 reveal the stability of the VECM systems. In conclusion we can define that the effect of the shocks in our VAR/VECM systems are transitory since the variable returns to its previous equilibrium value of zero or constant after some periods (Lűtkepohl and Reimers, 1992).

The validation of the EH for the CDs' term structure is an indication that three and six months' interest rates are perfect substitutes for each other. Accordingly, monetary policy can affect the long term rates using the relationship between the short term rates and long term rates as a vehicle; i.e. the CDs' primary market can be considered an efficient vehicle for monetary policy implementation. Moreover, the validation of the EH indicates that market traders act rationally and use all the available information in an optimal way to predict the future movements of short term interest rates.

4.8 *CONCLUSION AND FURTHER REMARKS*

In this paper we investigate the empirical validity of the EH in the Jordanian money market, particularly the primary market, using the Central Bank of Jordan Certificates of Deposits (CDs). The main limitation that we may consider about our data set is that it consists only of two maturities of interest rates, the three and six months, and the six month interest rate series contains many missing values.

We use the Spline smoothing function to estimate the missing values. We also employ the cointegration analysis to test for the validity of the EH; i.e. identifying the long run relationship between the two interest rates, and the ECM for the exogeneity and causality tests.

The cointegration and the ECM results indicate strongly that both interest rates have long run equilibrium relationship and they share a common trend. Therefore, if any interest rate deviates from the equilibrium path as a consequence of shocks, eventually it will be forced to return to the equilibrium state. The first set of results which belongs to the whole sample period indicates clearly that long run interest rate; i.e. the six month rate, is the strong force of attraction that drives the movement of the three month rate while the reverse is not true; i.e three month rate does not cause six month rate, so the direction of causality is seen to be unidirectional.

Our findings regarding the direction of causality comply with the findings of many empirical works in the literature; i.e. many analysts found that long run interest rates are the main force of attraction[19]. However they may not comply with the main belief under the Expectations theory; that is, short term rate causes long term rate. According to the definition of the EH, long term rates are a function of the average of the current and expected future short term rates, or in the case of using the spread to explain the EH, the spread between the long and short term interest rates is also a function of the expected changes in future short term interest rates.

Given the fact that the direction of causality is a very important piece of information for all market players and particularly for policy designers, we use the forward recursive cointegration analysis to verify the robustness of the original findings. The results of the forward recursive cointegration analysis confirm the same original fact about the causality direction. In addition, the results show that there is an absence of cointegration

[19] See Ghazali and Low, 2002; Mansur, Masih and Ryan, 2005; and Musti and D'Ecclesia, 2008.

in the first three recursive periods. In order to identify the reasons behind the absence of cointegration, we consider two main assumptions; first the effect of the learning process especially at the beginning of the sample period, and second, the effect of structural breaks.

The findings of the time varying parameter test show no strong evidence of learning at the beginning of the sample period. However, after accounting for structural breaks, the findings of the cointegration and causality have been changed significantly. We find very strong evidence that after accounting for the two structural breaks, the direction of causality becomes bidirectional instead of unidirectional; i.e. both speeds of adjustments become significant, however α_{cd6m} still has the wrong sign (negative). The effect of the negative sign of α_{cd6m} is detected through the Impulse Response Function. The findings of the IRF indicate that the VAR VECM systems are stable, so if any deviation from the long run equilibrium occurred, both the three and six months' interest rates will go back to the equilibrium state at different speeds; that is the three month interest rate will go back faster than the six month interest rate.

The fact that the EH holds indicates that the spread between the six and three months interest rate has a predictive power for the future changes in the three month interest rate. The new result of the direction of causality (i.e. having bidirectional causality) not only complies with the main belief of the EH that short term interest rate causes long term interest rate, but also provides a huge support for the EH as long term interest rate also causes short term interest rate.

We may conclude that the spread between the six and three months interest rate conveys important information about market players' expectations of future interest rates at least for one maturity (the three month). In addition, having bidirectional causality is very important fact for policy makers because it has an important empirical application particularly the forecasting application (Granger 1988; Hondroyiannis, Lolos and Papapetrou, 2005),

This piece of information can be the main motivator for the policy designers to consider building the term structure; i.e. at least in the money market, by introducing other maturities of the CDs to the market like one month, nine month and twelve month through the same regular auctions. This will create a term structure of risk-free securities that extends up to one year.

We believe that extending the CDs' term structure to include all maturities will play an important role in developing the financial market in Jordan, given the fact that the Jordanian money market already suffers from the absence of other risk-free financial instruments with different maturities, and the fact that the secondary market for both the CDs and the Government securities is almost non-existent as a result of the huge volume of excess liquidity in the market over a long period of time.

We are aware that in an emerging market like the Jordanian money market any changes may cause distortion in the market but this will be for a short time only. In the long run market players will learn how to price the new maturities of the CDs efficiently. The

Central Bank of Jordan has to take advantage of the fact that market players are now competent at pricing efficiently and they can adapt to any changes especially if these changes are introduced in a gradual manner. It will take time for all the new maturities of interest rates to be linked with the existing ones and to follow a common trend, but if this linkage is obtained then we will have a term structure with a predictive power in the Jordanian money market.

4.8.1 *FURTHER REMARKS*

Developing the term structure for periods up to one year is the first step in developing the term structure for longer terms. Eventually it is hoped that this will motivate the Central Bank of Jordan to consider using the term structure as an effective tool to measure the transmission of its monetary policy. Most importantly the existence of a risk-free benchmark term structure will help in developing the financial market and will improve the pricing of other financial instruments.

Figure 4.1: ***Certificates of Deposits Interest Rates - (All Maturities: One Month, Three Month, Six Month and Twelve Month)***

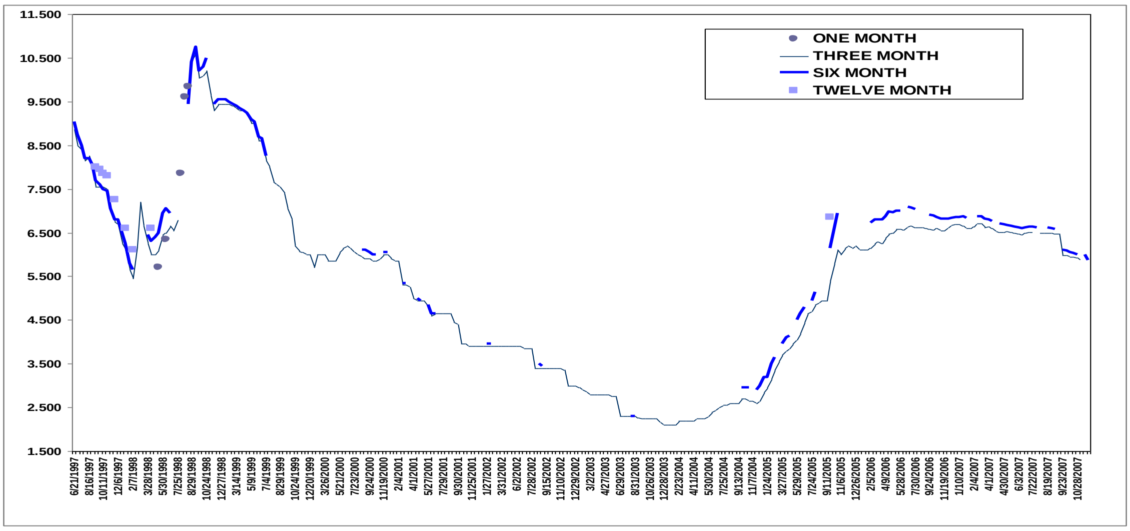


Figure 4.2: ***Certificates of Deposits Interest Rates (Three Month and Six Month With Missing Values)***

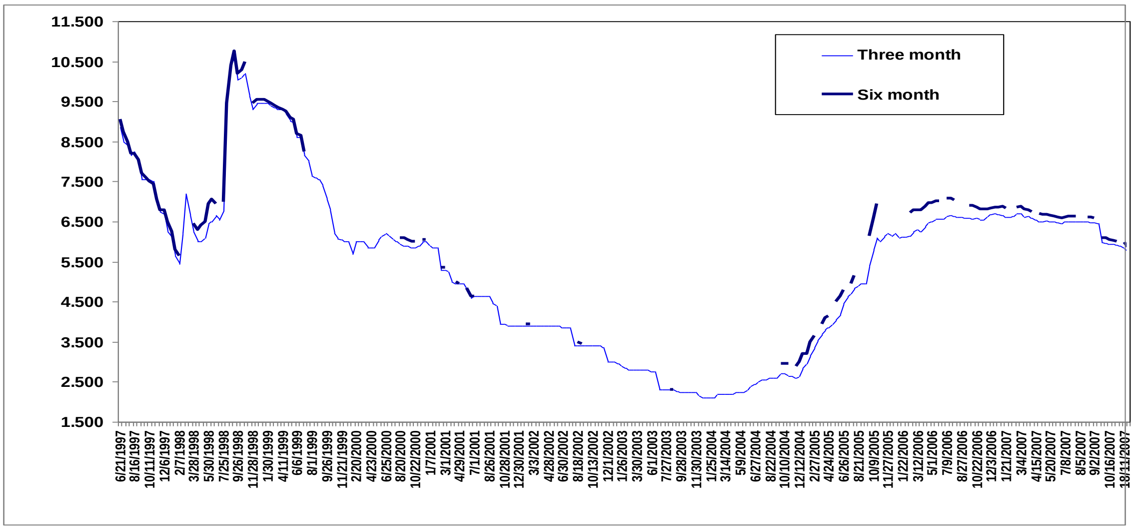


Figure 4.3: ***Certificates of Deposits Interest Rates – Spline Estimation (Three Month and Six Month)***

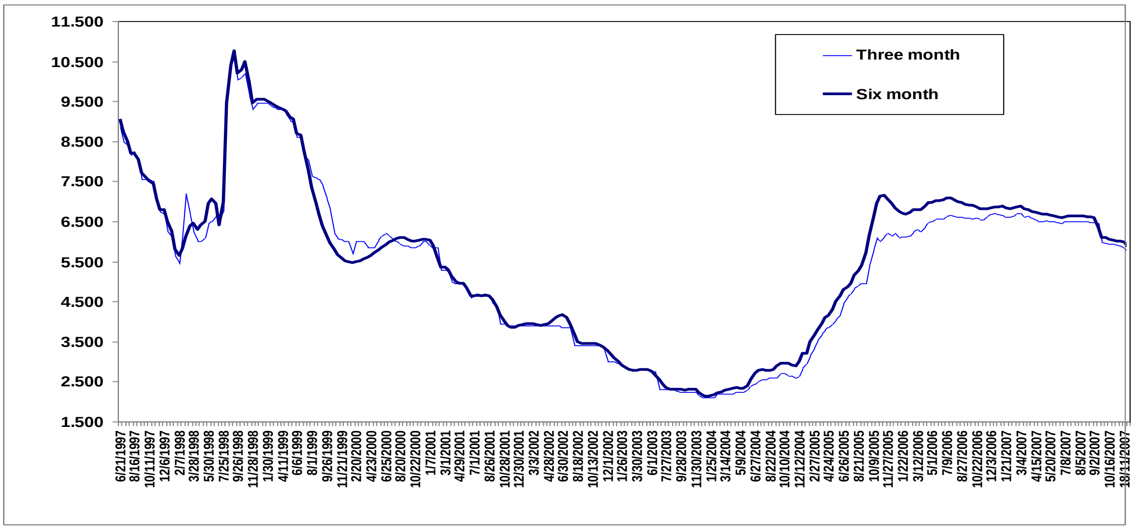


Figure 4.4: ***Time Varying Parameter of The Period (June 1997-Dec. 2007), Kalman Filter***

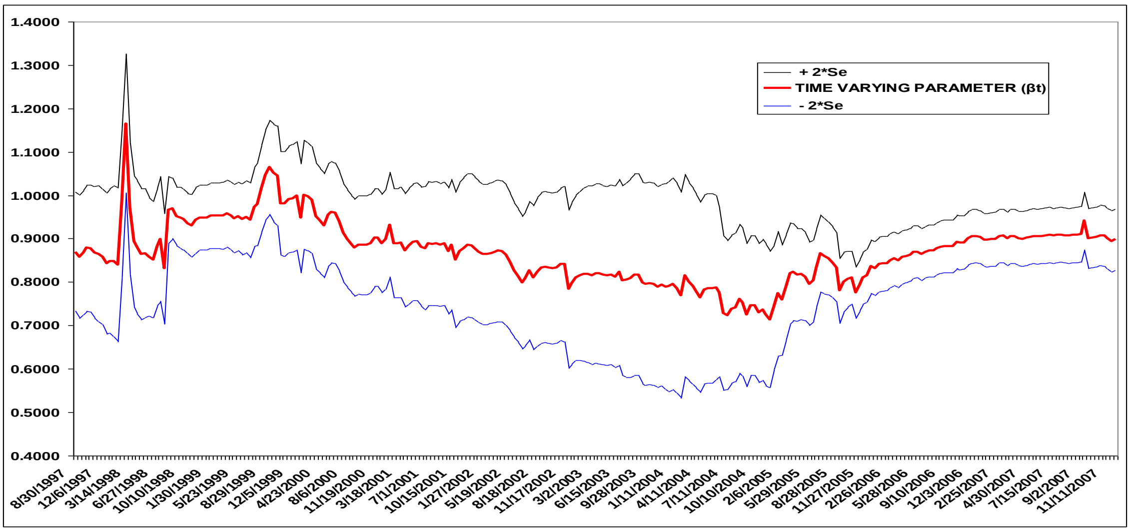


Figure 4.5: ***Time Varying Parameter of The Period (June 1997-Dec.1999), Kalman Filter***

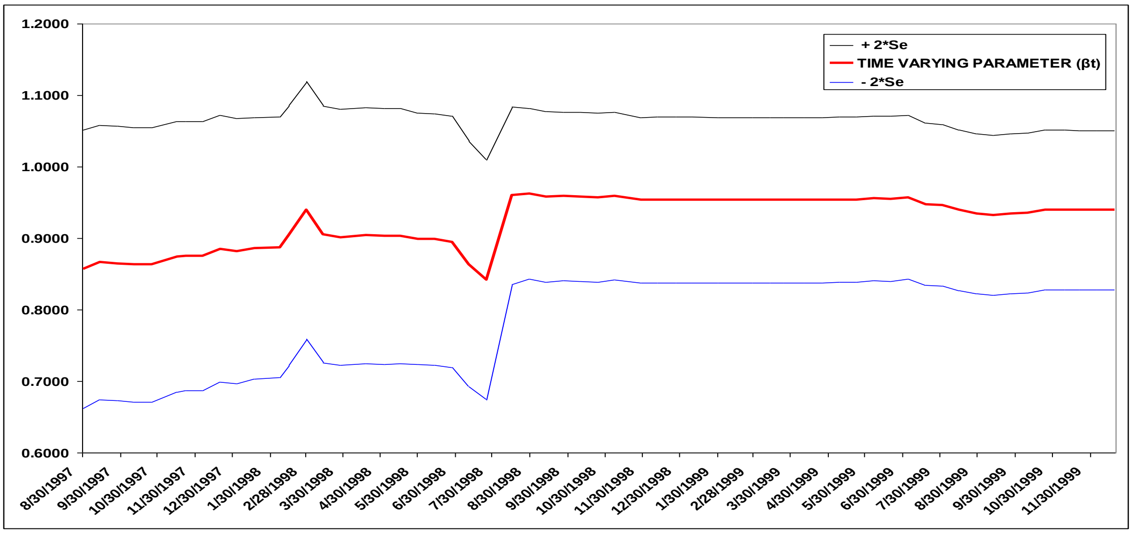


Figure 4.6: ***Time Varying Parameter of The Period (June 1997-Dec. 2000), Kalman Filter***

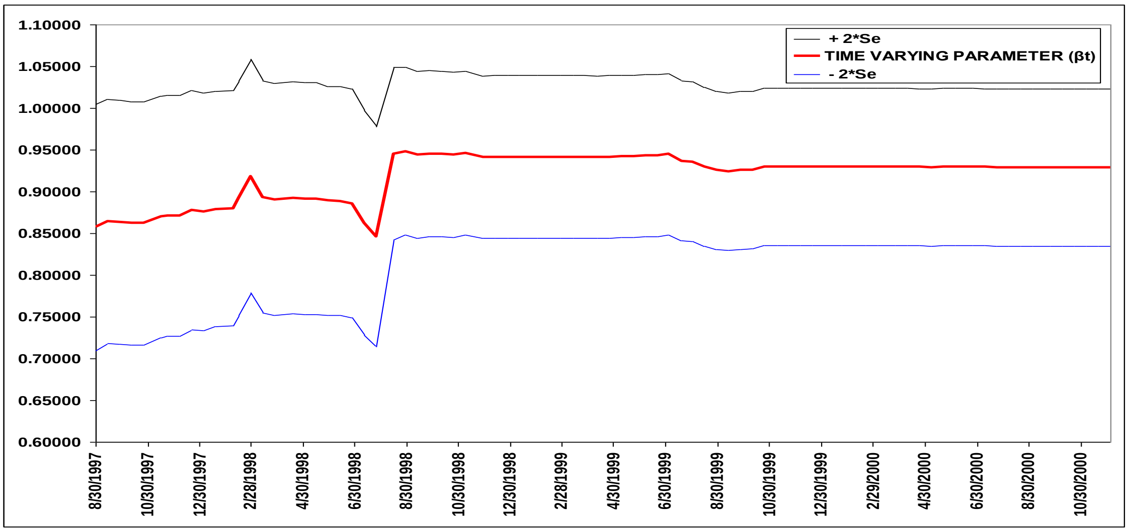


Figure 4.7: ***Time Varying Parameter of The Period (June 1997-Dec. 2001),Kalman Filter***

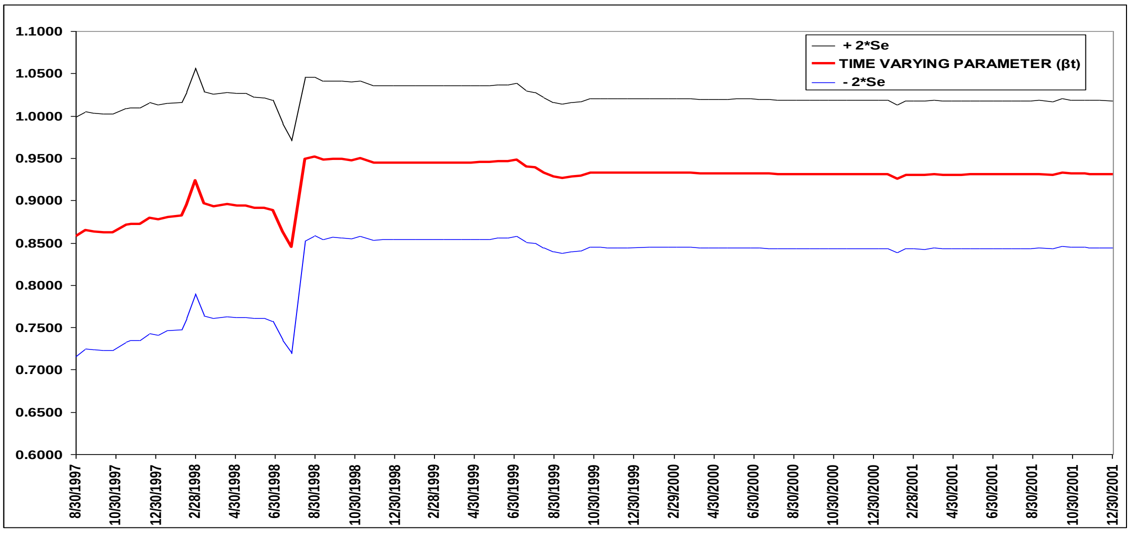
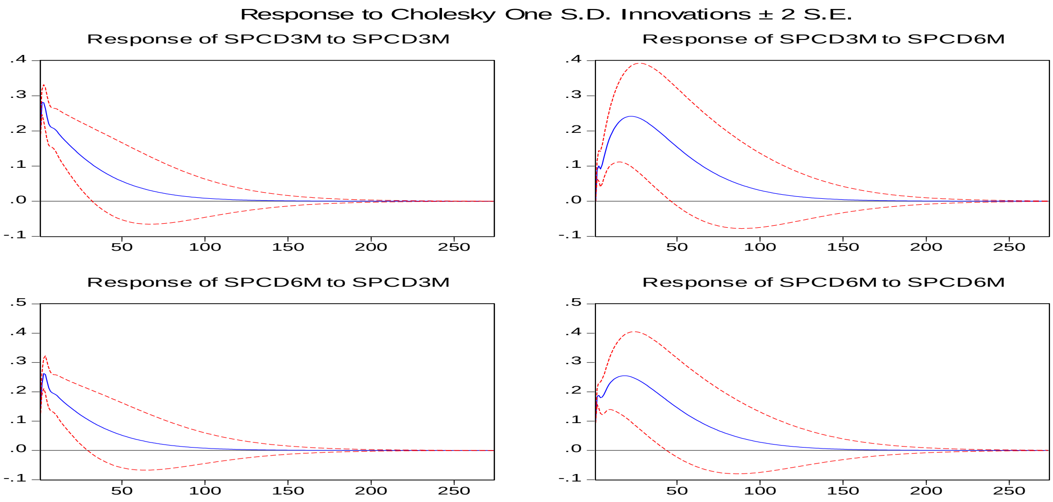


Figure 4.8: ***Impulse Response Functions to Shocks in Interest Rates (VAR System Without Dummy Variables)***



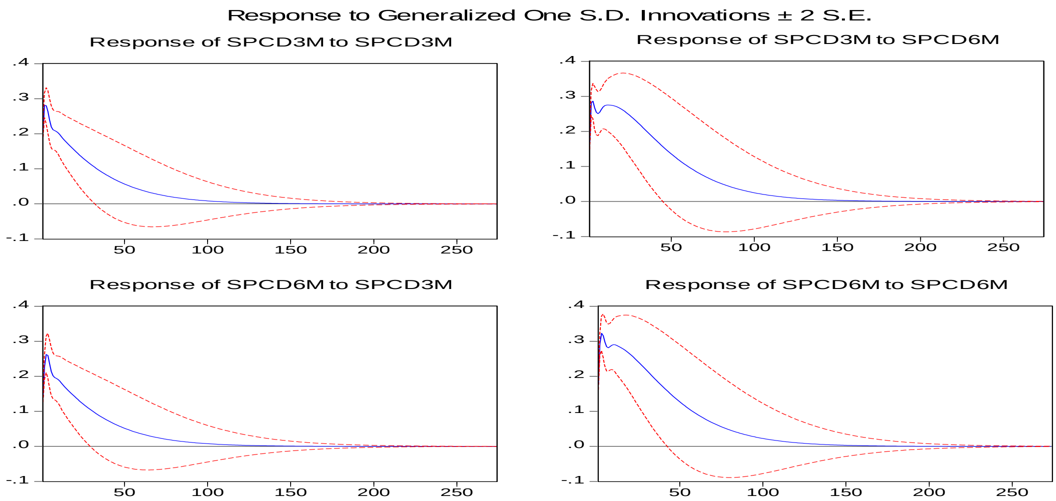


Figure 4.9: ***Impulse Response Functions to Shocks in Interest Rates (VAR System With Dummy Variables)***

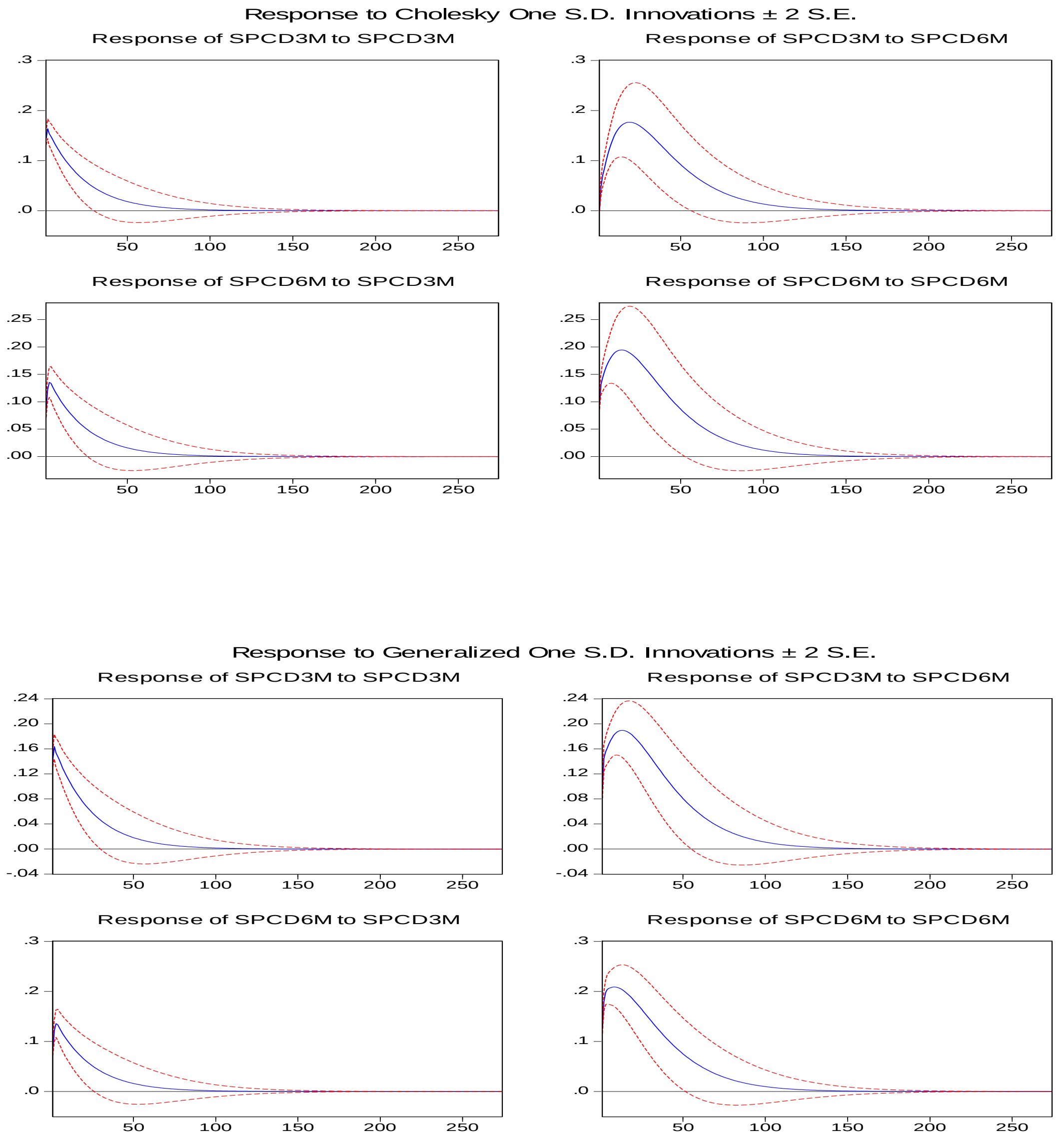
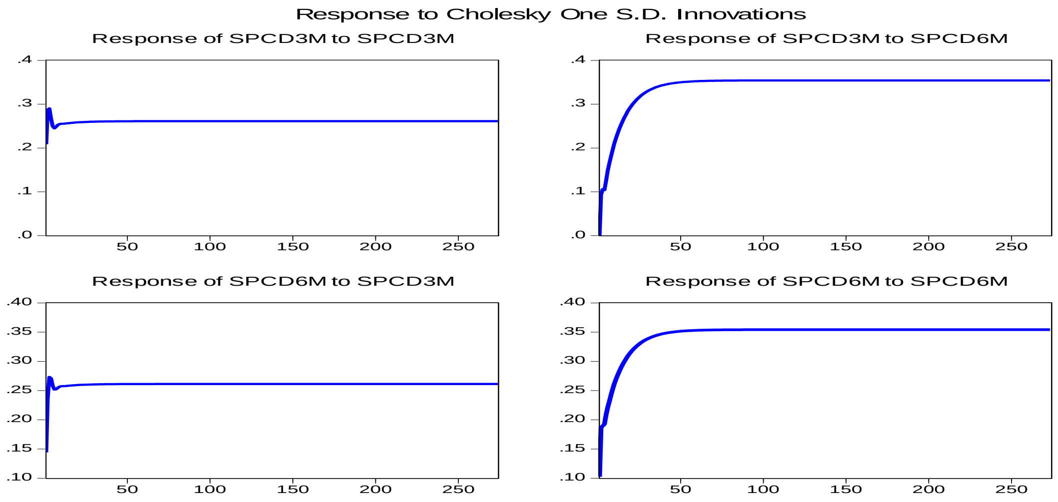


Figure 4.10: ***Impulse Response Functions to Shocks in Interest Rates (Unrestricted VECM System Without Dummy Variables)***



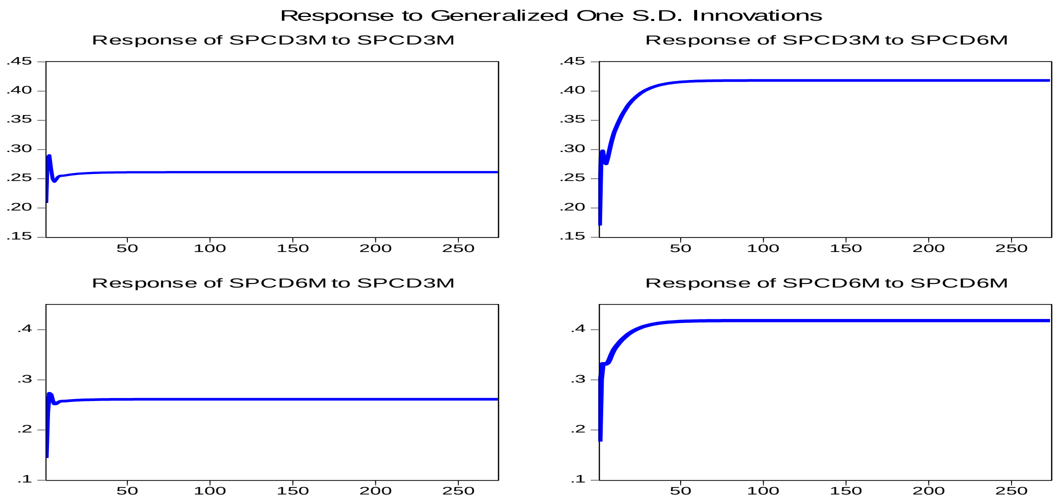


Figure 4.11: ***Impulse Response Functions to Shocks in Interest Rates (Unrestricted VECM System With Dummy Variables)***

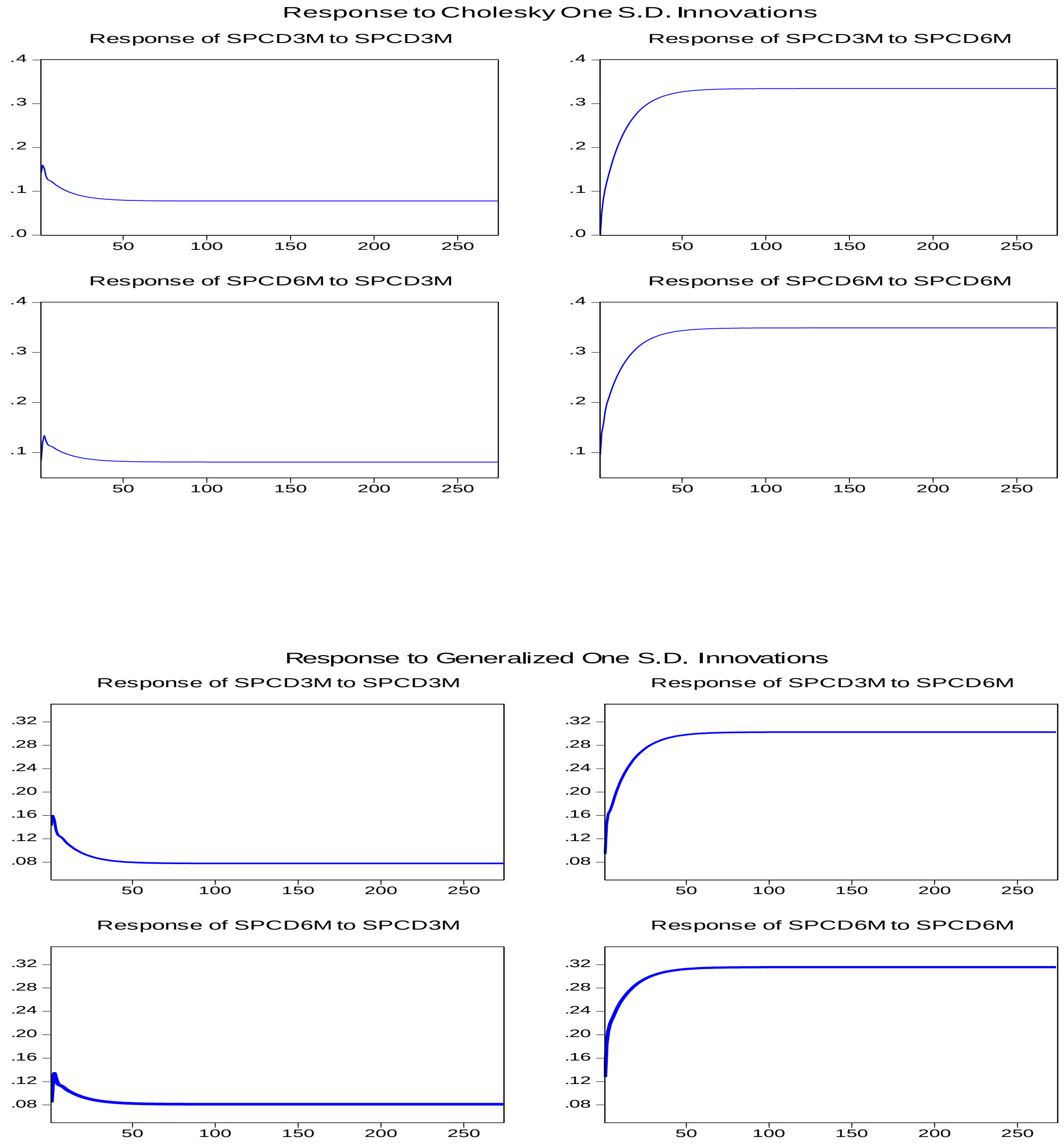
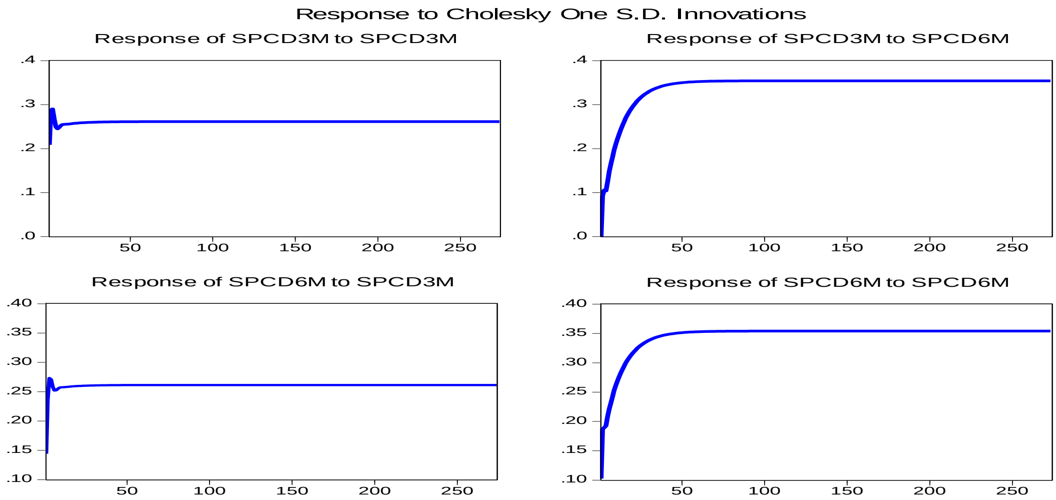


Figure 4.12: ***Impulse Response Functions to Shocks in Interest Rates (Restricted VECM System Without Dummy Variables)***



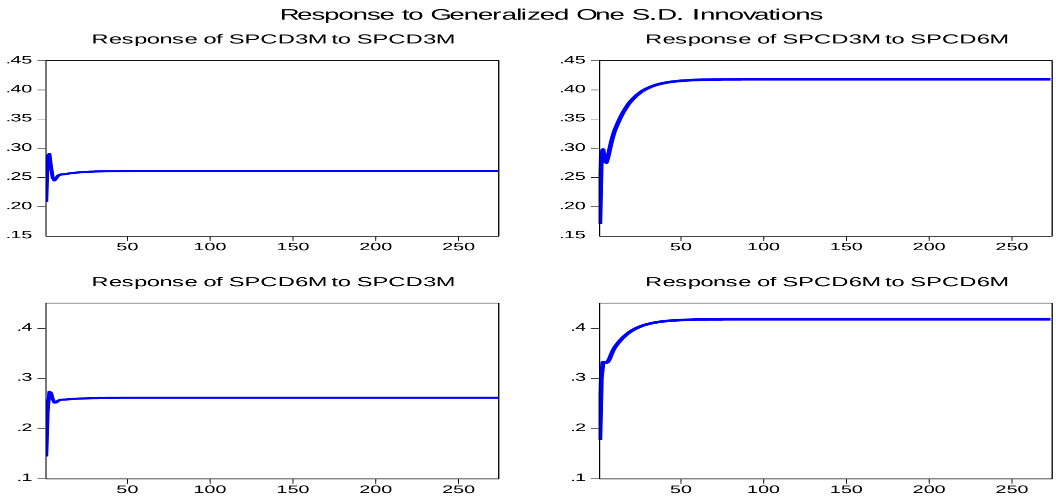
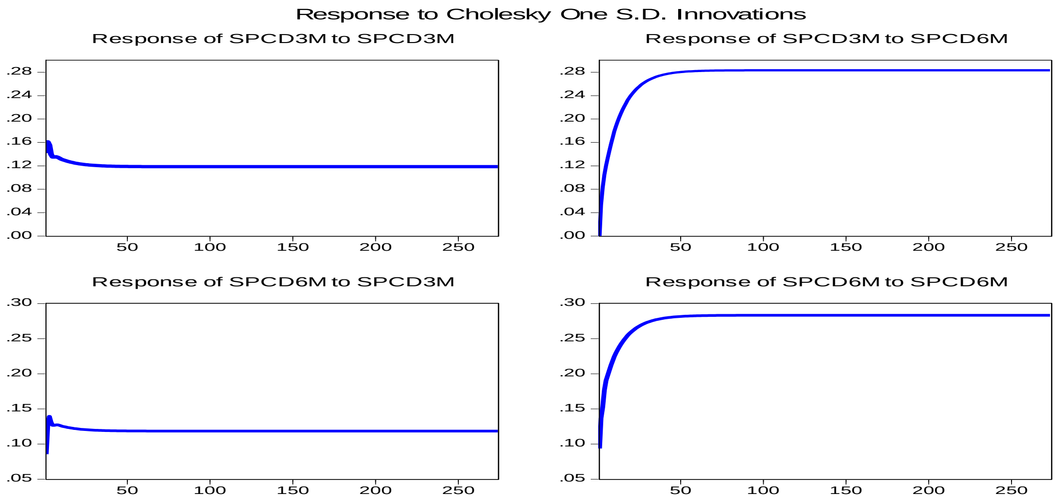


Figure 4.13: ***Impulse Response Functions to Shocks in Interest Rates (Restricted VECM System With Dummy Variables)***



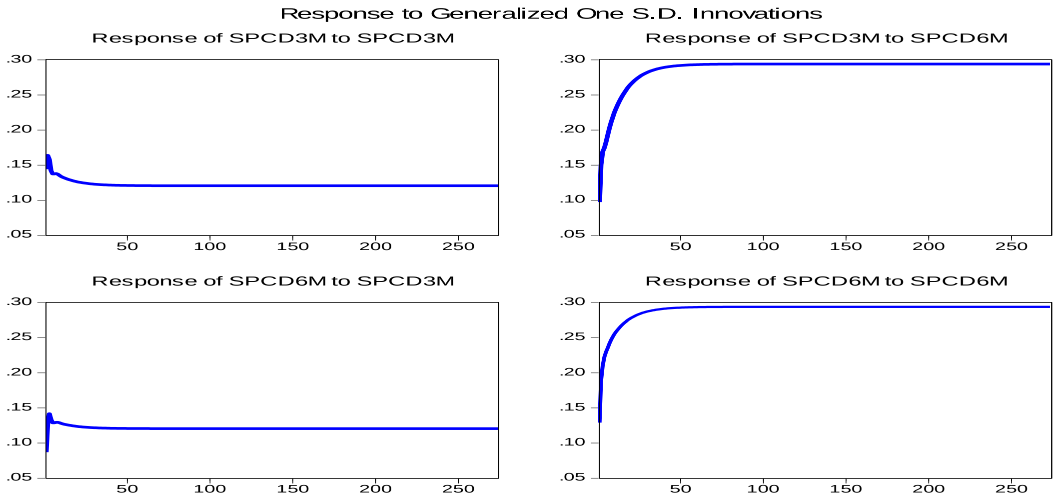


Table 4.1.1: ***Unit Root Test (ADF AIC), (Levels and First Differences)***

Test of the Order of Integration Using (AIC)	Exogenous: Constant	Exogenous: Constant, Linear Trend	Exogenous: None
Variables	**t-Statistics I(1) (No. of Lags)**	**t-Statistics I(1) (No. of Lags)**	**t-Statistics I(0) (No. of Lags)**
Levels			
Three Month Rate	-1.740797* (11)	-1.741719* (11)	
Six Month Rate	-1.854140* (7)	-1.769295* (7)	
First Difference			
Δ Three Month Rate			-3.754927** (10)
Δ Six Month Rate			-4.797158** (6)

Table 4.1.2: ***Unit Root Test (ADF SIC), (Levels and First Differences)***

Test of the Order of Integration Using (SIC)	Exogenous: Constant	Exogenous: Constant, Linear Trend	Exogenous: None
Variables	**t-Statistics I(1) (No. of Lags)**	**t-Statistics I(1) (No. of Lags)**	**t-Statistics I(0) (No. of Lags)**
Levels			
Three Month Rate	-1.762045* (1)	-1.536118* (1)	
Six Month Rate	-1.957032* (4)	-1.847121* (4)	
First Difference			
Δ Three Month Rate			-11.67318** (0)
Δ Six Month Rate			-5.655193** (3)

Table 4.2: ***Unit Root Test (PP), (Levels and First Differences)***

Test of the order of Integration Using (PP)	Exogenous: Constant	Exogenous: Constant, Linear Trend	Exogenous: None
Variables	**t-Statistics I(1) (Bandwidth)**	**t-Statistics I(1) (Bandwidth)**	**t-Statistics I(0) (Bandwidth)**
Levels			
Three Month Rate	-1.863412* (8)	-1.563252* (8)	
Six Month Rate	-1.972328* (10)	-1.744909* (10)	
First Difference			
Δ Three Month Rate			-11.73531** (1)
Δ Six Month Rate			-8.816585** (8)

Notes:
- The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 6.0, (2007).
- Levels
***Denote that the null hypothesis of non-stationarity can't be rejected at (1%,5%,10%) significance levels.**
- First difference
****Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

Table 4.3: ***The Cointegration Analysis, The Expectations Hypothesis Test and The Error Correction Model (ECM) – Whole Sample Period***

Panel A				
Cointegration Equation	**Normalized Cointegration Coefficients**			
	CD3M	**CD6M**		**Constant**
	1	***-0.999885**		**0.143781**
SE		**0.02529**		**0.14805**
t-Statistic [ ]		**[-39.5387]**		**[0.97116]**
Panel B				
Testing The Expectations Hypothesis Imposing Restrictions (1, -1)				
	CD3M	**CD6M**		**LR Statistic (Probability)**
Restrictions Can't Be Rejected (Expectations Hypothesis Holds)	**1**	**-1**		**1.76E-05 (0.997)**
Panel C				
Vector Error Correction Estimates (VECM)				
Coefficients of the VECM	**D(CD3M)**	**SE t-Statistic[ ]**	**D(CD6M)**	**SE t-Statistic[ ]**
Co integration Equation (ECT)	***-0.199010**	0.05066 **[-3.92819]**	**-0.06541**	0.04296 **[-1.52246]**
D(CD3M(-1))	**-0.052830**	0.10459 **[-0.50511]**	**-0.061954**	0.0887 **[-0.69848]**
D(CD3M(-2))	**0.180042**	0.10167 **[1.77082]**	***0.298319**	0.08622 **[3.45992]**
D(CD3M(-3))	**-0.112333**	0.10407 **[-1.07935]**	**-0.116666**	0.08826 **[-1.32186]**
D(CD6M(-1))	***0.703816**	0.12742 **[5.52378]**	***0.758728**	0.10805 **[7.02179]**
D(CD6M(-2))	***-0.585450**	0.13261 **[-4.41481]**	***-0.605682**	0.11246 **[-5.38581]**
D(CD6M(-3))	**0.125912**	0.12807 **[0.98315]**	**0.194477**	0.10861 **[1.79062]**
R – Squared	**0.298559**		**0.370270**	
Adjusted R – Squared	**0.282556**		**0.355904**	

***Significant at level 5%.**

Table 4.4: ***The Constructed Error Correction Model (ECM) – Whole Sample Period***

Vector Error Correction Estimates Using OLS Estimator (Robust SE)				
Coefficients of the VECM	**D(CD3M)**	**SE** **t-Statistic[ ]**	**D(CD6M)**	**SE** **t-Statistic[ ]**
Cointegration Equation (ECT)	***-0.199010**	0.047656 **[-4.175991]**	**-0.065410**	0.040981 **[-1.596098]**
D(CD3M(-1))	**-0.052830**	0.167095 **[-0.316167]**	**-0.061954**	0.119974 **[-0.516397]**
D(CD3M(-2))	**0.180042**	0.309546 **[0.581633]**	**0.298319**	0.273038 **[1.092590]**
D(CD3M(-3))	**-0.112333**	0.079963 **[-1.404817]**	**-0.116666**	0.071278 **[-1.636774]**
D(CD6M(-1))	***0.703816**	0.283008 **[2.486913]**	***0.758728**	0.203219 **[3.733553]**
D(CD6M(-2))	**-0.585450**	0.449173 **[-1.303396]**	**-0.605682**	0.407919 **[-1.484808]**
D(CD6M(-3))	**0.125913**	0.107871 **[1.167249]**	**0.194478**	0.104063 **[1.868845]**
R - Squared	**0.298559**		**0.370270**	
Adjusted R - Squared	**0.282556**		**0.355904**	

***Significant at level 5%.**

Table 4.5: ***Granger Causality Results – Whole Sample Period***

Dependent Variables	Short-Run Effects		Long-Run Effects (Weak Exogeneity) ECT Only (Wald Test)	Strong Exogeneity (ECT&Explanatory Variables)	
	D(CD3M) $A_1=A_2=A_3=0$	**D(CD6M)** $B_1=B_2=B_3=0$		$\alpha_{CD6M}=A_1=A_2=A_3=0$	$\alpha_{CD3M}=B_1=B_2=B_3=0$
	Wald F-Statistics (P-Value)		**F-Statistic ($P-VALUE$) of $\alpha_{CD3M}=0$ & $\alpha_{CD6M}=0$**	**Wald F-Statistics (P-Value)**	
D(CD3M)	**–**	***3.205 (0.0238)**	***17.439 (0.0000)**	**–**	***9.726 (0.0000)**
D(CD6M) **	**2.255 (0.0824)**	**–**	**2.548 (0.1117)**	**1.715 (0.1469)**	**–**

*** Significance at level 5%.**
**** The dependent variable D(CD6M) is strongly Exogenous (No Causality effect for both short and long run effects). Furthermore the coefficient of the ECT(i.e. α(CD6M)) in the unrestricted ECM has the wrong sign ((i.e. α(CD6M) equals - 0.065410).**

Table 4.6.1 : ***Bivariate cointegration tests (Model 2) - Forward recursive estimations***

Interest Rates (Bivariate Cointegration) For Different Sample Periods	Eigenvalues	No of Lags	λ Max		t Statistic	Critical Value at 5%	λ Trace		t Statistic	Critical Value at 5%	The Cointegrating Vector (Normalized)
			Null	Alt.			Null	Alt.			
June 1997–Dec. 1999 (63 Observations)	**0.152369**	**3**	**r = 0**	**r = 1**	**9.75**	**15.89**	**r = 0**	**r ≥ 1**	**12.04**	**20.26**	**No Coint******
June 1997–Dec. 2000 (84 Observations)	**0.132997**	**3**	**r = 0**	**r = 1**	**11.42**	**15.89**	**r = 0**	**r ≥ 1**	**14.86**	**20.26**	**No Coint******
June 1997–Dec. 2001 (109 Observations)	**0.112420**	**3**	**r = 0**	**r = 1**	**12.52**	**15.89**	**r = 0**	**r ≥ 1**	**14.81**	**20.26**	**No Coint******
June 1997–Dec. 2002 (135 Observations)	**0.108506**	**3**	**r = 0**	**r = 1**	**15.05**	**15.89**	**r = 0**	**r ≥ 1**	**17.29**	**20.26**	**(1, -1.014569)*****
June 1997–Dec. 2003 (159 Observations)	**0.108654**	**3**	**r = 0**	**r = 1**	**17.83**	**15.89**	**r = 0**	**r ≥ 1**	**20.09**	**20.26**	**(1, -1.013262)****
June 1997–Dec. 2004 (186 Observations)	**0.103426**	**3**	**r = 0**	**r = 1**	**19.87**	**15.89**	**r = 0**	**r ≥ 1**	**22.74**	**20.26**	**(1, -1.020052)***
June 1997–Dec. 2005 (211 Observations)	**0.091298**	**3**	**r = 0**	**r = 1**	**19.82**	**15.89**	**r = 0**	**r ≥ 1**	**22.65**	**20.26**	**(1, -1.009580)***
June 1997–Dec. 2006 (238 Observations)	**0.083670**	**3**	**r = 0**	**r = 1**	**20.45**	**15.89**	**r = 0**	**r ≥ 1**	**23.68**	**20.26**	**(1, -1.002193)***
June 1997–Dec. 2007 (274 Observations)	**0.083063**	**3**	**r = 0**	**r = 1**	**23.41**	**15.89**	**r = 0**	**r ≥ 1**	**27.31**	**20.26**	**(1, -0.999885)***

***The cointegrating vector is identified at 5% level of significance.**

**** The cointegrating vector is identified at 5% level of significance under the Maximum Eigenvalue.**

*****The cointegrating vector is identified at 10% level of significance under the Maximum Eigenvalue. The Max-Eigen Statistic equals 15.05 and the critical value equals 13.90, whereas no cointegrating vector was identified under the Trace Test.**

****** No cointegrating vector was identified either at 5% or 10% levels of significance.**

-Diagnostic test for the VAR residuals:- LM statistics indicate that the residuals are not serially correlated, the Jarque Bera test for normality indicates the rejection of the Null Hypothesis: Residuals are Multivariate normal for all recursive periods at 5% level of significance and the VAR residuals heteroskedasticity test indicates that the null Hypothesis of no Heteroskedasticity is rejected at 5% level of significance.

Table 4.6.2: ***Imposing Restrictions on The Bivariate Cointegrating Vectors (Testing The EH)***

Interest Rates (Bivariate Cointegration)	The Cointegrating Vector (Normalized)	LR Statistics After Imposing Restrictions That The Coeffecients Equal (1,-1)	Probability
June 1997–Dec. 1999 (63 Observations)	**No Coint**	–	—
June 1997–Dec. 2000 (84 Observations)	**No Coint**	–	—
June 1997–Dec. 2001 (109 Observations)	**No Coint**	–	—
June 1997–Dec. 2002 (135 Observations)	**(1,-1.014569)**	**0.188**	**0.664****
June 1997–Dec. 2003 (159 Observations)	**(1,-1.013262)**	**0.295**	**0.587****
June 1997–Dec. 2004 (186 Observations)	**(1,-1.020052)**	**0.831**	**0.362****
June 1997–Dec. 2005 (211 Observations)	**(1,-1.009580)**	**0.126**	**0.723****
June 1997–Dec. 2006 (238 Observations)	**(1.-1.002193)**	**0.005**	**0.942****
June 1997–Dec. 2007 (274 Observations)	**(1,-0.999885)**	**1.76E-05**	**0.997****

**** The restrictions cannot be rejected at (5% and 10%) levels of significance.**

Table 4.6.3: ***Granger Causality Test (Weak Exogeneity)***

Sample Periods	**THE SPEED OF ADJUSTMENT (α)**		**Testing The Hypothesis H0 : α_{CD3M}=0 & H0 : α_{CD6M}=0**	**LR Statistics**	**Probability**
	D(CD3M)= α_{CD3M} / **D(CD6M)= α_{CD6M}**	**Adjustment Coefficients (α Value) (Standard Error in Parentheses), t- Statistics**			
June 1997 - Dec. 1999 (63 Observations)	α_{CD3M}	–	α_{CD3M}=0	No Cointegration	
	α_{CD6M}	–	α_{CD6M}=0		
June 1997 - Dec. 2000 (84 Observations)	α_{CD3M}	–	α_{CD3M}=0	No Cointegration	
	α_{CD6M}	–	α_{CD6M}=0		
June 1997 - Dec. 2001 (109 Observations)	α_{CD3M}	–	α_{CD3M}=0	No Cointegration	
	α_{CD6M}	–	α_{CD6M}=0		
June 1997 - Dec. 2002 (135 Observations)	α_{CD3M}	***-0.272261 (0.10608) , -2.5667**	α_{CD3M}=0	**5.797**	**0.016***
	α_{CD6M}	**-0.051629 (0.08917) , -0.5790**	α_{CD6M}=0	**0.303**	**0.582**
June 1997 - Dec. 2003 (159 Observations)	α_{CD3M}	***-0.277524 (0.09758) , -2.8442**	α_{CD3M}=0	**7.230**	**0.007***
	α_{CD6M}	**-0.052996 (0.08171) , -0.6486**	α_{CD6M}=0	**0.387**	**0.534**

Table 4.6.3: ***Continued***

June 1997 - Dec. 2004 (186 Observations)	α_{CD3M}	***-0.266577 (0.08642) , -3.0846**	α_{CD3M}**=0**	**8.277**	**0.004***
	α_{CD6M}	**-0.055675 (0.07246) , -0.7684**	α_{CD6M}**=0**	**0.528**	**0.467**
June 1997 - Dec. 2005 (211 Observations)	α_{CD3M}	***-0.235464 (0.06641) , -3.5456**	α_{CD3M}**=0**	**10.842**	**0.001***
	α_{CD6M}	**-0.075851 (0.05645) , -1.3437**	α_{CD6M}**=0**	**1.604**	**0.205**
June 1997 - Dec. 2006 (238 Observations)	α_{CD3M}	***-0.196619 (0.05439) , -3.6152**	α_{CD3M}**=0**	**11.053**	**0.001***
	α_{CD6M}	**-0.063582 (0.04612) , -1.3785**	α_{CD6M}**=0**	**1.652**	**0.199**
June 1997 - Dec. 2007 (274 Observations)	α_{CD3M}	***-0.199010 (0.05066) , -3.9282**	α_{CD3M}**=0**	**12.861**	**0.000***
	α_{CD6M}	**-0.06541 (0.04296) , -1.5225**	α_{CD6M}**=0**	**1.987**	**0.159**

***Significant at level 5% .**

Table 4.7: ***The Time Varying Parameter Model * (Forward Recursive Estimation)***

Samples Periods	Hyper-Parameters (Variances)		Time Varying Constant (α_t)**** Last Observation at Time T [Se]	Time Varying Slope (β_t) Last Observation at Time T [Se]	The Average of The time Varying Slope (β_t)	Forecast Errors: Jarque Bera	Forecast Errors: Ljung-Box (16 Lags)	Log Likelihood
	$\sigma^2_{\omega 1t}$ "α_t Equation" [SE]** (t-Ratio)***	$\sigma^2_{\omega 2t}$ "β_t Equation" [SE]** (t-Ratio)***						
June 1997–Dec. 2007 (274 Observations)	**0.92048E-07 [0.27300E-04] (0.33718E-02)**	**1836.9 [3099.0] (0.59276)**	**0.48**	**0.90 [0.9705]**	**0.8701**	**9303.191**	**56.01**	**567.865**
June 1997–Dec. 1999 (63 Observations)	**71949 [0.59431E-05] (0.12106E+11)*** **	**0.99906E-03 [0.41904] (0.23842E-02)*** **	**0.84**	**0.94 [1.0508]**	**0.9230**	**24.274**	**19.68**	**85.820**
June 1997–Dec. 2000 (84 Observations)	**0.10547E+06 [0.12212E-05] (0.86365E+11)*** **	**0.14266E-10 [0.0000] (0.0000)*** **	**0.38**	**0.93 [1.02284]**	**0.9177**	**57.897**	**19.04**	**125.511**
June 1997–Dec. 2001 (109 Observations)	**95682 [0.86232E-06] (0.11096E+12)*** **	**0.30451E-09 [0.0000] (0.0000)*** **	**0.28**	**0.93 [1.0182]**	**0.9226**	**107.888**	**17.21**	**174.342**

***The Kalman Filter: The time Varying Parameter Model is estimated by REG-X program, Hall Stephen G. (1998b).**

****The Standard errors are not corrected for serial correlation; therefore there is serial correlation in the errors.**

***** Hessian Matrix is Singular, t-Statistics are unreliable.**

****** No standard errors are provided in the Reg-X software output for the time varying constant (α_t).**

Table 4.8.1: ***Bivariate Cointegration Tests (Model 2) With Dummy Variables (i.e. Including Two Structural Breaks) - Forward Recursive Estimation***

Interest Rates (Bivariate Cointegration) For Different Sample Periods	Eigenvalues	No of Lags	λ Max		t Statistic	Critical value at 5%	λ Trace		t Statistic	Critical value at 5%	The Cointegrating Vector (Normalized)
			Null	Alt.			Null	Alt.			
June 1997–Dec. 1999 (63 Observations)	**0.211800**	2	r = 0	r = 1	14.28	15.89	r = 0	r ≥ 1	19.27	20.26	**(1,- 0.892481)****
June 1997–Dec. 2000 (84 Observations)	**0.191758**	2	r = 0	r = 1	17.24	15.89	r = 0	r ≥ 1	25.09	20.26	**(1,- 0.857803)***
June 1997–Dec. 2001 (109 Observations)	**0.170523**	2	r = 0	r = 1	19.82	15.89	r = 0	r ≥ 1	29.15	20.26	**(1,- 0.930859)***
June 1997–Dec. 2002 (135 Observations)	**0.158081**	2	r = 0	r = 1	22.71	15.89	r = 0	r ≥ 1	34.52	20.26	**(1,-0.959247)***
June 1997–Dec. 2003 (159 Observations)	**0.156983**	2	r = 0	r = 1	26.64	15.89	r = 0	r ≥ 1	40.17	20.26	**(1,-0.968146)***
June 1997–Dec. 2004 (186 Observations)	**0.155867**	2	r = 0	r = 1	31.01	15.89	r = 0	r ≥ 1	45.88	20.26	**(1,-0.964084)***
June 1997–Dec. 2005 (211 Observations)	**0.160785**	2	r = 0	r = 1	36.46	15.89	r = 0	r ≥ 1	45.30	20.26	**(1,-0.949671)***
June 1997–Dec. 2006 (238 Observations)	**0.158238**	2	r = 0	r = 1	40.48	15.89	r = 0	r ≥ 1	49.97	20.26	**(1,-0.945380)***
June 1997–Dec. 2007 (274 Observations)	**0.148336**	3	r = 0	r = 1	43.35	15.89	r = 0	r ≥ 1	54.00	20.26	**(1,- 0.958647)***

***The cointegrating vector is identified at 5% level of significance.**

****The cointegrating vector is identified at 10% level of significance. The Trace Statistic equals 19.27 where the critical value equals 17.98 and the Maximum Eigenvalue statistic equals 14.28 where the critical value equals 13.91.**

- Diagnostic test for the VAR residuals:-

LM statistics indicate that the residuals are not serially correlated, the Jarque Bera test for normality indicates the rejection of the Null Hypothesis: Residuals are Multivariate normal for all recursive periods at 5% level of significance except for the period (June1997-Dec.1999), and the VAR residuals heteroskedasticity test indicates that the null Hypothesis of no Heteroskedasticity is rejected at 5% level of significance.

Table 4.8.2: ***Imposing Restrictions on The Bivariate Cointegrating Vectors (Testing The EH)***

Interest Rates (Bivariate Cointegration)	**The Cointegrating Vector (Normalized)**	**LR Statistics After Imposing Restrictions That The Coefficients Equal (1,-1)**	**Probability**
June 1997–Dec. 1999 (63 Observations)	**(1,- 0.892481)**	**1.690**	**0.194***
June 1997–Dec. 2000 (84 Observations)	**(1,- 0.857803)**	**3.725**	**0.054****
June 1997–Dec. 2001 (109 Observations)	**(1,- 0.930859)**	**1.719**	**0.190***
June 1997–Dec. 2002 (135 Observations)	**(1,-0.959247)**	**0.926**	**0.336***
June 1997–Dec. 2003 (159 Observations)	**(1,-0.968146)**	**1.068**	**0.301***
June 1997–Dec. 2004 (186 Observations)	**(1,-0.964084)**	**1.556**	**0.212***
June 1997–Dec. 2005 (211 Observations)	**(1,-0.949671)**	**3.772**	**0.052****
June 1997–Dec. 2006 (238 Observations)	**(1,-0.945380)**	**4.825**	**0.028*****
June 1997–Dec. 2007 (274 Observations)	**(1,- 0.958647)**	**3.455**	**0.063****

*** The restrictions cannot be rejected at (5% and 10%) levels of significance.**
**** The restrictions cannot be rejected at 5% level of significance.**
***** The restrictions cannot be rejected at 1% level of significance**

Table 4.8.3: ***Granger Causality Test (Weak Exogeneity) - Forward Recursive Estimation With Dummy Variables***

Sample Periods	**The Speed of Adjustment (α)**		**Testing The Hypothesis H0 : α_{cd3m} =0 & H0 : α_{cd6m}=0**	**LR Statistics**	**Probability**
	D(CD3M)= α_{CD3M} / **D(CD6M)= α_{CD6M}**	**Adjustment Coefficients (α Value) (Standard Error In Parentheses) , t-Statistics**			
June 1997 - Dec. 1999 (63 Observations)	α_{CD3M}	**-0.307736** (0.08175) , -3.7644	α_{CD3M}**=0**	9.256	**0.002***
	α_{CD6M}	**-0.193452** (0.079) , -2.4488	α_{CD6M}**=0**	4.282	**0.039***
June 1997 - Dec. 2000 (84 Observations)	α_{CD3M}	**-0.289097** (0.06915) , -4.1809	α_{CD3M}**=0**	9.366	**0.002***
	α_{CD6M}	**-0.169328** (0.06433) , -2.6322	α_{CD6M}**=0**	4.063	**0.044***
June 1997 - Dec. 2001 (109 Observations)	α_{CD3M}	**-0.256471** (0.05788) , -4.4311	α_{CD3M}**=0**	10.161	**0.001***
	α_{CD6M}	**-0.126426** (0.05227) , -2.4187	α_{CD6M}**=0**	3.318	0.069**
June 1997 - Dec. 2002 (135 Observations)	α_{CD3M}	**-0.235903** (0.05009) , -4.7093	α_{CD3M}**=0**	10.375	**0.001***
	α_{CD6M}	**-0.106157** (0.04448), -2.3869	α_{CD6M}**=0**	2.918	0.088**
June 1997 - Dec. 2003 (159 Observations)	α_{CD3M}	**-0.239363** (0.0469) , -5.1039	α_{CD3M}**=0**	12.396	**0.000***
	α_{CD6M}	**-0.103053** (0.0411) , -2.5076	α_{CD6M}**=0**	3.277	0.070**

Table 4.8.3: ***Continued***

June 1997 - Dec. 2004 (186 Observations)	α_{CD3M}	**-0.231764** (0.04154) , -5.5787	α_{CD3M}**=0**	15.53	**0.000***
	α_{CD6M}	**-0.106004** (0.03653) , -2.9021	α_{CD6M}**=0**	4.583	**0.032***
June 1997 - Dec. 2005 (211 Observations)	α_{CD3M}	**-0.221000** (0.03601) , -6.1367	α_{CD3M}**=0**	27.071	**0.000***
	α_{CD6M}	**-0.110362** (0.0324) , -3.4060	α_{CD6M}**=0**	8.968	**0.003***
June 1997 - Dec. 2006 (238 Observations)	α_{CD3M}	**-0.209165** (0.03232) **, -6.4719**	α_{CD3M}**=0**	30.351	**0.000***
	α_{CD6M}	**-0.104059** (0.02903) , -3.5850	α_{CD6M}**=0**	9.999	**0.002***
June 1997 - Dec. 2007 (274 Observations)	α_{CD3M}	**-0.211553** (0.03221) , -6.5672	α_{CD3M}**=0**	**31.179**	**0.000***
	α_{CD6M}	**-0.092332** (0.02893) , -3.1917	α_{CD6M}**=0**	7.915	0.005*

***Significant at level 5%.**
****Significant at level 10%.**

Table 4.9: ***The Cointegration Analysis, The Expectations Hypothesis Test and The Error Correction Model (ECM) - Whole Sample Period With Dummy Variables***

Panel A

Cointegration Equation	**Normalized Cointegration Coefficients**		
	CD3M	**CD6M**	**Constant**
	1	***-0.958647**	**-0.017086**
SE		**0.01968**	**0.1151**
t-Statistic [ ]		**[-48.7022]**	**[-0.14844]**

Panel B

TESTING THE EXPECTATIONS HYPOTHESIS
IMPOSING RESTRICTIONS (1, -1)

	CD3M	**CD6M**	**LR Statistic (Probability)**
Restrictions Can't Be Rejected At 1% & 5% (Expectations Hypothesis Holds)	**1**	**-1**	**3.46** **(0.063)**

Panel C

Vector Error Correction Estimates (VECM)

Coefficients of the VECM	**D(CD3M)**	**SE t-Statistic[ ]**	**D(CD6M)**	**SE t-Statistic[ ]**
Cointegration Equation (ECT)	***-0.211553**	0.03221 **[-6.56715]**	***-0.092332**	0.02893 **[-3.19174]**
D(CD3M(-1))	**0.008876**	0.0746 **[0.11898]**	**0.078455**	0.06700 **[1.17105]**
D(CD3M(-2))	**-0.066637**	0.07142 **[-0.93307]**	**0.079942**	0.06413 **[1.24649]**
D(CD3M(-3))	***-0.144739**	0.07112 **[-2.03526]**	***-0.134761**	0.06386 **[-2.11016]**
D(CD6M(-1))	***0.344620**	0.09287 **[3.71064]**	***0.371763**	0.0834 **[4.45749]**
D(CD6M(-2))	**-0.022033**	0.0975 **[-0.22596]**	**-0.114168**	0.08756 [-1.30387]
D(CD6M(-3))	**0.064034**	0.08741 **[0.73259]**	**0.110431**	0.07849 **[1.40687]**
DUMMY 1	***1.010607**	0.14944 **[6.76284]**	**0.230137**	0.1342 **[1.71494]**
DUMMY 2	***2.516615**	0.1595 **[15.7782]**	***2.191744**	0.14323 **[15.3020]**
R - Squared	**0.675846**		**0.673675**	
Adjusted R - Squared	**0.665911**		**0.663673**	

***Significant at level 5%.**

Table 4.10: ***The Constructed Error Correction Model (ECM) – Whole Sample Period With Dummy Variables***

Vector Error Correction Estimates Using OLS Estimator (Robust SE)				
Coffecients of the VECM	**D(CD3M)**	**SE** **t-Statistic[ ]**	**D(CD6M)**	**SE** **t-Statistic[ ]**
Cointegration Equation (ECT)	***-0.211553**	0.044646 **[-4.738404]**	***-0.092332**	0.037857 **[-2.438941]**
D(CD3M(-1))	**0.008876**	0.119890 **[0.074037]**	**0.078455**	0.093445 **[0.839580]**
D(CD3M(-2))	**-0.066637**	0.076946 **[-0.866032]**	**0.079942**	0.072659 **[1.100229]**
D(CD3M(-3))	***-0.144739**	0.063884 **[-2.265659]**	***-0.134761**	0.050542 **[-2.666312]**
D(CD6M(-1))	***0.344620**	0.145030 **[2.376201]**	***0.371763**	0.154221 **[2.410586]**
D(CD6M(-2))	**-0.022033**	0.110648 **[-0.199124]**	**-0.114168**	0.109419 **[-1.043403]**
D(CD6M(-3))	**0.064034**	0.106668 **[0.600315]**	**0.110431**	0.107292 **[1.029255]**
DUMMY 1	***1.010607**	0.072433 **[13.95235]**	***0.230137**	0.053209 **[4.325162]**
DUMMY 2	***2.516615**	0.088044 **[28.58363]**	***2.191744**	0.092898 **[23.59311]**
R - Squared	**0.675846**		**0.673675**	
Adjusted R - Squared	**0.665911**		**0.663673**	

***Significant at level 5%.**

Table 4.11: ***Granger Causality Results – Whole Sample Period With Dummy Variables***

Dependent Variables	Short-Run Effects		Long-Run Effects (Weak Exogeneity)	Strong Exogeneity (ECT&Explanatory Variables)	
	D(CD3M) $A_1 = A_2 = A_3 = 0$	D(CD6M) $B_1 = B_2 = B_3 = 0$	ECT Only (Wald Test)	$\alpha_{CD6M} = A_1 = A_2 = A_3 = 0$	$\alpha_{CD3M} = B_1 = B_2 = B_3 = 0$
	WALD F-STATISTICS (P-VALUE)		F-STATISTIC ($P - VALUE$) OF $\alpha_{CD3M} = 0$ & $\alpha_{CD6M} = 0$	WALD F-STATISTICS (P-VALUE)	
D(CD3m)	–	1.940 (0.1234)	*22.452 (0.0000)	–	*8.128 (0.0000)
D(CD6m)**	*7.756 (0.0001)	–	*5.948 (0.0154)	*6.206 (0.0001)	–

***Significance at level 5%.**

****The joint Wald F-statistic under Strong Exogeneity test indicates significance at level 5%. However the coefficient of the ECT (i.e. α(CD6M)) in the unrestricted ECM has the wrong sign (i.e. α(CD6M) equals - 0.092332).**

THE INFORMATION CONTENT OF THE SHORT END OF THE TERM STRUCTURE OF INTEREST RATES AND THE INFLATION RATE: EMPIRICAL EVIDENCE FOR JORDAN.

5.1 *INTRODUCTION*

The relationship between the term structure of interest rates and macroeconomic variables has been at the centre of interest for many researchers because of its important implications. A large body of the empirical literature focuses on examining whether the term structure of interest rates contains useful and reliable information about output growth and inflation; that is, whether it establishes the predictive power of the term structure.

In this chapter our main goal is to provide empirical evidence about the information contents of the short end of the term structure in Jordan through examining the relationship between the term structure and the inflation rate. The motivation behind our attempt to test this relationship is due to the fact that we found robust evidence that the Expectations Hypothesis (EH) holds for part of the term structure of interest rates in the previous chapter and this is an indication that part of the term structure has some predictive power. We believe that the findings of this chapter will shed some light on the information that is contained in the short end of the term structure of interest rate in Jordan maybe for the first time.

We concentrate on the inflation rate because of the availability of the data; i.e. the CPI monthly observations are available. The monthly frequency is preferable in our case because we are interested in studying the dynamic relationship between our variables. Regarding the interest rate data set, we use the interest rate on one of our main instruments in the money market that is issued regularly in the primary market, the Central Bank of Jordan Certificates of Deposits (CDs). Although it is a primary market rate, it is determined fully by the market players so it reflects the market's expectations about future economic activity. We are aware that the primary market yields are policy induced; therefore in most of the studies they prefer to use the secondary market interest rates and particularly the interest rates on Government securities; i.e. risk free rate. However, in our case, the secondary market for Government securities in Jordan is very thin and there are no regular issues in the primary market. Due to data limitation we are forced to use the only two available maturities of CDs' interest rates; the three and six months, hence our concentration will be on the short end of the term structure of interest rates.

The first step in our investigation is to test the validity of the Fisher hypothesis. We believe that if the empirical evidence confirms the existence of the Fisher effect then this will be considered as an indication that the movement in short term nominal interest rates is the reflection of the movement in the expected inflation; that is, the short term nominal interest rates have the ability to predict the inflation rate (Mishkin 1992). The next step is to investigate the information contents of the entire term structure; therefore, we investigate the dynamic relationship between the domestic term spread and the inflation rate. We focus mainly on the long run equilibrium relationship and on the causality relationship between the variables particularly the short run effect, the long run effect (weak exogeneity) and the total causality effect (strong exogeneity).

For the empirical testing we employ cointegration analysis based on the Johansen approach as our main tool to identify the long run equilibrium relationship. Then we employ the Error Correction Model (ECM) to test for Granger Causality. Finally we employ impulse response and variance decomposition analysis to examine the stability of the cointegrated systems and to identify the contribution of each explanatory variable on the variance fluctuations of the dependent variables particularly the inflation rate.

Moreover, we extend our investigation and examine other relationships such as whether the US term spread contains useful information about the Jordanian inflation rate. Our analysis is based on the fact that the exchange rate regime in Jordan has been pegged to the US dollars since 1995, so it is expected that there is a linkage between the two terms' structure of interest rates; the Jordanian rate and the US rate. We follow Mehl's (2006) approach where he examined in depth the ability of foreign yield curve to predict the domestic economic variables for many emerging economies such as Brazil, the Czech Republic, Hong Kong, Hungary, India, Korea, Malaysia, Mexico, the Philippines, Poland, Saudi Arabia, Singapore, South Africa and Taiwan, and provides robust evidence that in some emerging economies that have exchange regime pegged to US Dollars, the US yield curve plays a role in predicting the domestic inflation.

Moreover, it is known that the monetary policy stance (i.e. tightening or easing) has an influence on the shape of the term structure of interest rate and accordingly the term spread; hence it is believed that part of the predictive power of the term spread is due to the monetary policy. Economists like Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Estrella and Mishkin (1997), Dotsey (1998), Ghazali and Low (1999) and Hamilton and Kim (2002) examine whether the term spread contains information that is not explained by monetary policy variables; accordingly, they include additional variables that reflect the monetary policy in their analyses and test if the term spread remains significant even with the inclusion of additional variables. In this chapter we follow the same approach and test the influence of an additional variable that reflects the monetary policy on the predictability of the domestic term spread. We use the Repo rate which is one of the key interest rates that is determined directly by the Central Bank of Jordan and normally reflects the monetary policy stance.

We believe that the main contribution of this chapter is to provide empirical evidence about the information contents of the short end of the term structure in Jordan for the first time through investigating the predictive power of both the short term nominal interest rates in levels and the term spread. The existence of the long run equilibrium relationship and the causality relationship between the main variables is clear evident about the effectiveness of the information contents of the term structure.

This chapter is organised as follows: Section two describes in detail the properties of our data set; section three discusses the unit root test, the main methodology that has been used for testing the long run relationship between the main variables which is the cointegration analysis using the Johansen approach and the Granger Causality analysis using the Error Correction Model (ECM); section four discusses the main empirical results of the unit root test including the Monte Carlo Analysis, the cointegration analysis and the Granger Causality test; section five discusses the Impulse Response Function and Variance Decomposition; and section six presents the conclusion.

5.2 *THE DATA*

We use the interest rate of the auctioned CDs and we concentrate on two main maturities; the three and the six months[1]. We also use the Consumer Price index (CPI)[2] to calculate the inflation rate. The frequency of the Consumer Price Index (CPI) is monthly, while the frequency of the CDs' interest rates data is bi-weekly; therefore we use the end of the month observations for the CDs' interest rates so the frequency of all data sets becomes monthly. Regarding the inflation rate we use the annualised monthly inflation rate which is calculated as the first difference of the natural logarithm of the (CPI):

$$\pi_{t+h} = \left(\frac{1200}{h}\right) * \quad (\ln(CPI_{t+h}) - \ln(CPI_t)) \ ,$$

Where (π_{t+h}) represents the annualised monthly inflation rate and (h) represents the horizon of one month. The data set covers the period from June 1997 to December 2007 which makes the total number of monthly observations equal to 127.

[1] The full details of the CDs interest rates are described in chapter four.

[2] The CPI data are obtained from two resources: Department of Statistics,Jordan and the Central Bank of Jordan.

Regarding the US data we use the discount yield on US Treasury Bills that are traded in the Secondary Market[3], in particular the monthly discount yield on the three and six month US Treasury Bills. The data set covers the same period as above, so the number of observations equals 127.

We are also interested in testing whether the Central Bank of Jordan (CBJ) key interest rates have any impact on the inflation rate prediction process. Hence, we choose the weekly Repo rate because of the availability of the data through the whole sample period. The Repo facility is used at the initiative of banks so banks which seek temporary liquidity can utilize this facility as the last resort. The Repo rate is the price that banks pay to obtain the required liquidity and it is a penalty rate so it represents the ceiling for the CBJ key interest rates. We use the end of the month observations so the total number of observations equals 127.

5.3 *THE METHODOLOGY*

5.3.1 UNIT ROOT TEST

Determining the order of integration of the CDs' interest rate in levels, the domestic term spread, the US term spread, the inflation rate and the Repo rate is the first and most significant step before implementing any empirical testing.

[3] The discount yield on US Treasury Bills is the annualised rate of return based on the par value of the bills and is calculated on a 360 day basis. The data are obtained from the Federal Reserve Statistical Release / http://www.federalreserve.gov/releases/h15/data.htm

To identify the order of the integration we employ the Augmented Dickey Fuller (ADF) unit root test (Dickey and Fuller (1979, 1981) and the Phillips-Perron test (PP)[4]. We employ two models for the CDs' interest rate, the two term spreads and the Repo rate; the model with constant and the model with constant and trend as exogenous variables. For the first differences we employ the model with no constant or trend (i.e. Exogenous=None). Regarding the inflation rate[5], we employ the model with constant as exogenous variable and the model with no constant or trend (i.e. Exogenous=None).

5.3.2 *THE COINTEGRATION ANALYSIS*

Our main goal is to investigate whether there is a long run relationship between our variables. We believe that the existence of the long run equilibrium relationship provides strong support for the predictability of the term structure of interest rates.

In order to identify the long run relationship we perform a cointegration test based on Johansen's (1988) and Johansen and Juselius' (1990) approaches. In this chapter we will use the Johansen approach to perform both the bivariate and the multivariate cointegration analysis[6].

[4] For full description of the ADF and PP models, please see chapter three section 3.4.

[5] The Inflation rate is the first difference of CPI; therefore we exclude the trend from the unit root test.

[6] Please see chapter three section 3.3.3 for full details about the cointegration analysis. The full details include the procedures and tests that are applied before performing the cointegration analysis, the full description of the framework of the unrestricted VAR model, the derived error correction model (ECM) and the two likelihood ratio tests which are proposed by Johansen and Juselius (1990) to determine the number of cointegrating relationships among the variables.

The sample period covers almost 10 years, from 21 June 1997 to 31 December 2007, and the frequency of the data is monthly so we end up with 127 observations. We believe that the sample period is large enough and it will permit us to capture the real behaviour of the targeted variables, mainly the long run relationship.

Since we are interested in testing the long run relationship among different variables, then X_t[7] will be a vector of different dimensions as follows:

5.3.2.1: *THE VALIDITY OF THE FISHER HYPOTHESIS (FH)*

The first cointegration analyses are designed to test the validity of Fisher Hypothesis (FH) and they consist of two bivariate analysis. The first one examines whether there is a long run relationship between the three month interest rate and the inflation rate and the second examines whether there is such a relationship between the six month interest rate and the inflation rate. The existence of the cointegrating vector under each bivariate case $[1, -\beta]$ will enable us to test the validity of the FH through imposing restrictions on the cointegrating vector in the following form $[1, -1]$. The non rejection of the restrictions will indicate that the strong form of the Fisher effect holds and this means that nominal interest rate moves one-to-one with the inflation rate and the real interest rate is stationary. The two bivariate cointegration analyses will be performed in the following forms:

[7] The definition of X_t is described in chapter three section 3.3.3.

A: The first bivariate cointegration analysis is between the three month interest rate (CD3M) and the inflation rate (INFRATE). Accordingly X_t will be a vector of dimension (2 x 1):

$$X_t = \begin{bmatrix} CD3M \\ INFRATE \end{bmatrix}$$

B**:** The second bivariate cointegration analysis is between the six month interest rate (CD6M) and the inflation rate (INFRATE). Accordingly X_t will be a vector of dimension (2 x 1):

$$X_t = \begin{bmatrix} CD6M \\ INFRATE \end{bmatrix}$$

5.3.2.2: THE BIVARIATE COINTEGRATION ANALYSES BETWEEN EACH OF THE TWO TERM SPREADS (THE DOMESTIC AND THE US) AND THE MONTHLY INFLATION RATE

The second cointegration analyses examine whether there is a long run relationship between each term spread; i.e. the domestic and the US, and the inflation rate. We are dealing in this section with the level of inflation rate and not with the changes of inflation rate; therefore we will not use the "inflation change equation"[8] that has been used in most of the studies that examine the ability of the term spread to predict and forecast the changes of inflation rate. The main reason behind adapting a different

[8] For more details about the “Inflation change equation”, please see chapter two section 2.6.3.

methodology to the one used in the literature is due to the properties of the variables under investigation. For instance in our case the two term spreads appear to be non stationary while in the studies that use the "inflation change equation", it is assumed that the order of integration for all the involved variables is stationary, otherwise they will have a spurious regression. We may consider that the chosen method which is the unrestricted (VAR) in our case is the general form that describes the relationship between each term spread and the inflation rate in levels while the "inflation change equation" is the specific form. We perform two cointegration analyses using the following forms:

A: The first bivariate cointegration analysis is between the domestic term spread (JORSPD) and the inflation rate (INFRATE). Accordingly X_t will be a vector of dimension (2 x 1):

$$X_t = \begin{bmatrix} JORSPD \\ INFRATE \end{bmatrix}$$

B**:** The second bivariate cointegration analysis is between the US term spread (USTBSPD) and the inflation rate (INFRATE). Accordingly X_t will be a vector of dimension (2 x 1):

$$X_t = \begin{bmatrix} USTBSPD \\ INFRATE \end{bmatrix}$$

5.3.2.3: THE MULTIVARIATE COINTEGRATION ANALYSIS BETWEEN THE DOMESTIC TERM SPREAD, THE MONTHLY INFLATION AND THE REPO

The last cointegration analysis is a multivariate one and it is performed to identify the influence of the Repo rate which is a monetary policy variable on the predictability of the domestic term spread. Accordingly X_t will be a vector of dimension (3 x 1):

$$X_t = \begin{bmatrix} JORSPD \\ INFRATE \\ REPO \end{bmatrix}$$

5.3.3 GRANGER CAUSALITY TEST AND THE ERROR CORRECTION MODEL (ECM)

According to Granger (1986, 1988), the existence of cointegration among variables indicates that there is a long run relationship among them; that is they share a common trend, and as a result causality must exist at least in one direction. We test for causality assuming we have cointegration between the targeted variables[9].

We apply the advanced test of Granger Causality following most of the economists in the recent literature. We use the Error Correction Model (ECM) to test the causality effect and to identify which of the variables plays the role of the attractor or whether all variables are adjusting towards each other.

[9] See Mosconi and Giannine (1992).

The ECM representation shows that the changes of the dependent variables are a function of two key parts: the first part is the sum of the changes of the lagged explanatory variables and the sum of the changes of the lagged dependent variable and the second part is the Error Correction Term (ECT). It is agreed by analysts that the Error Correction Term (ECT) adds another dimension for testing the causality which is the long run causality. Accordingly the ECM framework allows analysts to test for short and long run causality effects.

Testing the short run causality is usually done through imposing restrictions on the sum of the lagged explanatory dynamic variables, while testing for the long run effect is done through imposing restrictions on the coefficient of ECT which is called the speed of adjustment. The sign and the magnitude of the coefficient of the ECT are used as indication of the direction of causality (Masih and Masih, 1996; Islam and Ahmed, 1999). In general, the long run causality test leads to the identification of the direction of Granger Causality (i.e. unidirectional or bidirectional) which is considered important for economists and policy designers. We perform the causality tests using the ECM in the following forms:

5.3.3.1: *THE ERROR CORRECTION MODELS (THE TWO SHORT TERM INTEREST RATES AND THE INFLATION RATE)*

The following error correction models will be used for testing the causality relationship between the two short term interest rates and the inflation rate if and only if the following two main conditions are met; there is a long run relationship between each short term nominal interest rate and the inflation rate and the validity of the Fisher hypothesis holds. The derived ECM will take the following forms in case the main conditions are met:

A: The ECM that is derived from the bivariate cointegration test between the three month interest rate and the inflation rate.

$$D(CD3M)_t = \sum_{i=1}^{k-1} \mathrm{A}_i \; D(CD3M)_{t-i} + \sum_{i=1}^{k-1} \mathrm{B}_i \; D(INFRATE)_{t-i} + \alpha_{CD3M}\, \mathrm{ECT}_{t-1} + \mu_{1t}$$

Eq.5.3.3.1

$$D(INFRATE)_t = \sum_{i=1}^{k-1} a_i \; D(CD3M)_{t-i} + \sum_{i=1}^{k-1} b_i \; D(INFRATE)_{t-i} + \alpha_{INFRATE}\, \mathrm{ECT}_{t-1} + \mu_{2t}$$

Eq.5.3.3.2

Where

CD3M = the three month interest rate.

INFRATE = the Jordanian inflation rate (Horizon = 1m).

D = the difference operators.

ECT_{t-1} = the Error Correction Term = (CD3M + (β_{21} β_{11})INFRATE + π) where π is the constant in the cointegrating vector.

α_{CD3M} = the speed of adjustment in the D(CD3M) equation.

$\alpha_{INFRATE}$ = the speed of adjustment in the D(INFRATE) equation.

μ_{1t} and μ_{2t} = the error terms that are assumed to satisfy the Gaussian assumption.

B**:** The ECM that is derived from the bivariate cointegration test between the six month interest rate and the inflation rate.

$$D(CD6M)_t \quad = \sum_{i=1}^{k-1} \mathrm{A}_i \;\; D(CD6M)_{t-i} + \sum_{i=1}^{k-1} \mathrm{B}_i \;\; D(INFRATE)_{t-i} + \alpha_{CD6M}\,\mathrm{ECT}_{t-1} + \mu_{1t}$$

Eq.5.3.3.3

$$D(INFRATE)_t = \sum_{i=1}^{k-1} a_i \;\; D(CD6M)_{t-i} + \sum_{i=1}^{k-1} b_i \;\; D(INFRATE)_{t-i} + \alpha_{INFRATE}\,\mathrm{ECT}_{t-1} + \mu_{2t}$$

Eq.5.3.3.4

Where

CD6M = the six month interest rate.

INFRATE = the Jordanian inflation rate (Horizon = 1m).

D = the difference operators.

ECT_{t-1} = the Error Correction Term = (CD6M + (β_{21} β_{11})INFRATE + π) where

π is the constant in the cointegrating vector.

α_{CD6M} = the speed of adjustment in the D(CD6M) equation.

$\alpha_{INFRATE}$ = the speed of adjustment in the D(INFRATE) equation.

μ_{1t} and μ_{2t} = the error terms that are assumed to satisfy the Gaussian assumption.

5.3.3.2: *THE ERROR CORRECTION MODELS (THE TWO TERM SPREADS AND THE INFLATION RATE)*

The second error correction models will be derived from the cointegration analyses between the two term spreads, i.e. the domestic and the US, and the inflation rate. The derived ECM will take the following forms:

A: The ECM that is derived from the bivariate cointegration test between the domestic term spread and the inflation rate.

$$D(JORSPD)_t = \sum_{i=1}^{k-1} \mathrm{A}_i \;\; D(JORSPD)_{t-i} + \sum_{i=1}^{k-1} \mathrm{B}_i \;\; D(INFRATE\,)_{t-i} + \alpha_{JORSPD}\,\mathrm{ECT}_{t-1} + \mu_{1t}$$

Eq.5.3.3.5

$$D(INFRATE\,)_t = \sum_{i=1}^{k-1} a_i \;\; D(JORSPD)_{t-i} + \sum_{i=1}^{k-1} b_i \;\; D(INFRATE\,)_{t-i} + \alpha_{INFRATE}\,\mathrm{ECT}_{t-1} + \mu_{2t}$$

Eq.5.3.3.6

Where

JORSPD = the domestic term spread.

INFRATE= the Jordanian inflation rate (Horizon = 1m).

D = the difference operators.

ECT_{t-1} = the Error Correction Term = (JORSPD + (β_{21} β_{11})INFRATE + π) where π is the constant in the cointegrating vector.

α_{JORSPD} = the speed of adjustment in the D(JORSPD) equation.

$\alpha_{INFRATE}$ = the speed of adjustment in the D(INFRATE) equation.

μ_{1t} and μ_{2t} = the error terms that are assumed to satisfy the Gaussian assumption.

B**:** The ECM that is derived from the bivariate cointegration test between the US term spread and the inflation rate.

$$D(USTBSPD)_t = \sum_{i=1}^{k-1} \mathrm{A}_i \;\; D(USTBSPD)_{t-i} + \sum_{i=1}^{k-1} \mathrm{B}_i \;\; D(INFRATE\,)_{t-i} + \alpha_{USTBSPD}\,\mathrm{ECT}_{t-1} + \mu_{1t}$$

Eq.5.3.3.7

$$D(INFRATE)_t = \sum_{i=1}^{k-1} a_i \ D(USTBSPD)_{t-i} + \sum_{i=1}^{k-1} b_i \ D(INFRATE)_{t-i} + \alpha_{INFRATE}\,\mathrm{ECT}_{t-1} + \mu_{2t}$$

Eq.5.3.3.8

Where

USTBSPD= the US term spread.

INFRATE= the Jordanian inflation rate (Horizon = 1m).

D = the difference operators.

ECT_{t-1} = the Error Correction Term = (USTBSPD + (β_{21} β_{11})INFRATE + π) where π is the constant in the cointegrating vector.

$\alpha_{USTBSPD}$ = the speed of adjustment in the D(USTBSPD) equation.

$\alpha_{INFRATE}$ = the speed of adjustment in the D(INFRATE) equation.

μ_{1t} and μ_{2t}= the error terms that are assumed to satisfy the Gaussian assumption.

5.3.3.3: THE ERROR CORRECTION MODEL (THE DOMESTIC TERM SPREAD, THE INFLATION RATE AND THE REPO RATE)

The third ECM model is derived from the cointegration analysis between the domestic term spread (JORSPD), the inflation rate (INFRATE) and the Repo rate (REPO). The derived ECM will take the following form:

$$D(JORSPD)_t = \sum_{i=1}^{k-1} A_i \ D(JORSPD)_{t-i} + \sum_{i=1}^{k-1} \mathrm{B}_i \ D(INFRATE)_{t-i} + \sum_{i=1}^{k-1} C_i \ D(REPO)_{t-i} + \alpha 1_{JORSPD}\,\mathrm{ECT1}_{t-1} + \alpha 2_{JORSPD}\,\mathrm{ECT2}_{t-1} + \mu_{1t}$$

Eq.5.3.3.9

$$D(INFRATE)_t = \sum_{i=1}^{k-1} a_i \ D(JORSPD)_{t-i} + \sum_{i=1}^{k-1} b_i \ D(INFRATE)_{t-i} + \sum_{i=1}^{k-1} c_i \ D(REPO)_{t-i} +$$

$$\alpha 1_{INFRATE}\,\mathrm{ECT1}_{t-1} + \alpha 2_{INFRATE}\,\mathrm{ECT2}_{t-1} + \mu_{2t}$$

Eq.5.3.3.10

$$D(REPO)_t = \sum_{i=1}^{k-1} \hat{a}_i \ D(JORSPD)_{t-i} + \sum_{i=1}^{k-1} \hat{b}_i \ D(INFRATE)_{t-i} + \sum_{i=1}^{k-1} \hat{c}_i \ D(REPO)_{t-i} +$$

$$\alpha 1_{REPO}\,\mathrm{ECT1}_{t-1} + \alpha 2_{REPO}\,\mathrm{ECT2}_{t-1} + \mu_{3t}$$

Eq.5.3.3.11

Where

JORSPD = the domestic term spread.

INFRATE = the Jordanian inflation rate (Horizon = 1m).

REPO = the Repo rate.

D = the difference operators.

$\mathrm{ECT1}_{t-1}$ = the first Error Correction Term.

$\mathrm{ECT2}_{t-1}$ = the second Error Correction Term.

$\alpha 1_{JORSPD}$ and $\alpha 2_{JORSPD}$ = the speeds of adjustment in the D(JORSPD) equation.

$\alpha 1_{INFRATE}$ and $\alpha 2_{INFRATE}$ = the speeds of adjustment in the D(INFRATE) equation.

$\alpha 1_{REPO}$ and $\alpha 2_{REPO}$ = the speeds of adjustment in the D(REPO) equation.

μ_{1t}, μ_{2t} and μ_{3t} = the error terms that are assumed to satisfy the Gaussian assumption.

We use the derived ECM to perform the following three causality tests following the approach that was employed by Masih and Masih (1996), Asafu-adjaye (2000), Hondroyiannis and Papapetrou (2000), Hondroyiannis, Lolos and Papapetrou (2005), and Ang. and McKibbin (2007) :

-Weak exogeneity: Testing the weak exogeneity is the same as saying testing the long run non causality effects. This test can be implemented either by using the restricted ECM that is derived from the Johansen cointegration analysis which is based on the likelihood ratio test and follows a Chi-square distribution (Asafu-adjaye, 2000) or by using the Wald F-test. We test the significance of the speeds of adjustment α; i.e. the coefficients of the error correction term (ECT), by testing the null hypothesis $H_0: \alpha = 0$.

- The short run non causality effects: Testing the short run effects is the same as saying testing the significance of the sum of the changes of the lagged explanatory variables. We test the significance using the joint Wald F-test.

-Strong exogeneity: We impose stronger restrictions by testing the joint Wald F-test of both the coefficients of ECT and the explanatory variables; i.e. the lagged dynamic terms. This test does not distinguish between the short and long run causality effects. It is more restrictive and indicates the overall causality in the system. The non-significance of all explanatory variables including ECT indicates the absence of Granger Causality (Ang. and McKibbin 2007). According to Hondroyiannis, Lolos and Papapetrou (2005: p 179), “A variable is defined as strongly exogenous when it is weakly exogenous and it is not affected by any of the endogenous variables in the system".

5.4 THE EMPIRICAL RESULTS

5.4.1 UNIT ROOT TEST

5.4.1.1 : CERTIFICATES OF DEPOSITS INTEREST RATES, US TREASURY BILLS DISCOUNT YIELD AND THE REPO RATE

The results of the ADF test (AIC and SIC) which are reported in tables 5.1.1 and 5.1.2 clearly show that we cannot reject the null hypothesis of non stationarity at all significance levels (1%, 5%, and 10%). Accordingly the CDs' interest rate, the US Treasury Bills discount yield and the Repo rate appear to be integrated of order one I(1). Moreover the results of the first difference show clearly that we reject the null hypothesis of non stationarity at all significance levels (1%, 5% and 10%), so all the above variables are integrated of order I(0) in their first differences. The results of the PP unit root test in table 5.2 confirm ADF results.

5.4.1.2: THE DOMESTIC TERM SPREAD AND THE US TERM SPREAD

The results of the unit root test for the domestic term spread are shown in tables 5.3.1 and 5.3.2. The domestic term spread appears to be integrated of order one I(1) in level and I(0) in first difference under ADF test. While under (PP) test it appears to be I(0), results are shown in table 5.4. To verify the real truth about the order of integration of the domestic term spread, we make smoothing for the CDs' interest rates (both the three and the six month) by calculating the monthly average of the bi-weekly observations and then calculate the term spread using the smooth monthly interest rates.

The results of the unit root test for the smooth CDs' interest rate are reported in tables 5.1.1, 5.1.2 and 5.2 respectively. Both unit root tests (ADF and PP) indicate that the smooth CDs' interest rates are I(1) in levels and I(0) in first differences which comply with the original results. Moreover, the smooth domestic term spread appears to be I(1) in level under both ADF and PP tests, these results are shown in tables 5.3.1 , 5.3.2 and 5.4 respectively, and these results comply with ADF original unit root results. Moreover, to verify the non stationarity of the domestic term spread series we use an additional tool which is the spectrum analysis.

The idea of the typical shape of the spectrum for economic variables in levels was introduced for the first time by Granger in his 1966 seminal paper. Granger argued that if the long run fluctuation in economic variables is decomposed into frequencies then the spectral power concentration will be higher at low frequency; after that it declines smoothly and exponentially as the frequency increases.

Granger declared that most of the economic variables follow the typical spectral shape because they contain main trend in mean and this trend raises the value of the spectrum power at low frequency[10]. According to Granger and Morgenstern (1964, p. 91)[11] "The existence of a trend in mean is only one way in which a time-series can show its non-stationary character". In view of that, if the spectrum of any economic time series

[10] Nelson and Plosser in their influential 1982 paper study the unit root properties of many macroeconomic variables and provide evidence suggesting that most of the macroeconomic variables contain unit root. Although their study covers only the US macroeconomic variables, it plays a major role in motivating the research in the area of the properties of macroeconomics variable.

[11] The paper of Granger and Morgenstern (1964) is within the Essays in Econometrics (collected papers of Clive W. J. Granger) Volume 1: Spectral Analysis, Seasonality, Nonlinearity, Methodology, and Forecasting.

follows closely the typical spectral shape, then this can be considered clear evidence about the non stationarity of the time series.

Given the above facts, the spectrum shape of the domestic term spread is used as an indicative tool to confirm the non stationarity of the series. The spectrum of the domestic term spread as shown in figure 5.1 evidently follows the typical spectral shape where the spectral power concentrates at low frequency, then declines smoothly at higher frequency, so this suggests that the domestic term spread is a non stationary series. Based on the smoothing procedure results and the spectrum analysis we consider the domestic term spread to be I(1).

Regarding the US term spread, the results of ADF test in tables 5.3.1 and 5.3.2 show that under the model with constant the US spread is I(1) at 1% significance level while under the model with constant and trend, the spread is I(1) at 5% significance level. For the first difference the results show clearly the order of integration is I(0). Moreover, the results under PP test, as shown in table 5.4, are different from the results under the ADF test where the US term spread appears to be I(0) under the model with constant and I(1) at 1% significance level under the model with constant and trend. Regarding the first difference the results indicate the order of integration to be I(0).

The contradiction in the results of the US term spread motivates us to undertake further investigation in order to verify the true order of the integration. Given that the US interest rates are monthly averages of the daily observations so they are already smoothed rates, hence we employ another tool to confirm the real order of integration which is fractional integration analysis. The fractional integration analysis enables us to define whether the US term spread has long memory or short memory. We use the ARFIMA (p,d,q) model to identify the fractional integration and the main task here is to define the value of the parameter (d) because this value determines whether the series has short or long memory. The ARFIMA model as described in the literature takes the following form (Box-Steffensmeier and Tomlinson 2000):

$$\varphi(L)(1-L)^d x_t = \Theta(L)\ \varepsilon_t$$

Where

d is a real number.

ε_t is an error term with zero mean and variance σ^2.

$\varphi(L)$ is the Lags under AR component.

$\Theta(L)$ is the Lags under MA component

In this model there are three main parameters (p,d,q). The parameter (p) refers to the number of the lags in the autoregressive (AR) portion of the series, the parameter (q) refers to the number of the lags in the moving average (MA) portion of the series and the parameter (d) refers to the integration of the series, and it also determines the persistence of the series. The parameter (d) can take any value between zero and one. So if d=1 then the series is integrated (non stationary) and if d=0 then it is stationary. However if (d) value occurs between zero and one (0<d<1), then the series is considered fractionally integrated. According to the literature, the fractionally integrated series can be defined as stationary but has long memory if 0 < d< 0.5, and non stationary with long memory if 0.5 < d< 1. Both are mean reverting and the variance is finite when (0 < d< 0.5) and infinite when (0.5 < d< 1).

We estimate the ARFIMA for the US term spread in order to define the value of (d) using different lags for p and q, although we believe that the optimal lags is zero for both AR and MA lags. The estimated value of (d) equals 0.5 as shown in table 5.5; accordingly, the US term spread series can be considered a long memory series. Moreover, we use the spectrum analysis to verify the non stationarity of the US term spread series following the same procedure that has been used previously in the case of the domestic term spread.

The spectrum of the US term spread as shown in figure 5.2 also follows the typical spectral shape where the spectral power concentrate at low frequency then it declines smoothly at higher frequency, so this suggests that the US term spread is a non stationary series. Based on the ARFIMA model and the spectrum analysis we consider the US term spread to be I(1).

5.4.1.3: THE INFLATION RATE

Regarding the inflation series, we show in figure 5.3 the monthly inflation rate in Jordan for the period from 1997 to 2007 and in figure 5.4 the shape of the spectrum of the inflation series. The spectrum which is used as an initial diagnostic procedure suggests that the inflation series can be considered as a non stationary process, although the shape of the spectrum is slightly different from the typical shape. It is obvious that the concentration of the spectral power is high at low frequency but it is also spreading over a range of frequencies.

Economists such as Levy and Dezhbakhsh (2003) examined the shape of the spectrum for the output levels in developing countries and they attribute the slight difference in the shape of the spectrum to the low quality of the data; that is the data contain noise within, and to the fact that the fluctuation in the output variables mainly comes from short term components instead of long term (according to Granger 1966). In our case we believe that the main reason behind the spectral density shape is the low quality of the inflation data.

Moreover, the ADF unit root results in tables 5.3.1 and 5.3.2 suggest that the inflation series of horizon one month in level is stationary I(0) under the model with constant, it is non stationary I(1) under the model with no constant and no trend (none), and it is stationary I(0) in its first difference. In addition, under the PP test it appears to be stationary I(0) in both level and first difference. In order to verify the robustness of the unit root results, we proceed to define the inflation rate over a 12 month period[12], shown in figure 5.5, and this clearly appears non stationary: indeed, as tables 5.3.1, 5.3.2 and 5.4 show, the ADF and PP tests strongly suggest non stationarity. Of course ADF's two tests results (the inflation over one month and the inflation over 12 month) clearly contradict one another as:

$$\pi_t^{12} = P_t - P_{t-12} = (P_t - P_{t-1}) + (P_{t-1} - P_{t-2}) + ... + (P_{t-11} - P_{t-12}) = \pi_t^{1} + \pi^{1}{}_{t-1} + ... + \pi^{1}{}_{t-11}$$

12 $\pi_{t+12} = 100 * [\ \ln(CPI_{t+12}) - \ln(CPI_t)\ ]$

where $\pi^{j}{}_{t}$ is the rate of inflation at time (t) over (j) periods. So if monthly inflation is stationary then annual inflation which is simply the sum of monthly inflation must also be stationary. We believe that the explanation for this contradiction lies in the presence of measurement error. This is evident in figure 5.3 as we can clearly see here that many months exhibited negative inflation; this is not a phenomenon which is observed by Jordanians and hence it would seem to be a problem with the actual measurement of the price level.

If this is the case then we can also show why taking a longer period for the inflation calculation would give a more meaningful test statistic. We begin by assuming that the true price level in logs is a random walk.

$$P_t^* = P_{t-1}^* + \varepsilon_t \qquad \text{Eq 5.4.1.3.1}$$

But the observed log of the price level is subject to measurement error

$$P_t = P_t^* + \nu_t \qquad \text{Eq 5.4.1.3.2}$$

Where both ε_t and ν_t are IID noise processes and observed inflation is given by

$$\pi_t^j = P_t - P_{t-j} \qquad \text{Eq 5.4.1.3.3}$$

Now the monthly inflation rate can be written in the following form:

$$\pi^{1}{}_{t} = P_t - P_{t-1}$$

$$\pi^{1}{}_{t} = P^{*}{}_{t-1} + \varepsilon_t + v_t - (P^{*}_{t-1} + v_{t-1})$$

$$\pi^{1}{}_{t} = \varepsilon_t + v_t - v_{t-1} \qquad \text{Eq 5.4.1.3.4}$$

and hence the variance will equal

$$\text{var}(\pi^{1}_{t}) = \sigma^{2}_{\varepsilon} + 2\sigma^{2}_{v} \qquad \text{Eq 5.4.1.3.5}$$

Assuming that correlation between the noises equals zero

$\rho(v_t, v_{t-i}, \varepsilon_t) = 0$

Where i=1, 2,…, j.

Moreover the yearly inflation rate can be written as:

$$\pi^{12}_{t} = \varepsilon_t + \varepsilon_{t-1} + \varepsilon_{t-2} + \ldots + \varepsilon_{t-11} + v_t - v_{t-12} \qquad \text{Eq 5.4.1.3.6}$$

and hence the variance equals:

$$\text{var}(\pi^{12}_{t}) = 12\sigma^{2}_{\varepsilon} + 2\sigma^{2}_{v} \qquad \text{Eq 5.4.1.3.7}$$

Assuming that correlation between the noises equals zero

$\rho(v_t, v_{t-i}, \varepsilon_t, \varepsilon_{t-i}) = 0$

Where i=1, 2,…, j -1,,j.

It is now evident that by measuring inflation over a longer period the size of the random walk variance grows relative to the size of the measurement error and hence measurement error has less effect on measured inflation. The existence of the measurement error provides strong evidence that the shape of the spectral density of the inflation series comes from the low quality of the inflation data; that is the inflation data series contains noises within. To examine the influence of the noisy data on the size distortion and the empirical power of the DF test more completely, we now turn to a formal Monte Carlo Simulation.

5.4.1.3.1 *MONTE CARLO ANALYSIS*

Various unit root tests have been employed in the empirical work to identify the order of integration of economic variables. So far the DF test remains the most famous one. A substantial body of research examines the main characteristics of the DF test and particularly its main shortcomings such as low power, large size distortion and sensitivity to the true data generating process (DGP). Diebold and Rudebusch (1989a, 1991) and DeJong et al. (1992) examine the power of the DF test when the process has short memory with a unit root close to unity and provide strong evidence that the DF test has low power when the process is fractionally integrated.

The size distortion of the DF test is also examined heavily in the literature. Perron (1989), Hamori and Tokihisa (1997), Montañés and Reyes (1998), Leybourne and Newbold (2000), Sen (2001, 2003, 2008) and Kim, Leybourne and Newbold (2004) examine the behaviour of the DF test in the case of structural breaks. Cheung and Lai (1998), and Cook and Manning (2004) examine the influence of the lag selection process using standard information criteria on the size distortion of the ADF test. Granger and Hallman (1991) and Kramer and Davies (2002) examine the robustness of the DF test in the case of improper transformations of the data. Phillips and Perron (1988), Schwert (1989) and Agiakloglou and Newbold (1992) analyse the performance of the DF test when the process that generates the time series contains moving average term. Perron and Ng (1996, 2001) examine the influence of negative moving average errors and the lag selection process on the size distortion of the unit root test[13]. Elliott, Rothenberg and Stock (1996) examine the size distortion of the DF test when the series has an unknown mean or linear trend using different generating processes. The main findings for all these studies show that the distribution of the unit root test statistics is different from the distribution proposed by Dickey Fuller. Accordingly a severe size distortion occurs and the power of the DF test becomes questionable.

In this section, we examine the performance of the DF test when the process that generates the time series contains noise. The main focus will be on the size distortion of the DF test as the noise increases in the data.

5.4.1.3.2 *MONTE CARLO ANALYSIS/EXPERIMENT DESIGN*

The Monte Carlo experiment begins with the Data Generating Process. The steps of data generating are as follows:

[13] They test the size distortion of the Phillips-Perron test and argue that although the Dickey Fuller test is more accurate, the problem of size distortion is not negligible.

Step one: Generate a data set using the simplest model of time series which is a non-stationary normal random walk. So the first data set (x_t) is a random walk process without a drift and it is generated by an AR (1) model of the form:

$$x_t = \alpha x_{t-1} + \varepsilon_t \quad , \qquad t= 1, 2, \ldots\ldots, T \qquad \text{Eq 5.4.1.3.2.1}$$

Where,

$\alpha = 1$

x_O = 0 (the initial value)

ε_t = Random disturbance is generated from normal distribution with zero mean and constant variance (σ^2) equals one, i.e. ε_t ~ N(0,1).

Step two: Create noises in the data set (x_t) by adding random disturbances with zero mean and fixed variance and create a measured variable (y_t).

$$y_t = x_t + \omega_t \ , \qquad t= 1, 2, \ldots\ldots, T \qquad \text{Eq 5.4.1.3.2.2}$$

Where we may vary the variance of this error to investigate the effect of different levels of measurement error relative to the random walk component,

ω_t ~ N(0,0), N(0,0.5), N(0,1), N(0,1.5), N(0,2), N(0,3), N(0,4), N(0,5), N(0,6), and N(0,7).

We consider the following samples sizes T= 25, 50, 100, 150, and 200 observations and we perform 50,000 replications for each sample size and for each variance. We chose

50,000 replications on the grounds that for each sample size using variance zero ($\omega_t \sim$ N(0,0)) we needed 50,000 replications to exactly replicate the standard Dickey Fuller critical values.

In order to show the size distortion of the DF test as noise increases in the data, we calculate the percentage of rejection of the null hypothesis at 5% level of significance using the normal critical values of the DF test with constant model[14].

The relationship between the size distortion of the standard unit root tests; i.e. the Dickey Fuller and the Phillips-Perron tests, and the existence of extra noise in the data has been investigated previously in the literature, particularly in the studies of Elliott, Rothenberg and Stock (1996) and Perron and Ng (1996, 2001). However the main difference between our study and theirs is that Elliott, Rothenberg and Stock (1996) concentrate on generating the errors using different methods such as using moving average (MA(1)), Autoregressive (AR(1)) and GARCH moving average, and Perron and Ng (1996, 2001) concentrate on the errors that have negative moving average and on the lag selection process, while we concentrate on the random measurement errors. Moreover, we investigate the effect of different sizes of the variance of the measurement errors on the size distortion of the DF test while they did not.

[14] DF test asymptotic critical values at 5% level of significance under sample sizes (25, 50, 100, 150, and 200) are as follows: -2.99%, -2.92%, -2.89%, -2.88% and -2.88%.

5.4.1.3.3 EMPIRICAL RESULTS OF MONTE CARLO ANALYSIS

In table 5.6 we show clearly that the percentage of rejection of the null hypothesis at 5% level of significance increases dramatically as the noise increases in the data. The null hypothesis of non stationarity is rejected more often in favour of the alternative (the stationarity).

The benchmark case in this experiment is the one where the variance equals zero (no noise embedded) and both generated data sets (x_t) and (y_t) are equal. The percentage of rejection of the null hypothesis for all samples' sizes is exactly 5% (see table 5.6) which means that the DF test is able to identify the truth about the unit root using the normal critical values (95%) of the time. When the noise increases, from variance 0.5 till variance 7, the size distortion becomes larger and the percentage of rejection increases dramatically which means that the DF test provides misleading results using the same normal critical values.

The results also show that the size distortion becomes larger when the sample size increases, even at lower variances, which implies that even very large samples containing measurement error will give incorrect inference. Figure 5.6 demonstrates that under sample sizes 50, 100, 150 and 200, the percentage of the rejection of the null hypothesis increases faster than the case of sample size 25. The influence of the noise appears more quickly when the sample size is big; for example the percentage of rejection reaches 100% at variance six for both sample sizes 150 and 200 and at variance seven for sample size 100 while in the case of sample 25 we need to add more noises to reach 100%.

It is crystal clear that the distribution of the t-statistic when the data set contains noises is different from the distribution proposed by Dickey Fuller where the process is a pure random walk. In this section we propose a new set of critical values that can be used as an indication to identify the unit root in noisy data. The proposed critical values in table 5.7 are derived from the distribution of t-statistic values across the replications. The critical values at 1%, 5% and 10% are calculated as the first and fifth and tenth percentiles of the t-statistic distribution. As a benchmark, the critical values at variance zero equal exactly the asymptomatic critical values under the DF test. It is obvious that the critical values become bigger (in absolute values) when the noise increases in the data and this mean that the new t-statistic distribution will have heavier and fatter tails than normal fat tails.

The main objective of this experiment is to prove that the rejection of the null hypothesis of unit root under the DF test in some cases should not be taken without further investigation. We prove by Monte Carlo simulation that the size distortion of the DF test becomes larger as the noise increases in the data and faster as the sample size becomes bigger.

We believe that the DF normal critical values can be misleading and implausible when the data set contains noise. Instead the proposed critical values (table 5.7) can be more reliable in identifying the truth about unit root properties. Based on the Monte Carlo experiment and the spectrum analysis we consider the monthly inflation rate to be I(1).

5.4.2 THE COINTEGRATION ANALYSIS

The cointegration analysis using the Johansen approach is performed for the whole sample period after all necessary conditions are fulfilled; such that the order of integration for the targeted variables appears to be I(1) and an optimal lag order is chosen for the VAR systems. The diagnostic tests for the VAR systems residuals indicate that the residuals are not serially correlated according to LM statistics, the residuals are not normally distributed according to the Jarque Bera test which indicates the rejection of the null hypothesis: residuals are multivariate normal at 5% level of significance, and the residuals are heteroskedastic according to the VAR residuals heteroskedasticity test which indicates that the null hypothesis of no heteroskedasticity is rejected at 5% level of significance[15]. The main findings of the cointegration analysis are as follows:

5.4.2.1 THE VALIDITY OF THE FISHER HYPOTHESIS (FH)

Under the bivariate cointegration test between the three month interest rate (CD3M) and the inflation rates (INFRATE), the Johansen approach identifies one cointegrating vector at 5% level of significance. Both the trace and the maximal eigenvalue tests indicate the same number of cointegrating vectors (r = 1); these results are shown in table 5.8. The cointegrating vector indicates that there is a long run relationship between the two variables. In addition, the estimated parameter (β) which has the correct sign indicates that the three month nominal interest rate and the inflation rate move in the

[15] The results of the normality and heteroskedasticity tests are not complying with the assumptions of the residuals (i.e. Gaussian conditions) but this is normal in financial data.

same direction, although we believe that the value of the parameter (β) is extremely large (β = -38.08) compared with results from other studies. The cointegrating vector is shown in detail in table 5.9 Panel A.

The value of the estimated parameter (β) varies considerably among studies. Crowder and Hoffman (1996) and Granville and Mallick (2004) find that the value of the parameter β is larger than one (β>1) but it remains a reasonable value. Payne and Ewing (1997) and Booth and Ciner (2001) who use data from different countries find mixed results; for some countries the parameter is (0<β<1) while for others it is (β>1). Satake (2005) who uses two inflation indices and two different methods such as including and excluding the trend from the cointegration analysis also finds mixed results, for some cases the parameter is (0<β<1) while for others it is (β>1). Most of these studies conclude that the existence of the cointegrating vector by itself partially validates FH; however the rejection of the imposed restrictions [1,-1] is found to be an indication of the absence of the full Fisher effect.

Despite the fact that the value of the parameter (β) in our case is very large, we proceed and test whether the full Fisher effect exists through imposing the restrictions [1,-1] on the estimated parameters [1,-38.08]. The results are shown in table 5.9 Panel B, and indicate clearly the rejection of the imposed restriction at 5% level of significance, which means that FH does not hold. Given the fact that the monthly inflation data which are used in the analysis are characterised as noisy data and in order to evaluate whether the noise has any influence on our results[16] we extend our investigation and re-run another cointegration analysis using the same three month interest rate and the inflation rate which is calculated on a yearly basis[17] instead of the monthly inflation rate.

The results in table 5.11 indicate that there is no cointegrating vector between the two variables and this supports the previous conclusion which is that the Fisher Hypothesis does not hold. In addition, by examining figures 5.7 and 5.8, we can clearly see that the three month interest rate and the inflation rates (both the monthly and the yearly) do not trend together, and in particular in figure 5.8; therefore it is quite reasonable that there is no cointegration between the three month rate and the yearly inflation rate. Our results comply with Mishkin's (1992) main conclusion which states that the Fisher effect will be absent if the variables are not trended together; but that if the nominal interest rate and inflation rate exhibit trends for a period of time then the Fisher effect cannot be rejected.

Furthermore, under the bivariate cointegration test between the six month interest rate (CD6M) and the inflation rates (INFRATE), the Johansen approach identifies one cointegrating vector at 5% level of significance. The trace and the maximal eigenvalue tests indicate the same number of cointegrating vectors (r = 1); these results are shown in table 5.8. The results are similar to the previous case, where we have one cointegration vector, and the estimated parameter (β) has the correct sign but the value of the parameter (β) is extremely large (-28.42).

[16] Satake (2005) has the same case where the noise in the inflation data disturbs the cointegration tests.

[17] Please see footnote no. 9

We impose restrictions on the estimated parameters [1,-28.42] but the restrictions are rejected; therefore we conclude that FH does not hold (results are shown in table 5.10 Panels A and B). In order to obtain robust results we follow the same procedures as the case of the three month rate and re-run another cointegration analysis using the same six month interest rates and the inflation rate which is calculated on a yearly basis. The findings in table 5.11 indicate that there is no cointegrating vector between the two variables; in addition, in figures 5.9 and 5.10 we can clearly see that the two variables do not trend together particularly in figure 5.10 between the six month rate and the yearly inflation rate.

In summary, the cointegration analysis suggests that there is a long run relationship between the two short term nominal interest rates and the monthly inflation rate. The correct sign of the parameter (β) suggests that the two short term nominal interest rates (the three and six months) move in the same direction as inflation rate but of course not in unity as FH suggests. The imposed restrictions on the estimated parameter are rejected which confirm that FH does not hold. We believe that the noise in the monthly inflation data causes the value of the estimated parameter (β) to be extremely large; accordingly it is most likely that the imposed restrictions will be rejected. In order to obtain robust results we re-run another cointegration analysis using the two interest rates with the yearly inflation data; i.e. the yearly data are smoother than the monthly data. The results clearly indicate the absence of the cointegrating vectors between the variables which means that the long run Fisher effect is absent in Jordan’s case.

5.4.2.2 *THE BIVARIATE COINTEGRATION ANALYSES BETWEEN EACH OF THE TWO TERM SPREADS (THE DOMESTIC AND THE US) AND THE MONTHLY INFLATION RATE*

In figures 5.11 and 5.12 we display the two term spreads with the inflation rate. Regarding the bivariate cointegration test between the domestic spread (JORSPD) and the inflation rates (INFRATE), the Johansen approach identifies one cointegrating vector at 5% level of significance. The trace and the maximal eigenvalue tests indicate the same number of cointegrating vectors (r = 1); the results are shown in table 5.12. The cointegrating vector confirms that there is a long run relationship between the two variables. The results of the cointegrating vector are shown in detail in table 5.13 Panel A.

Moreover, under the bivariate cointegration test between the US spread (USTBSPD) and the inflation rates (INFRATE), the Johansen approach also identifies one cointegrating vector at 5% level of significance. The trace and the maximal eigenvalue tests indicate the same number of cointegrating vectors (r = 1); these results are shown in table 5.12. The cointegrating vector confirms that there is a long run relationship between the two variables. The results of the cointegrating vector are shown in detail in table 5.16 Panel A.

5.4.2.3 THE MULTIVARIATE COINTEGRATION ANALYSIS BETWEEN THE DOMESTIC TERM SPREAD, THE MONTHLY INFLATION, AND THE REPO

The multivariate cointegration analysis is designed to test whether there is a long run relationship between the JORSPD, the inflation rate and the repo rate. The Johansen approach identifies just one cointegrating vector instead of two at 5% level of significance; these results are shown in table 5.19. The results confirm that there is a long run relationship between the domestic term spread (JORSPD) and the inflation rate while there is no long run relationship between the Repo rate and the inflation rate or between the repo rate and the domestic spread, and the results of the cointegrating vector are shown in detail in table 5.20 panel A.

In summary, the main finding of the bivariate cointegration analysis indicates that there is a long run relationship between each term spread and the inflation rate. The estimated parameters under the two cointegrating vectors are significant according to the standard error and the t-statistic. The existence of the long run relationship is an indication that the two term spreads may contain some information about the inflation rate.

Following the cointegration analysis, we derive the error correction models (ECM) from the Johansen framework. We show in tables 5.13, 5.16, and 5.20 Panel B the components of each equation under each ECM. The left hand side of any equation represents the changes in the dependent variables whereas the right hand side contains the two main parts which are the Error Correction Term (ECT) coefficients; i.e. the speeds of adjustment, and the coefficients of the lagged dynamic terms (i.e. for both the dependent and explanatory variables). The R^2 and adjusted R^2 are also displayed.

The derived ECM will be used to test the causality relationships among the different variables. However, before performing the causality tests to evaluate the predictive power of the ECM, we will investigate the parameters' constancy for each equation under each ECM using the stability tests that are proposed by Brown et al. (1975); the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ). The main goal of performing the stability tests is to evaluate whether the monthly inflation rate series which is characterised as a noisy series has an influence on the constancy of the parameters and consequently on the stability of the error correction models (ECM). The stability of (ECM) is a very important requirement for the prediction process; according to Hansen (1992), model stability is an essential requirement for the prediction and model stability is equivalent to parameter stability.

5.4.3 *STABILITY TESTS*

We perform the stability tests (CUSUM and CUSUMSQ) on each equation under each ECM with the aim of examining the stability of the long run parameters together with the short run dynamic following Pesaran and Pesaran (1997). The results of the (CUSUM) and (CUSUMSQ) are normally displayed through graphs and if the plots of the (CUSUM) and (CUSUMSQ) remain within the 5% significance boundary, then this is an indication about the stability of the parameters and consequently the stability of the model.

In order to perform the (CUSUM) and (CUSUMSQ) tests we construct the same error correction models (ECM)[18] and re-estimate them using the OLS estimator. These results are shown in tables 5.14, 5.17, and 5.21. We use the Newey West HAC standard errors and covariance method to obtain robust Standard Errors (SE) for all the coefficients of the constructed error correction models since the diagnostic tests of the residuals under VAR systems confirm that the residuals are heteroskedastic.

The results of the stability tests will determine whether the estimated parameters under the ECM are stable or not. The stability of the parameters in our case is an indication that the ECM is stable and contains useful and reliable information that can be used in the prediction of the inflation rate. The results of the stability tests are shown in table 5.23 and it is clear that they are mixed:

5.4.3.1 *THE FIRST ECM CONTAINS TWO EQUATIONS, THE DOMESTIC TERM SPREAD AND THE INFLATION RATE*

- The plots of the (CUSUM) are displayed in figures 5.13 and 5.14 and they indicate reasonable stability within 5% significance bounds. Although the (CUSUM) of the domestic spread equation show big deviations in some periods and this may refer to the abnormal fluctuations in the CDs interest rates in some periods as a reflection of the behaviour of market players to the signals that they have been sent by the Central Bank of Jordan.

[18] We use the cointegrating vector from the Johansen test outcome to construct the Error Correction term (ECT) and then we build the ECM using both the constructed (ECT) and the appropriate lags of each explanatory variables.

-The plots of the (CUSUMSQ) are displayed in figures 5.15 and 5.16 and it is obvious that under the domestic spread the plots lie outside the boundaries which indicate instability, although the (CUSUMSQ) plot becomes almost constant after period 50. The plots of (CUSUMSQ) of the inflation equation lie within the boundaries and this is a strong indication that the parameters under the inflation equation are stable.

5.4.3.2 *THE SECOND ECM CONTAINS TWO EQUATIONS, THE US TERM SPREAD AND THE INFLATION RATE*

- The plots of the (CUSUM) are displayed in figures 5.17 and 5.18 and they indicate reasonable stability within 5% significance bounds.

-The plots of the (CUSUMSQ) are displayed in figures 5.19 and 5.20 and it is obvious that, under both equations the US term spread and the inflation rate, the plots lie inside the boundaries, which indicates stability. The results are robust and confirm the constancy of the parameters under each equation.

5.4.3.3 *THE THIRD ECM CONTAINS THREE EQUATIONS, THE DOMESTIC TERM SPREAD, THE INFLATION RATE AND THE REPO RATE*

- The plots of the (CUSUM) are displayed in figures 5.21, 5.22 and 5.23 and they indicate reasonable stability within 5% significance bounds.

-The plots of the (CUSUMSQ) are displayed in figures 5.24, 5.25 and 5.26 and it is obvious that under the inflation equation, the plot of the (CUSUMSQ) lies within the boundaries, while under both the domestic term spread and the repo rate, the plots lie outside the boundaries, which indicates instability. The results confirm the constancy of the parameters under inflation equation, while the parameters under the other two equations are found to be instable.

According to the stability tests and in particular CUSUMSQ plots, the findings are robust and indicate that the parameters under each inflation equation are stable. In addition the parameters under the US term spread equation are also stable, while the parameters under each domestic term spread equation and the repo rate equation show instability. We may conclude that the noise in the monthly inflation data has no significant influence and the stability of the parameters of the inflation equations under the three error correction models is an indication that the information contents of each equation are useful and reliable for prediction.

In addition to the CUSUM and CUSUMSQ stability tests, we perform an additional test which is the recursive coefficient estimates. In this test we show the evolution of the estimates for all the coefficients under each equation. The results of the recursive coefficient estimates are displayed through graphs and the plots lie within two standard error bands. If the coefficients show no significant variation then this is an indication of stability. The results in figures 5.27, 5.28, 5.29, 5.30, 5.31, 5.32 and 5.33 show that in most of the cases the big variations occur at the beginning of the period, but when more data are added, the estimated recursive coefficient became less volatile, particularly in figures 5.27, 5.29, and 5.31 which are related to the inflation equations. In conclusion, there is no strong evidence about the instability.

5.4.4 THE ERROR CORRECTION MODEL (ECM) AND CAUSALITY TEST

We perform the Granger Causality test to evaluate the predictive power of the ECM. The results of the Granger Causality test will enable us to define whether one variable has the ability to improve the forecasting performance of another variable. Our target is to test not only the weak exogeneity which represents the long run causality but also the short run causality and finally the total causality; i.e. strong exogeneity.

The weak exogeneity test can be performed through imposing restrictions on the speeds of adjustment using the ECM that is derived from the Johansen framework; however the other two causality tests cannot be performed using the same procedure. In order to perform the three causality tests we use the constructed error correction models[19] to apply the Wald F-statistic; the results are shown in tables 5.15, 5.18, and 5.22. The results of the causality tests in detail are as follows:

5.4.4.1: THE BIVARIATE SYSTEMS

5.4.4.1.1: THE ERROR CORRECTION MODEL (THE DOMESTIC SPREAD AND THE INFLATION RATE)

Under the error correction model that contains the domestic spread (JORSPD) and the inflation rate (results are shown in table 5.14), the two speeds of adjustment α_{JORSPD} = -0.048584 and $\alpha_{INFRATE}$ = 6.935852 have the right sign and both are significant according to the SE and t-statistic.

[19] Please see footnote 14.

- Weak Exogeneity: We impose restrictions on the two coefficients of the ECT (α_{JORSPD} =0 and $\alpha_{INFRATE}$=0). The Wald F-statistic and the probability results in table 5.15 indicate the significance of both α_{JORSPD} and $\alpha_{INFRATE}$ at level 5% (F-statistic =6.510 and Probability=0.0120 for α_{JORSPD}) and (F-statistic = 63.582 and Probability=0.0000 for $\alpha_{INFRATE}$). The Wald F-test results confirm that the domestic term spread and the inflation rate are not weakly exogenous; therefore the direction of the causality is bidirectional. That is, the domestic spread causes the inflation rate and the reverse is correct.

- The short-run effect: Regarding the first equation where the domestic spread is the dependent variable, we impose restrictions on the sum of the lagged explanatory variables; i.e. the inflation rate. The joint Wald F-statistic and the probability indicate the non-significance at level 5% (F-statistic =1.574 and Probability=0.2115). Regarding the second equation where the inflation rate is the dependent variable, we impose restrictions on the sum of the lagged explanatory variables; i.e. the domestic spread, and the joint Wald F-statistic and the probability indicate the significance at 5% (F-statistic =5.108 and Probability=0.0074).

- Strong Exogeneity: We use the joint Wald F-statistic to test the significance of the combination of the coefficient of the ECT and the sum of the lagged explanatory variables. Regarding the first equation, we impose the restrictions **(α_{JORSPD} =B_1=B_2=0),** and the joint Wald F-statistic and the probability indicate the significance at level 10% (F-statistic =2.589 and Probability = 0.0562). Regarding the second equation, we impose the restrictions ($\alpha_{INFRATE}$ **=** $\mathbf{A_1}$ **=** $\mathbf{A_2}$ **=0**) and the joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =26.465 and Probability=0.0000). Although the strong exogeneity test suggests that the domestic spread is strongly exogenous at 5%, this this result is mainly influenced by the short run effect not by the long run effect. In addition the strong exogeneity test indicates that the inflation rate is not strongly exogenous at 5% level of significance. The main conclusion is that the causality is bidirectional.

5.4.4.1.2: THE ERROR CORRECTION MODEL (THE US SPREAD AND THE INFLATION RATE)

Under the error correction model that contains the US spread (USTBSPD) and the inflation rate (results are shown in table 5.17), the two speeds of adjustment $\alpha_{USTBSPD}$ = -0.022154 and $\alpha_{INFRATE}$ = 9.868821 have the right sign and both are significant according to the SE and t-statistic.

- Weak Exogeneity: We impose restrictions on the two coefficients of the ECT ($\alpha_{USTBSPD}$ =0 and $\alpha_{INFRATE}$ =0). The Wald F-statistic and the probability results in table 5.18 indicate the non-significance of $\alpha_{USTBSPD}$ at level 5% (F-statistic =2.713 and Probability=0.1022) and the significance of $\alpha_{INFRATE}$ at level 5% (F-statistic = 77.625 and Probability=0.0000). The Wald test results confirm that the US spread is weakly exogenous while the inflation rate is not. Therefore, the direction of the causality is unidirectional; i.e. the US spread causes the inflation rate and the reverse is not correct.

We believe that the main finding of the causality test is robust because it is reasonable that the US spread causes the inflation rate while the feedback is not possible.

- The short-run effect: Regarding the first equation where the US term spread is the dependent variable, we impose restrictions on the sum of the lagged explanatory variables; i.e. the inflation rate. The joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =3.541 and Probability=0.0321). Regarding the second equation where the inflation rate is the dependent variable, we impose restrictions on the sum of the lagged explanatory variables; i.e. the US spread, and the joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =4.836 and Probability=0.0096).

- Strong Exogeneity: Regarding the first equation, we impose the restrictions **($\alpha_{USTBSPD}$ =$\mathbf{B_1}$=$\mathbf{B_2}$=0)** and the joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =2.686 and Probability = 0.0497). Regarding the second equation, we impose the restrictions ($\alpha_{INFRATE}$ **= $\mathbf{A_1}$= $\mathbf{A_2}$=0**), and the joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =32.185 and Probability=0.0000). The strong exogeneity test indicates that the inflation rate and the US spread are not strongly exogenous. However, the results of the US spread are influenced by the short run effect not by the long run effect; hence the US spread which is found to be weakly exogenous is considered also strongly exogenous. The main conclusion is that the causality is unidirectional.

5.4.4.2 *THE MULTIVARIATE SYSTEMS*

Under the error correction model that contains the domestic spread (JORSPD), the inflation rate and the Repo rate (results are shown in table 5.21), the two speeds of adjustment in equations one and two α_{JORSPD} = -0.328796 and $\alpha_{INFRATE}$ = 23.11915 have the right signs and significance according to the SE and t-statistic, while the speed of adjustment in the third equation α_{REPO} = .096523 has the wrong sign and is not significant according to the SE and t-statistic.

- Weak Exogeneity: We impose restrictions on the coefficients of the ECT the (α_{JORSPD} =0), ($\alpha_{INFRATE}$ =0) and (α_{REPO} = 0). The speeds of adjustment under the first and second equations are significant at level 5% (F-statistic =7.434 and Probability=0.0076 for α_{JORSPD}) and (F-statistic =24.757 and Probability=0.0000 for $\alpha_{INFRATE}$), while under the third equation the speed of adjustment is not significant at 5% (F-statistic=0.189 and the probability=0.6651 for α_{REPO}). The results indicate that both the domestic term spread and the inflation rate are not weakly exogenous while the repo rate is weakly exogenous. The results of the domestic term spread and the inflation rate are robust and comply with all previous results.

-The short-run effect: Regarding the first equation where the domestic spread is the dependent variable, we impose restrictions on each sum of the lagged explanatory variables (i.e. the inflation rate and the repo rate) and then on the total sum of lagged explanatory variables. The joint Wald F-statistic indicates the non significance of each explanatory variable at 5% (F-statistic =1.056 and Probability =0.3978, for the inflation rate) and (F-statistic =1.515 and Probability =0.1713, for the repo rate). However, the joint Wald F-statistic indicates the significance at 10% level of the total sum of lagged explanatory variables (F-statistic =1.660 and Probability =0.0770).

Regarding the second equation where the inflation rate is the dependent variable, the joint Wald F-statistic and the probability indicate the significance of each sum of lagged explanatory variables and of the sum of all lagged explanatory variables at 5% (F-statistic =6.581 and Probability =0.0000, for the domestic term spread), (F-statistic =5.017 and Probability =0.0001, for the Repo rate) and (F-statistic =5.074 and Probability =0.0000 for the sum of domestic term spread and Repo rate).

Since we are interested in identifying whether the domestic term spread continues to contain useful information about the inflation rate beyond that contained in the monetary policy variable, we compare the results of the short run effect for the inflation equation under the multivariate system (table 5.22), where we add an additional variable that reflects the monetary policy; i.e. the Repo rate, and also include more lags for each variable, with the results of the short run effect for the inflation equation under the bivariate system (table 5.15). The joint Wald F-statistic of the sum of lagged domestic term spread under the multivariate system are (F-statistic =6.581 and Probability =0.0000) while under the bivariate system are (F-statistic =5.108 and Probability=0.0074), it is noticeable that the results remain significant in both cases, and accordingly we may conclude that the domestic term spread contains information beyond that contained in the monetary policy variable.

Regarding the third equation where the repo rate is the dependent variable, the joint Wald F-statistic and the probability indicate the significance of the lagged explanatory variable; i.e. domestic spread at level 5% (F-statistic =5.982 and Probability=0.0000), the non significance of the lagged explanatory variable; i.e. the inflation rate at level 5% (F-statistic =0.711 and Probability=0.6627) and the significance of all lagged explanatory variables at level 5% (F-statistic =3.830 and Probability=0.0000).

- Strong Exogeneity: Regarding the first equation we impose the restrictions $(\alpha_{JORSPD} = \mathbf{B}_1 = \mathbf{B}_2 = \mathbf{B}_3 = \mathbf{B}_4 = \mathbf{B}_5 = \mathbf{B}_6 = \mathbf{B}_7 = \mathbf{C}_1 = \mathbf{C}_2 = \mathbf{C}_3 = \mathbf{C}_4 = \mathbf{C}_5 = \mathbf{C}_6 = \mathbf{C}_7 = \mathbf{0})$, and the joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =2.294 and Probability = 0.0079). Regarding the second equation, we impose the restrictions $(\alpha_{INFRATE} = \mathbf{A}_1 = \mathbf{A}_2 = \mathbf{A}_3 = \mathbf{A}_4 = \mathbf{A}_5 = \mathbf{A}_6 = \mathbf{A}_7 = \mathbf{C}_1 = \mathbf{C}_2 = \mathbf{C}_3 = \mathbf{C}_4 = \mathbf{C}_5 = \mathbf{C}_6 = \mathbf{C}_7 = \mathbf{0})$, and the joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =5.137 and Probability=0.0000). Regarding the third equation, we impose the restrictions $(\alpha_{REPO} = \mathbf{A}_1 = \mathbf{A}_2 = \mathbf{A}_3 = \mathbf{A}_4 = \mathbf{A}_5 = \mathbf{A}_6 = \mathbf{A}_7 = \mathbf{B}_1 = \mathbf{B}_2 = \mathbf{B}_3 = \mathbf{B}_4 = \mathbf{B}_5 = \mathbf{B}_6 = \mathbf{B}_7 = \mathbf{0})$, and the joint Wald F-statistic and the probability indicate the significance at level 5% (F-statistic =3.575 and Probability=0.0001). Although the results indicate that all variables are not strongly exogenous, we consider the Repo rate strongly exogenous because the significance comes mainly from the short run effect. Therefore we may conclude that the main findings in this case continue to comply with the original findings; that is, the domestic spread and the inflation rate are endogenous variables and the causality is bidirectional.

The main findings of the causality tests can be summarised as follows:

- The results of the bivariate systems confirm that we have a bidirectional causality between the domestic spread and the inflation rate and unidirectional causality between the US term spread and the inflation rate; that is the US term spread causes the inflation rate while the feedback is not possible. The causality relationships provide additional support about the information content of the two spreads.

- The main result of the multivariate system between the domestic spread, the inflation and the Repo confirms that the Repo rate which reflects the monetary policy stance does not affect the predictability of the domestic term spread; that is, the domestic term spread contains information beyond that contained in the Repo rate.

5.5 IMPULSE RESPONSE AND VARIANCE DECOMPOSITION

In order to analyse the dynamic property of each VAR model, we employ both the Impulse response and the variance decomposition techniques. Both techniques provide the same information about the behaviour of the dependent variables in the VAR system to the shocks in the explanatory variables. The impulse response technique shows the time path of the dependent variable while the variance decomposition technique evaluates the percentage of the contribution of each explanatory variable to the variance's fluctuation of each dependent variable.

5.5.1 IMPULSE RESPONSE

We use both the Cholesky and the Generalized methods to perform the impulse response technique. All the impulse responses of the VAR systems are shown in figures 5.34 to 5.36. The main conclusion is that all VAR systems are stable because we did not detect any explosive behaviour; on the contrary, all shocks decline to zero.

5.5.2 VARIANCE DECOMPOSITION

The results of the variance decomposition techniques are as follows:

5.5.2.1 THE VARIANCE DECOMPOSITION OF THE DOMESTIC TERM SPREAD AND THE INFLATION RATE FOR DIFFERENT TIME HORIZONS

In tables 5.24.1 and 5.24.2 we show the percentage of the contribution of innovations of each of the variables in the bivariate system to the variances of the domestic term spread and the inflation rate respectively.

The results in table 5.24.1 show that the shocks to the domestic term spread itself account for most of the variability in the domestic term spread over all horizons although as the horizon increases the effect stays the same, whereas the shocks to the inflation rate have low effect on the variability of the domestic term spread and the increase over the horizon is not that significant. The results in table 5.24.2 show that the shocks to the inflation rate itself account for most of the variability in the inflation rate over all horizons although as the horizon increases the effect stays the same. However, the shocks to the domestic term spread have very low effect on the variability of the inflation rate and the increase over the horizon is not that significant.

5.5.2.2 THE VARIANCE DECOMPOSITION OF THE US TERM SPREAD AND THE INFLATION RATE FOR DIFFERENT TIME HORIZONS

In tables 5.25.1and 5.25.2 we show the percentage of the contribution of innovations of each of the variables in the bivariate system to the variances of the US term spread and the inflation rate respectively.

The results in table 5.25.1 show that the shocks to the US term spread itself account for most of the variability in the US term spread over all horizons, although as the horizon increases the effect decreases slightly, whereas the shocks to the inflation rate have low effect on the variability of the US term spread and the increase over the horizon is not that significant. The results in table 5.25.2 show that the shocks to the inflation rate itself account for most of the variability in the inflation rate over all horizons although as the horizon increases the effect stays the same, whereas the shocks to the US term spread have low effect on the variability of the inflation rate and the increase over the horizon is not that significant. Moreover, the effect of the US term spread on the inflation is larger than the effect of the domestic term spread when comparing the results in table 5.25.2 with those in table 5.24.2.

5.5.2.3: THE VARIANCE DECOMPOSITION OF THE DOMESTIC TERM SPREAD, THE INFLATION RATE AND THE REPO RATE FOR DIFFERENT TIME HORIZONS

In tables 5.26.1, 5.26.2 and 5.26.3 we show the percentage of the contribution of innovations of each of the variables in the multivariate system to the variances of the domestic term spread, the inflation rate and the Repo rate respectively.

The results in table 5.26.1 show that the shocks to the domestic term spread itself account for most of the variability in the domestic spread over all horizons although as the horizon increases the effect declines. In addition the shocks to the Repo rate contribute significantly to the variability of the domestic term spread while the effect of the shocks on the inflation rate is not that significant.

The results in table 5.26.2 show that the shocks to the inflation rate itself account for most of the variability in the inflation rate over all horizons although as the horizon increases the effect declines slightly. In addition the shocks to the domestic term spread and the Repo rate have almost the same effect on the variability of the inflation rate which can be described as non significant. The results in table 5.26.3 show that the shocks to the Repo rate itself account for most of the variability in the Repo rate over all horizons although as the horizon increases the effect declines. In addition the shocks to the domestic term spread contribute significantly to the variability of the Repo rate while the effect of the shocks on the inflation rate is not that significant

In summary, the results of the causality relationship confirm strongly that both term spreads cause the inflation rate and this is an indication that both spreads have an ability to predict the inflation rate. Furthermore, the stability tests confirm that the parameters under each inflation equation are stable and this also verifies the predictability of the components of the inflation equations. On the other hand the results of the variance decomposition suggest that the predictive power of the two term spreads may not be robust, taking into consideration that the shocks to the domestic term spread and to the US term spread have low effect on the variability of the inflation rate. Moreover, the results confirm that the domestic term spread contains significant information beyond that contained in the Repo rate; however if we compare the results in table 5.26.2 with the results in table 5.24.2, we notice that by including the Repo rate in the analysis the contribution of the domestic term spread to the variance of the inflation has been increased.

When the term structure contains information about economic activities such as the future inflation rate, then this is an indication that the term structure reflects the financial market participants' expectations about future inflation. Normally, the Central Banks tend to affect the market prices and the quantity of money in the economy by altering financial market participants' expectations about the future inflation rate using the term structure as a monetary policy tool; i.e. using the slope of the term structure to reflect the monetary policy stance.

The fact that we find some information in the US and the Jordanian term spreads about the inflation rate is not sufficient evidence that monetary policy affects the economic activities, particularly the inflation rate in Jordan; this transmission mechanism needs more investigation. As mentioned earlier, the exchange regime in Jordan has been pegged to the US dollar for a long time and the CBJ defends this peg and builds the foreign reserves by targeting the interest rate spread between the US Treasury Bills rates and Jordanian Dinar CDs' rates. The main goal from this policy is to maintain the attractiveness of the Jordanian Dinar CDs' rates in respect of the US Treasury Bills rates.

As a result, the pricing of the CDs depends on several factors such as the targeted excess liquidity in the market which reflects the stance the CBJ takes on its monetary policy; and its outlook about the future inflation rate and the targeted interest rate spread between the US Treasury Bills and Jordanian Dinar CDs. Therefore the information content in the domestic term structure is not purely country-specific; i.e. it depends on the movement in the US term structure.

For the time being, the linkage between the two term structures was successful in achieving the main goal which is building the foreign reserves; however this linkage contains some major risks such as the possibility that the financial crises in the US economy will spill over to the Jordanian economy. In view of that, it is essential for policy designers to adapt a strategy to develop the domestic financial markets; i.e. the money and the capital markets, to be the main source of funding instead of depending on the international capital flow which is affected significantly when the financial crises occur[20]. The existence of efficient and well developed domestic financial markets will make the term structure of interest rates a better financial indicator for all market players, particularly the monetary authority. For example, any future changes in the monetary policy targeting; i.e. targeting the inflation rate directly instead of the current

[20] This argument has been fully illustrated in Mehl's study (2006).

policy, will require a better country-specific financial indicator that reflects market participants' expectations about the future economic activities.

5.6 CONCLUSION AND FURTHER REMARKS

In this chapter we examine whether the short end of the term structure contains useful and reliable information about the inflation rate. First we examine the information contents in the short term nominal interest rates and then we proceed to examine the information contents of the entire term structure using the slope of the term structure; i.e. the domestic term spread.

We concentrate on the long run relationship between the main variables such as the relationship between the three month nominal interest rate and the inflation rate, the six month nominal interest rate and the inflation rate, and the term spread and the inflation rate. We believe that the existence of the long run equilibrium relationship among the variables is clear evidence that the short end of the term structure in Jordan contains useful information. We use the cointegration analysis to examine the existence of the long run relationship and the ECM to examine the causality relationship among the main variables.

Given the fact that the exchange regime in Jordan has been pegged to the US dollar since 1995, we expand our investigation and examine whether the US term spread has any predictive power of the inflation rate. In addition we examine whether an additional variable has any influence on the predictability of the domestic term spread such as the monetary policy variables. Our main concern is to determine whether the domestic term spread contains information beyond that contained in the monetary policy variables.

In order to apply the cointegration analysis we identify first the order of integration for all the targeted variables. The contradiction on the unit root results motivates us to use different tools and methods to verify the true order of integration for some of the major variables particularly the monthly inflation rate. We design a Monte Carlo experiment to show what happens if the inflation rate series contains measurement errors; i.e. noises. The results of the Monte Carlo experiment show that we cannot consider the standard critical values that are suggested by Dickey and Fuller to define if the monthly inflation rate is stationary or non stationary. According to this experiment the monthly inflation rate is considered to be I(1).

The main findings of cointegration analysis indicate that there is no long run equilibrium relationship between each short term nominal interest rate (the three and six month interest rates) and the inflation rate while there is long run equilibrium relationship between each term spread (the domestic and the US) and the inflation rate, which is considered clear evidence that both term spreads contain some information about the inflation rate. In addition, the results show that the estimated coefficients of the domestic term spread remain highly significant despite the fact that an additional variable has been included in the analysis, which indicates that the spread contains information beyond that explained by the monetary policy variables.

Moreover, before performing the causality tests and to ensure that the noise in the monthly inflation data has no influence on the stability of the parameters of the error correction models (ECM), we perform CUSUM and CUSUMSQ stability tests. The graphs of the stability tests confirm strongly that the parameters under each inflation equation are reasonably stable which means that the components of the inflation equation; both the long run parameters together with the short run dynamic, contain useful and reliable information for the prediction. Moreover, the results of the Granger Causality test verify the predictability of the two term spreads and confirm that the direction of causality is bidirectional between the domestic term spread and inflation rate and unidirectional between the US term spread and the inflation rates.

Finally, the variance decomposition results indicate that the shocks to the explanatory variables, particularly the shocks to the domestic term spread and to the US term spread, contribute slightly to the variability in the variance of the inflation rate. This simply confirms that both term spreads have some information about the inflation rate.

5.6.1 FURTHER REMARKS

We are aware that one of the main shortcomings of using data from developing countries is the low quality of the data. In this chapter and due to the data limitation we dealt with the short end of the term structure of interest rates and with inflation data that are characterised as noisy data. Although we find empirical evidence that there is a long run equilibrium relationship between the domestic term spread and the inflation rate, which indicates that the term spread contains some information about the inflation, we believe that the term spread which represents the slope of the short end of the term structure may not be a better measurement of the steepness of the term structure and accordingly it is not an optimal indicator that reflects the overall market's expectations about future expected inflation..

In the empirical literature, many studies such as Mishkin (1991), Jorion and Mishken (1991), Frankel and Lown (1994) and Gerlach (1997) provide robust empirical evidence that when the term spread represents the slope of the very short end of the term structure then normally it does not contain useful information about the changes in inflation, while if the term spread represents the slope of the medium term or the long term segments of the term structure; that is, it represents the overall steepness of the term structure, then the term spread is found to contain useful information for the prediction of inflation.

Based on these facts we believe that the domestic term spread between the six and three month rates may contain some information but if the relationship between the domestic term spread and the inflation rate is re-examined in the future, when longer maturities of interest rates on risk-free financial assets become available in the Jordanian financial markets, then we may obtain more robust evidence about the predictability of the term structure because in this case the term spread will be a better measurement of the overall steepness of the term structure.

Figure 5.1: ***Spectral Density For The Domestic Term Spread (JORSPD)***

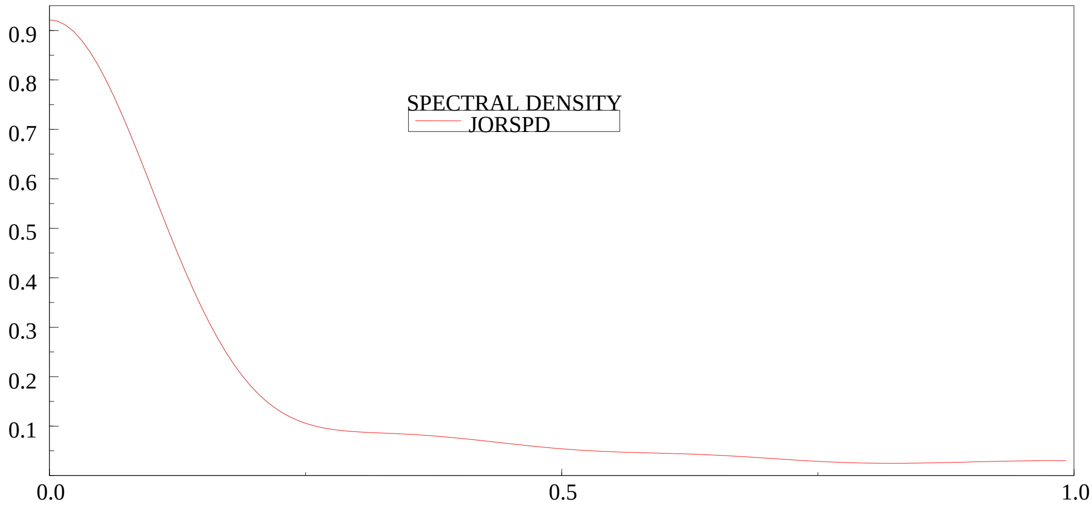


Figure 5.2: ***Spectral Density For The US Term Spread (USTBSPD)***

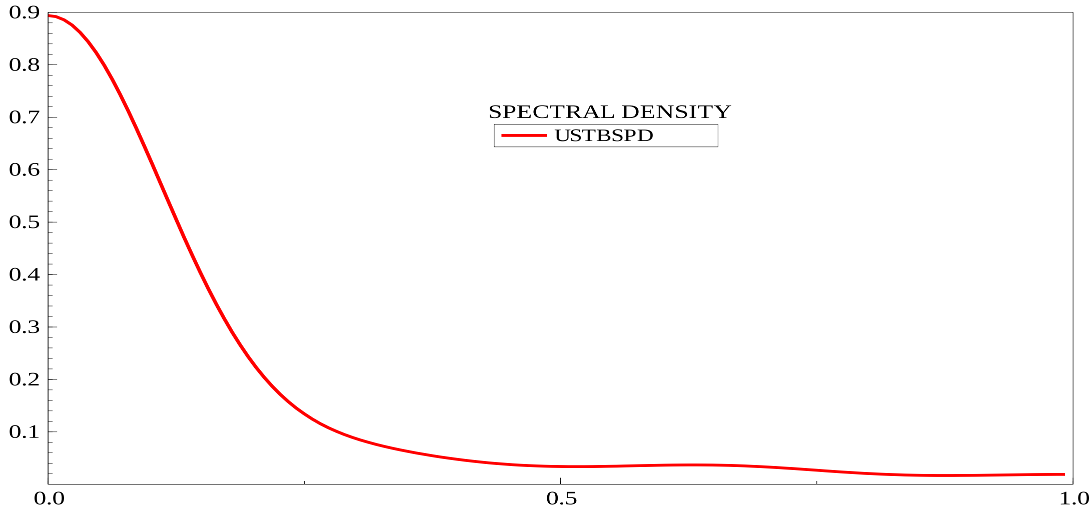


Figure 5.3: ***The Monthly Inflation Rate (Annualized)***

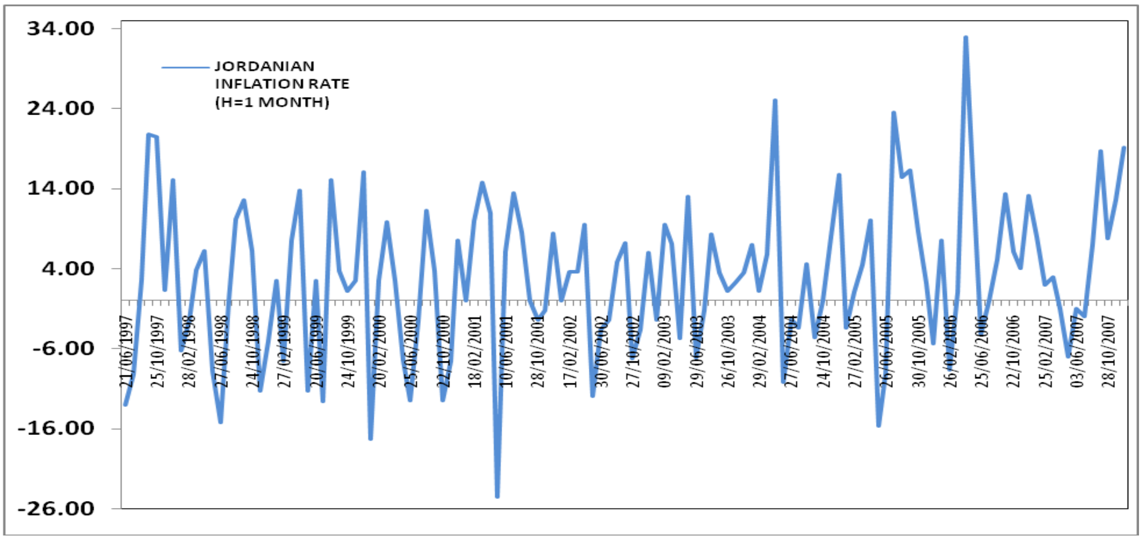


Figure 5.4: ***Spectral Density For The Monthly Inflation Rate***

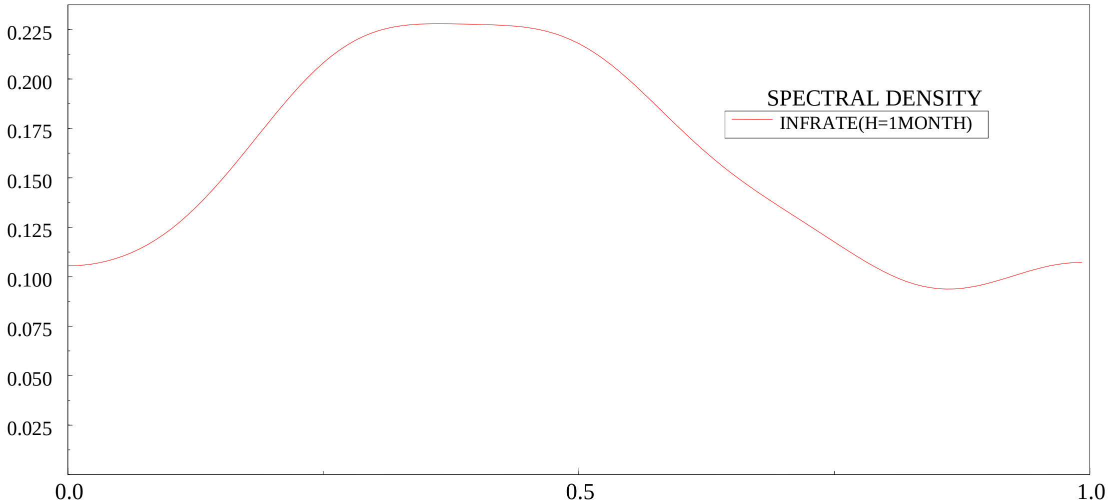


Figure 5. : ***The Yearly Inflation Rate (Annualized)***

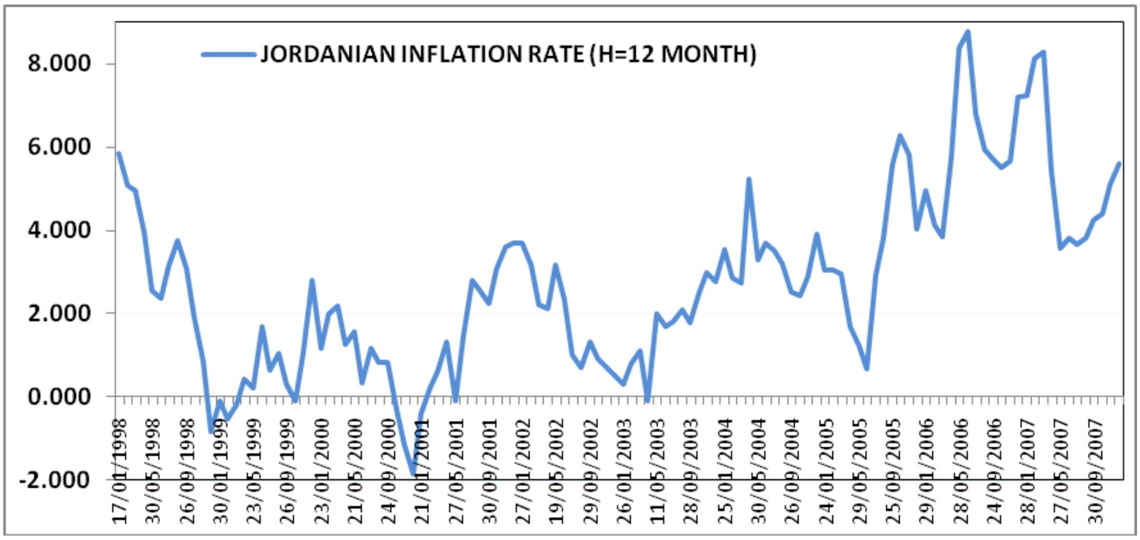


Figure 5.6: ***The Comparison Between The Percentages Of Rejection Under Dickey Fuller Test***

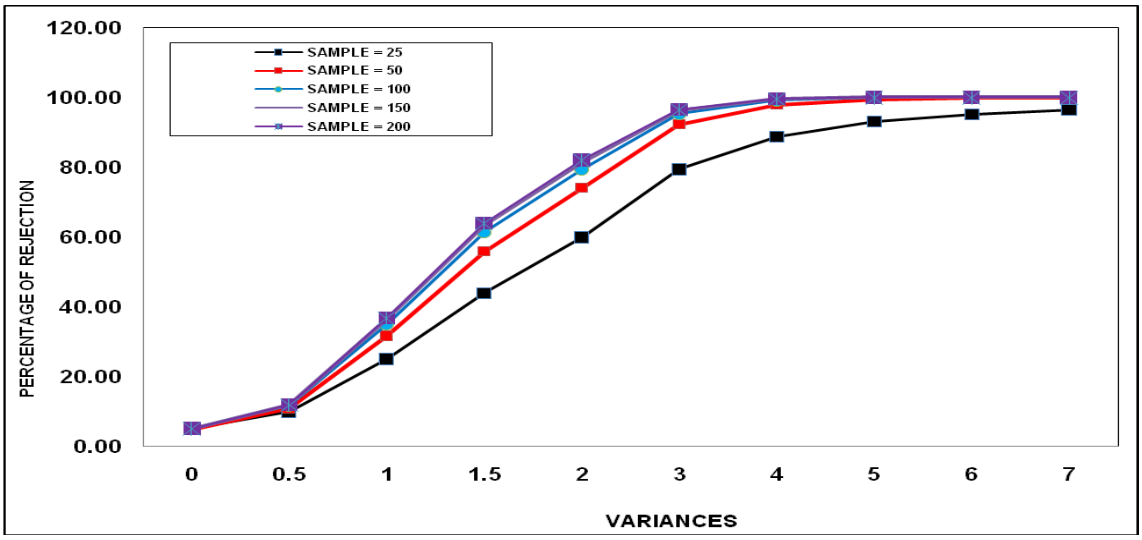


Figure 5.7: ***Three Month CDs Interest Rate / Inflation Rate (H=1 Month)***

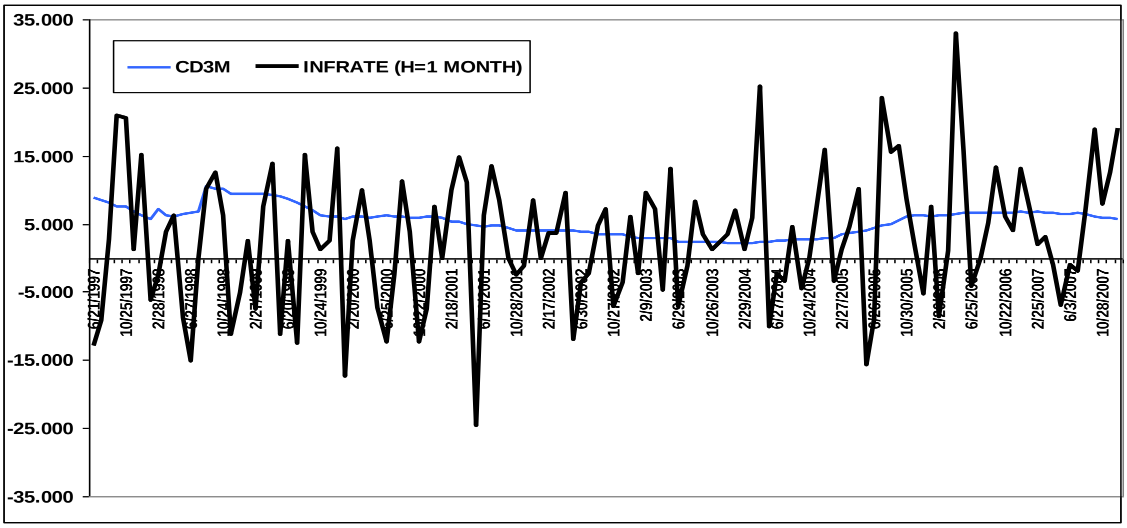


Figure 5.8: ***Three Month CDs Interest Rate / Inflation Rate (H=12 Month)***

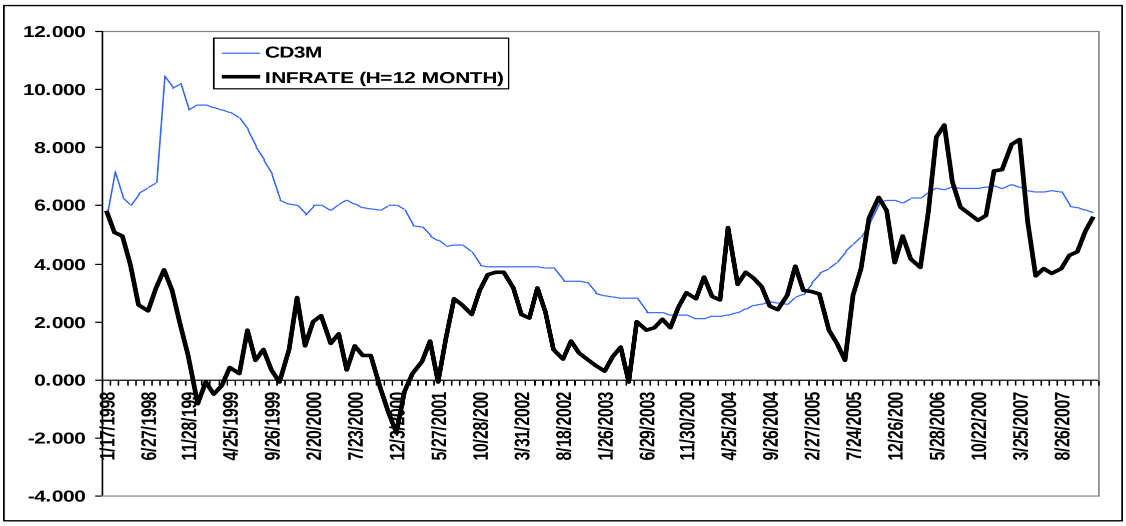


Figure 5.9: ***Six Month CDs Interest Rate / Inflation Rate (H=1 Month)***

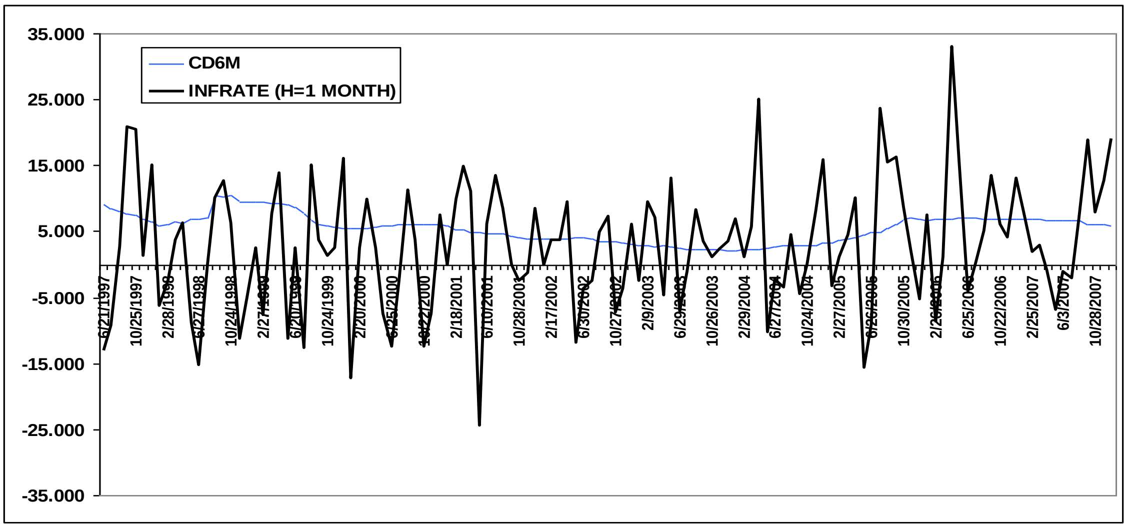


Figure 5.10: ***Six Month CDs Interest Rate / Inflation Rate (H=12 Month)***

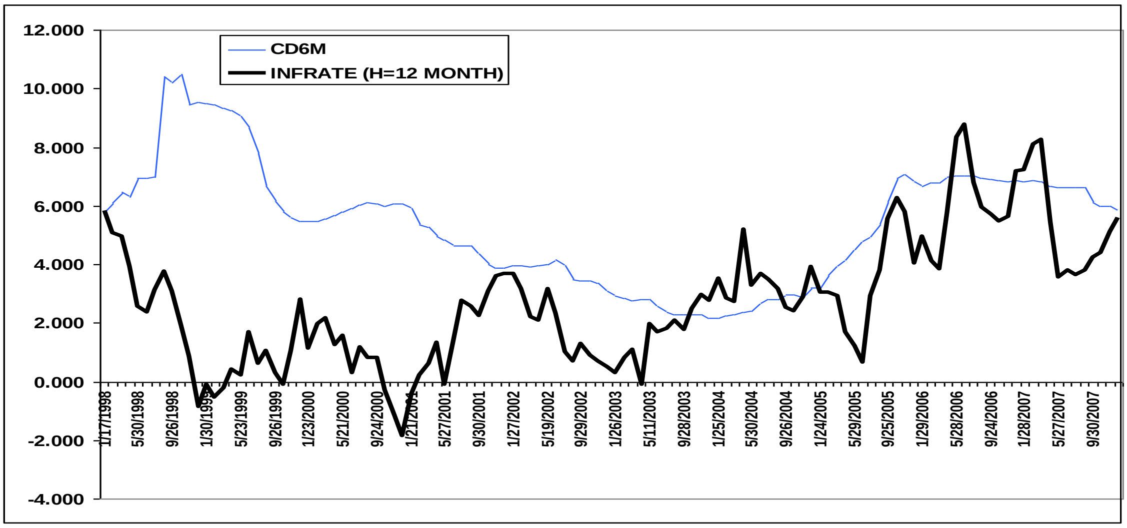


Figure 5.11: ***JORSPD / Inflation Rate***

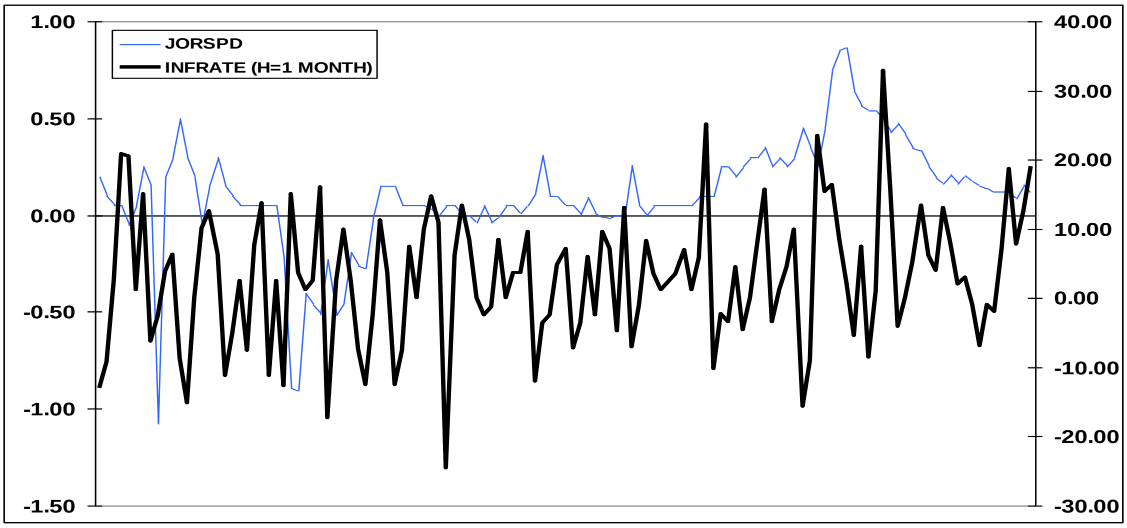


Figure 5.12: ***USTBSPD / Inflation Rate***

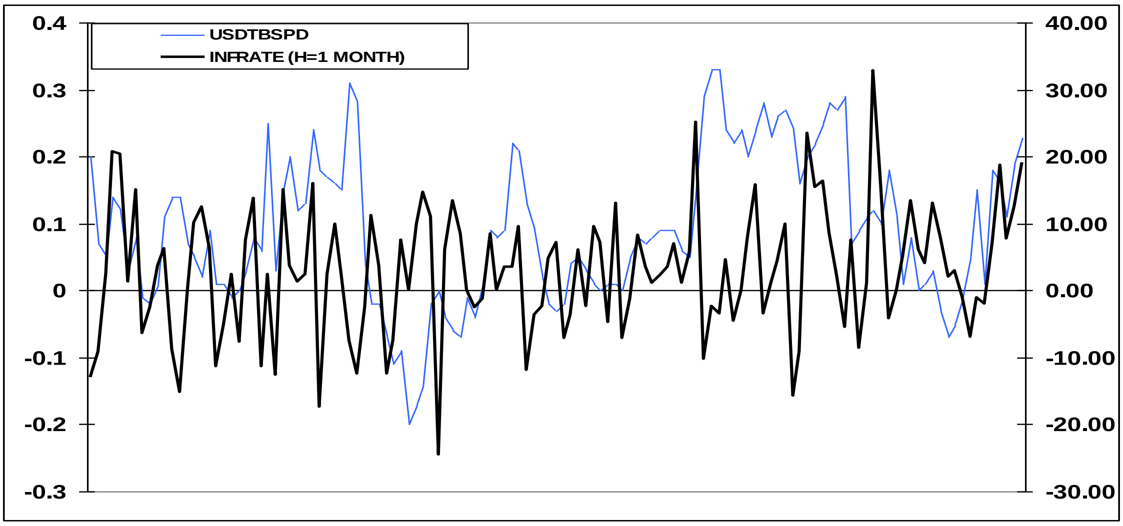


Figure 5.13: ***JORSPD / Inflation Rate CUSUM – D(JORSPD) Equation***

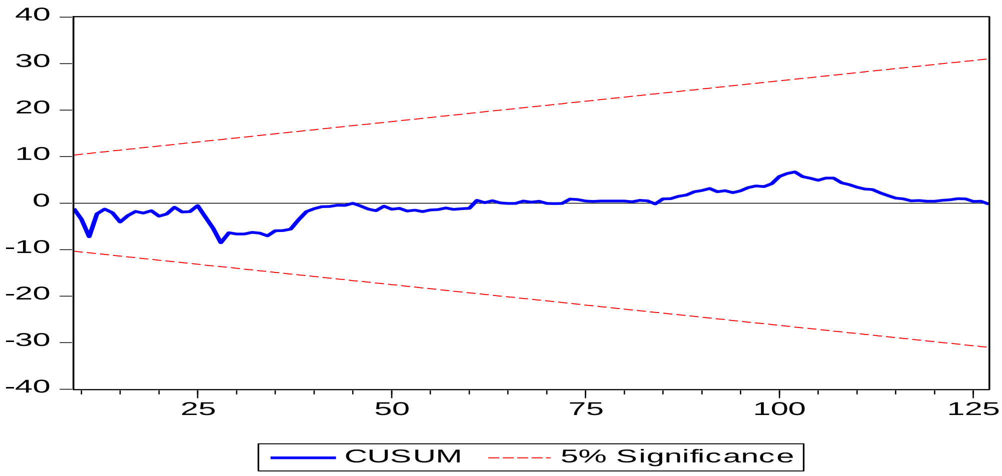


Figure 5.14: ***JORSPD / Inflation Rate CUSUM – D(INFRATE) Equation***

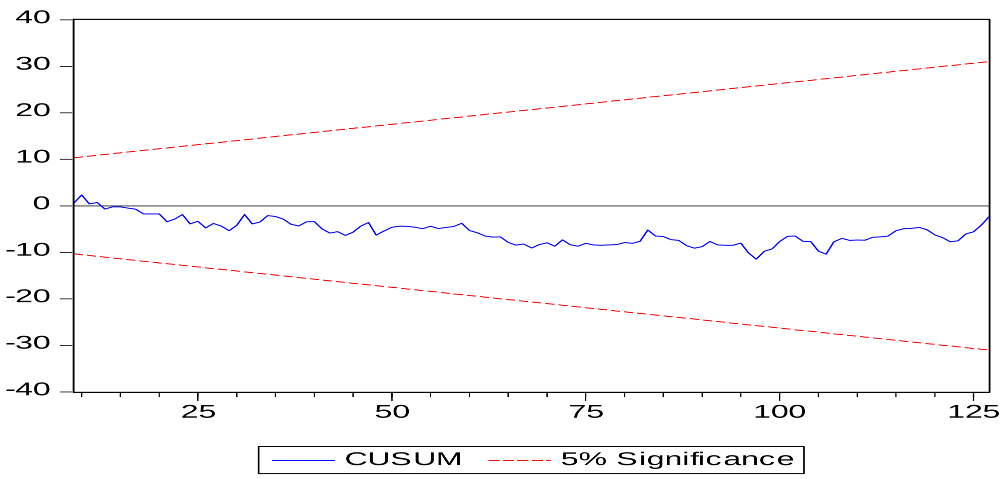


Figure 5.15: ***JORSPD / Inflation Rate CUSUM Of Square– D(JORSPD) Equation***

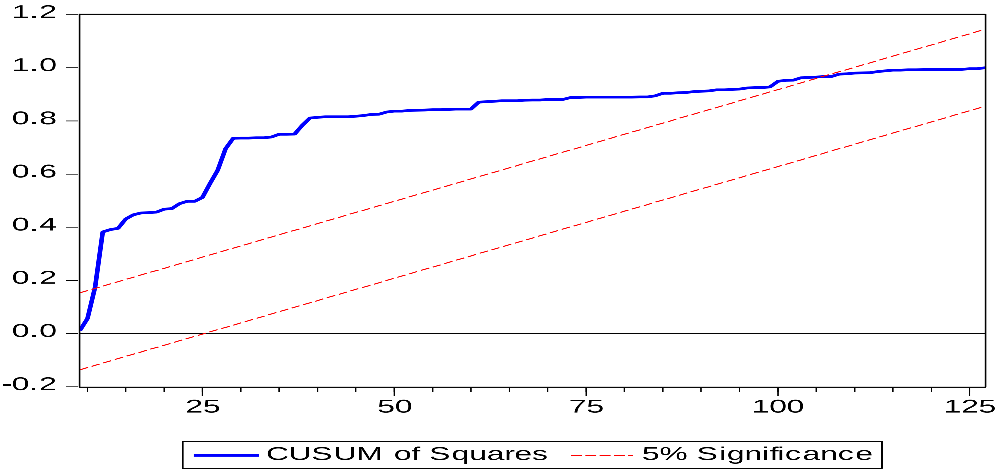


Figure 5.16: ***JORSPD / Inflation Rate CUSUM Of Square – D(INFRATE) Equation***

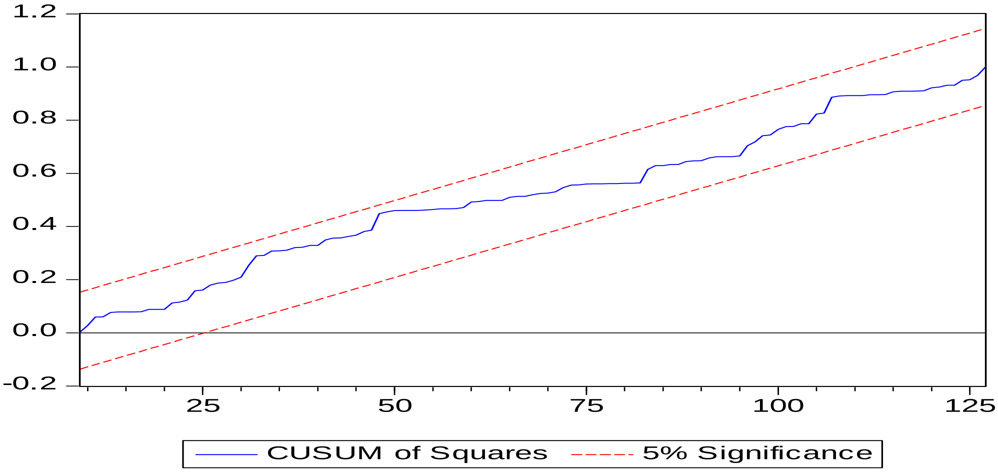


Figure 5.17: ***USTBSPD / Inflation Rate CUSUM – D(USTBSPD) Equation***

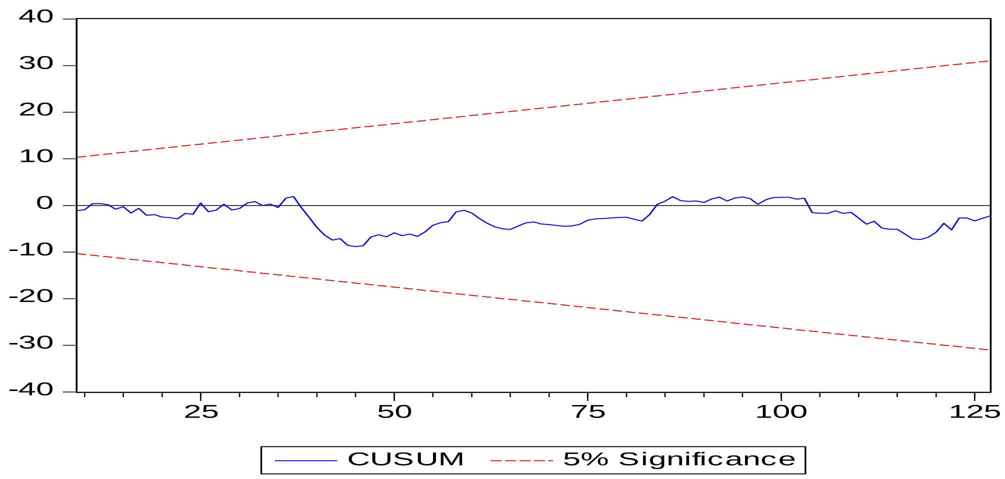


Figure 5.18: ***USTBSPD / Inflation Rate CUSUM – D(INFRATE) Equation***

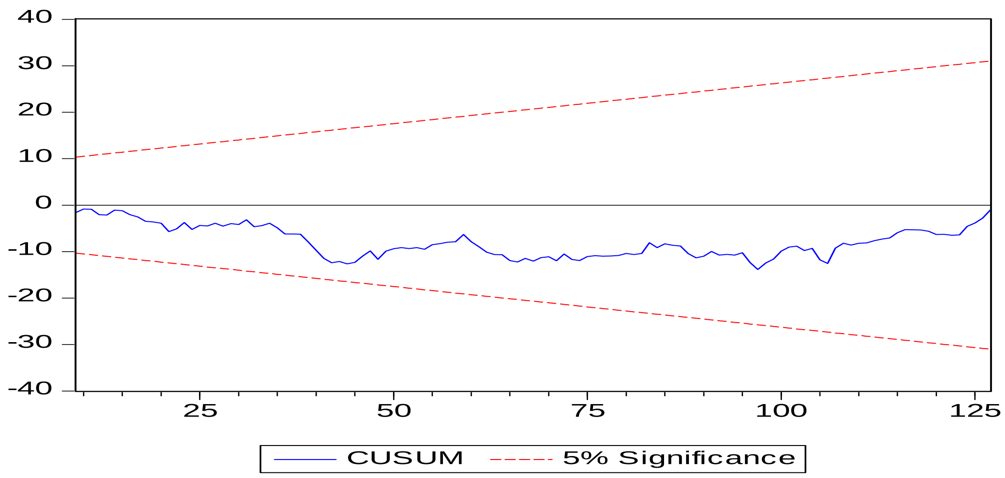


Figure 5.19: ***USTBSPD / inflation rate CUSUM of square – D(USTBSPD) equation***

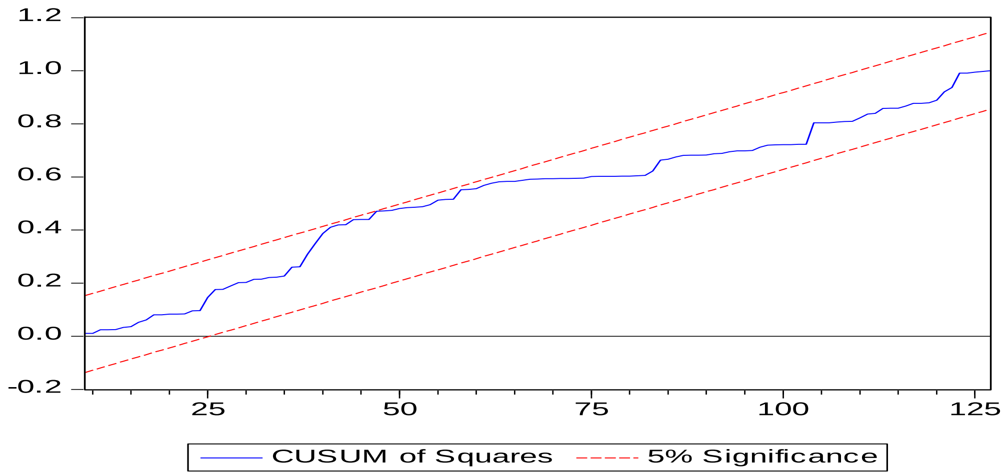


Figure 5.20: ***USTBSPD / Inflation Rate CUSUM Of Square– D(INFRATE) Equation***

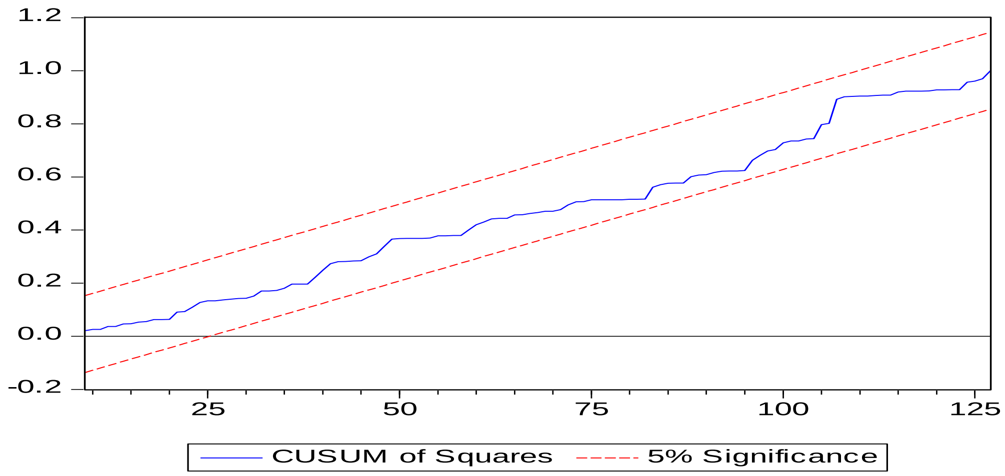


Figure 5.21: ***JORSPD / Inflation Rate / REPO Rate CUSUM – D(JORSPD) Equation***

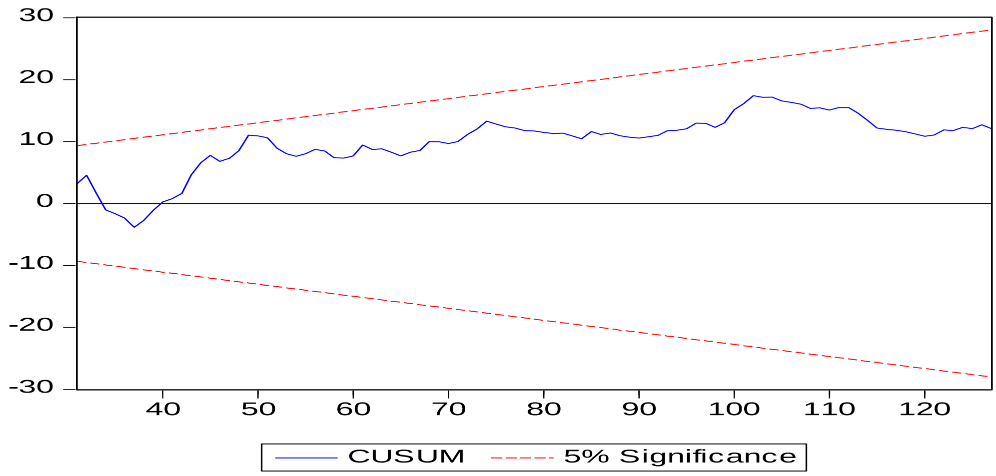


Figure 5.22: ***JORSPD / Inflation Rate / REPO Rate CUSUM – D(INFRATE) Equation***

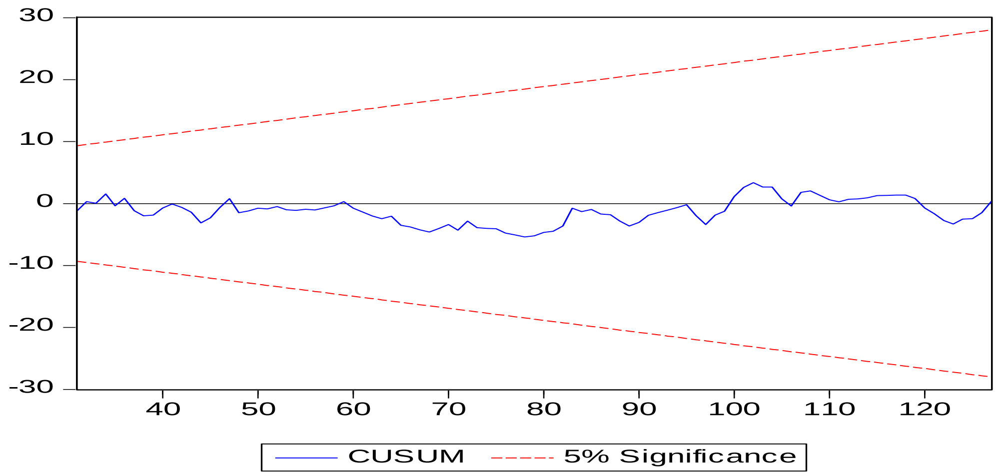


Figure 5.23: ***JORSPD / Inflation Rate / REPO Rate CUSUM – D(REPO) Equation***

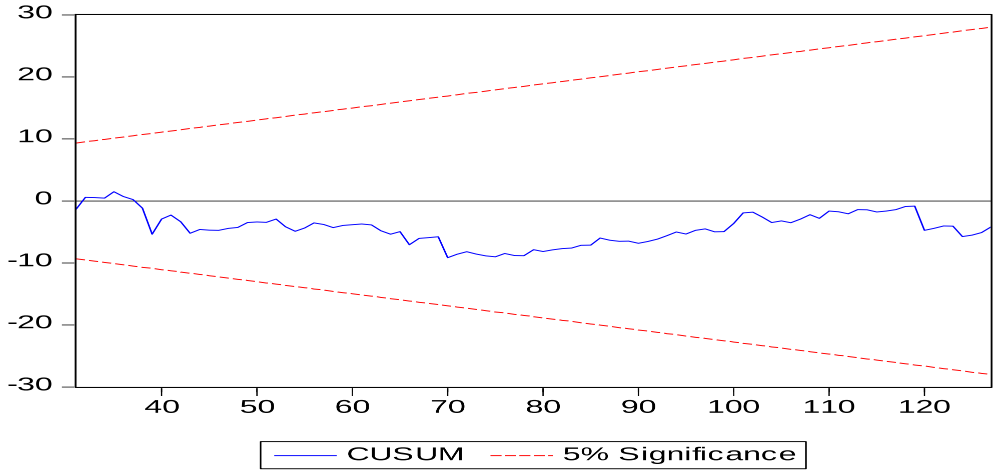


Figure 5.24: ***JORSPD / Inflation Rate / REPO Rate CUSUM Of Square– D(JORSPD) Equation***

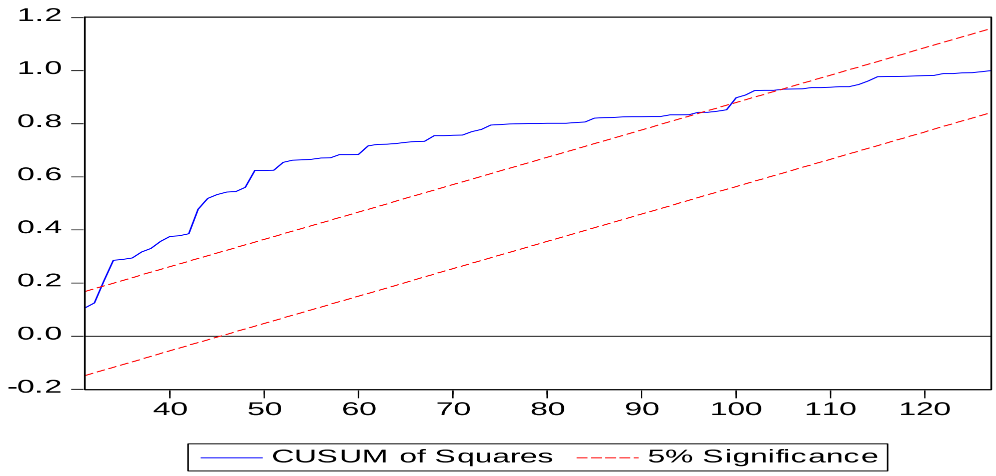


Figure 5.25: ***JORSPD / Inflation Rate / REPO Rate CUSUM Of Square– D(INFRATE) Equation***

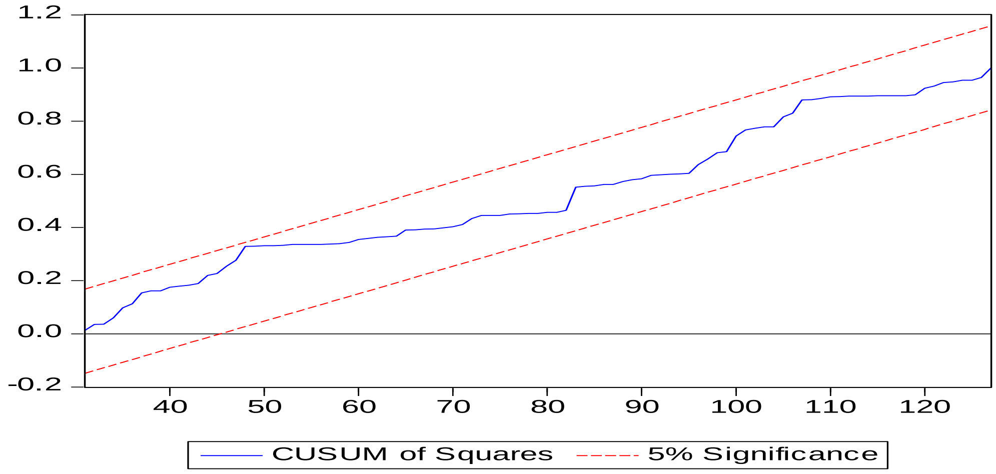


Figure 5.26: ***JORSPD / Inflation Rate / REPO Rate CUSUM Of Square– D(REPO) Equation***

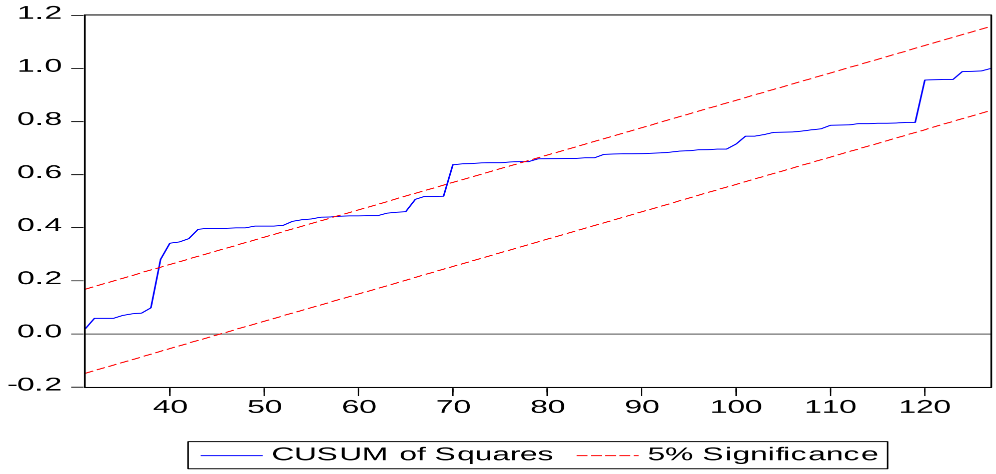


Figure 5.27: ***JORSPD / Inflation Rate Recursive Coefficients– D(JORSPD) Equation***

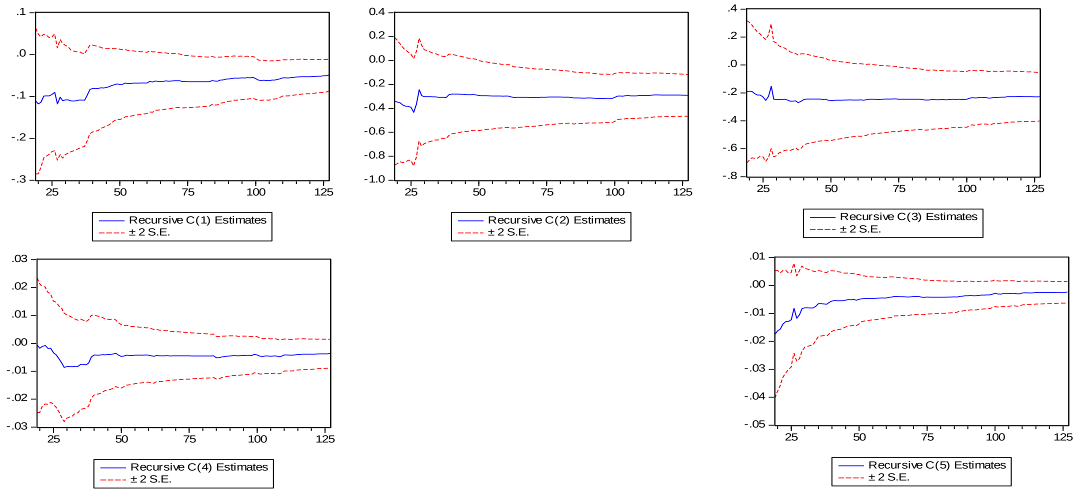


Figure 5.28: ***JORSPD / Inflation Rate Recursive Coefficients– D(INFRATE) Equation***

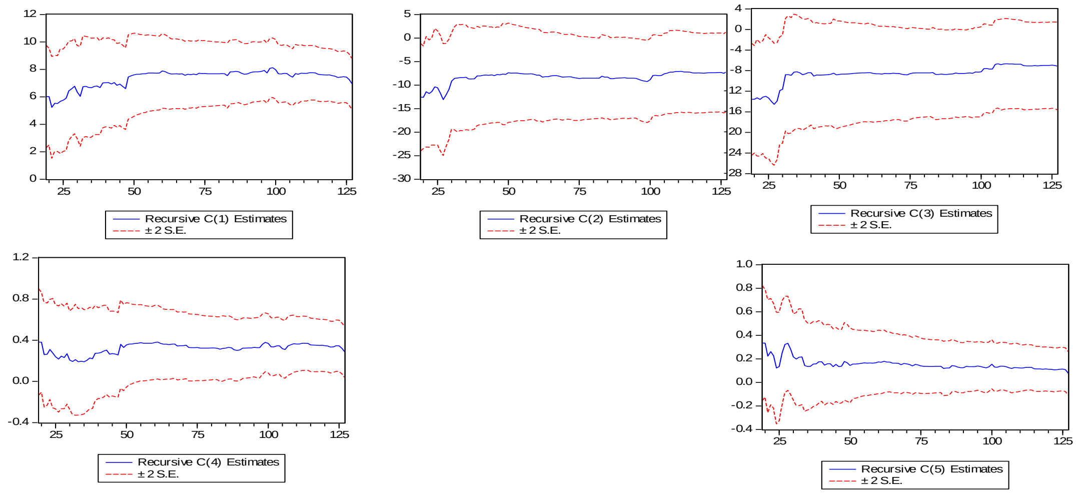


Figure 5.29: ***USTBSPD / Inflation Rate Recursive Coefficients– D(USTBSPD) Equation***

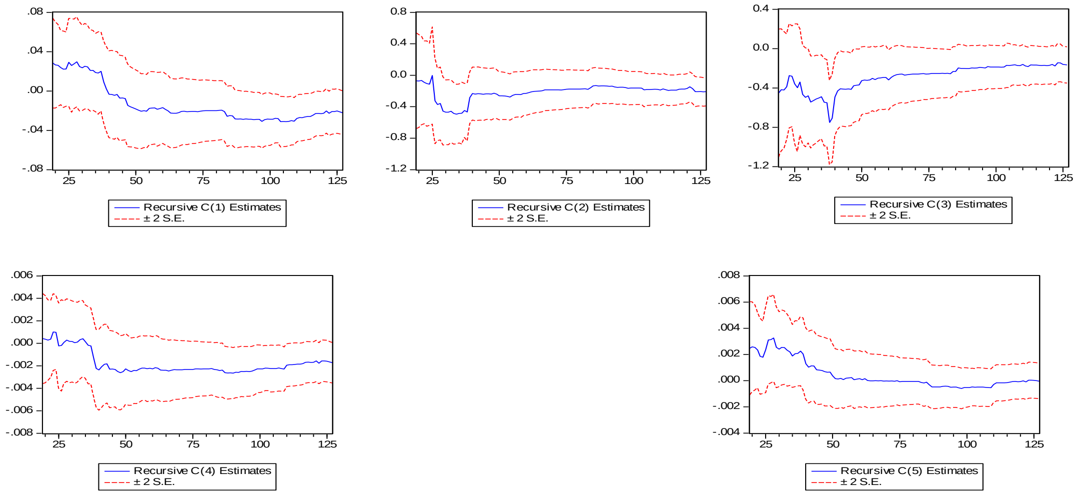


Figure 5.30: ***USTBSPD / Inflation Rate Recursive Coefficients– D(INFRATE) Equation***

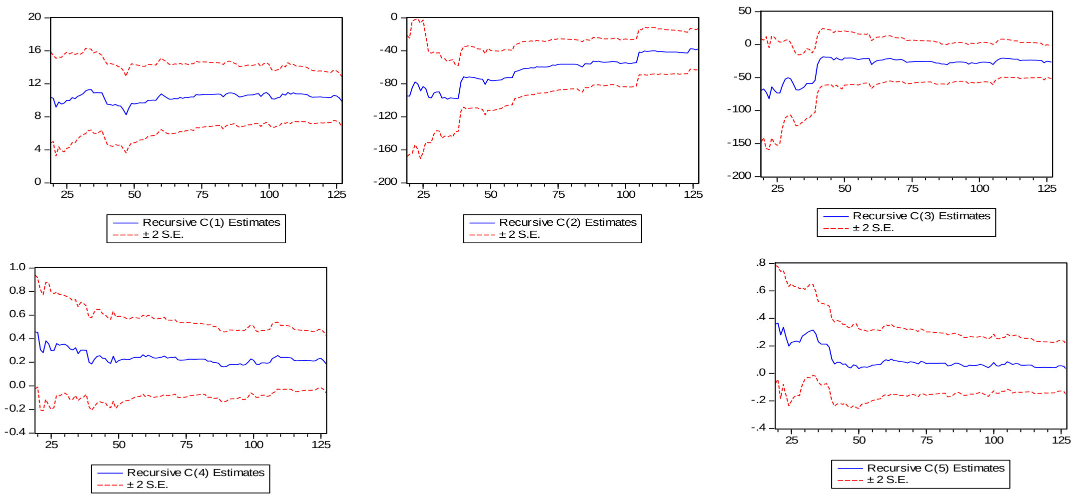


Figure 5.31: ***JORSPD / Inflation Rate / REPO Rate Recursive Coefficients–D(JORSPD) Equation***

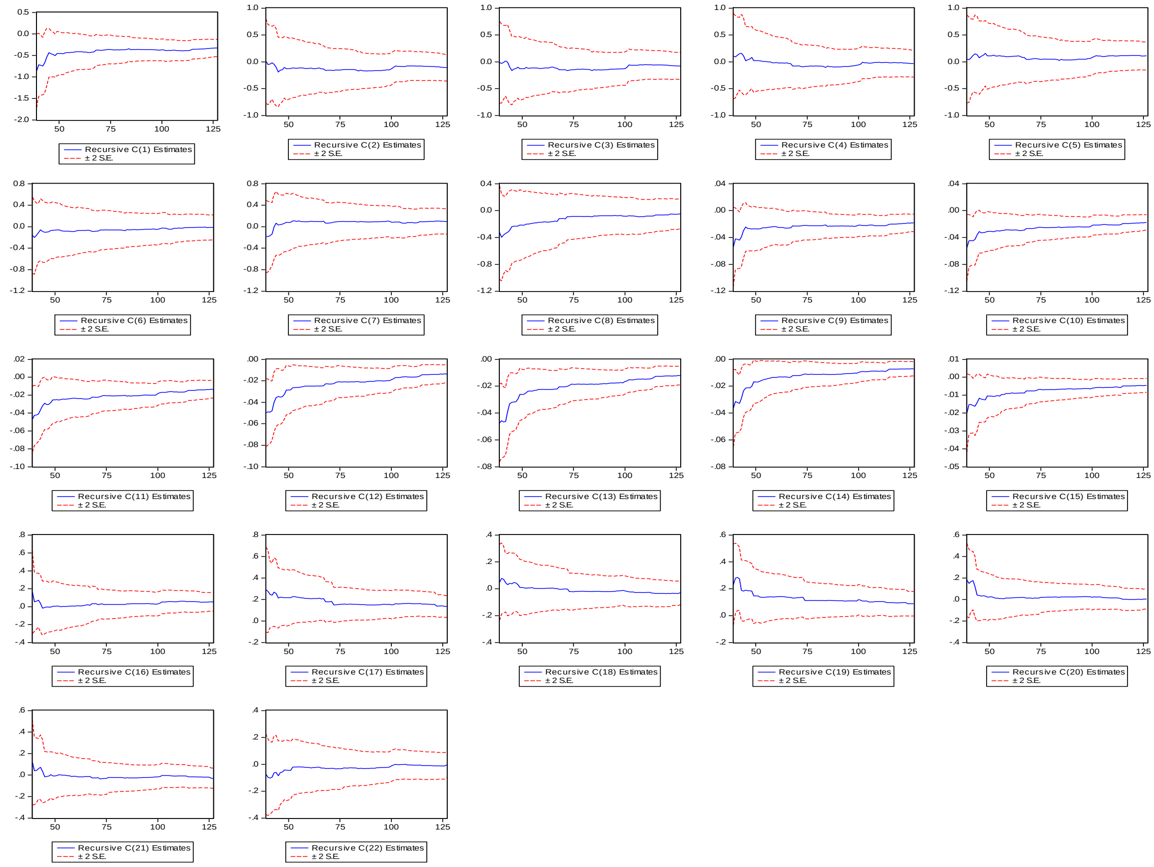


Figure 5.32: ***JORSPD / Inflation Rate / REPO Rate Recursive Coefficients– D(INFRATE) Equation***

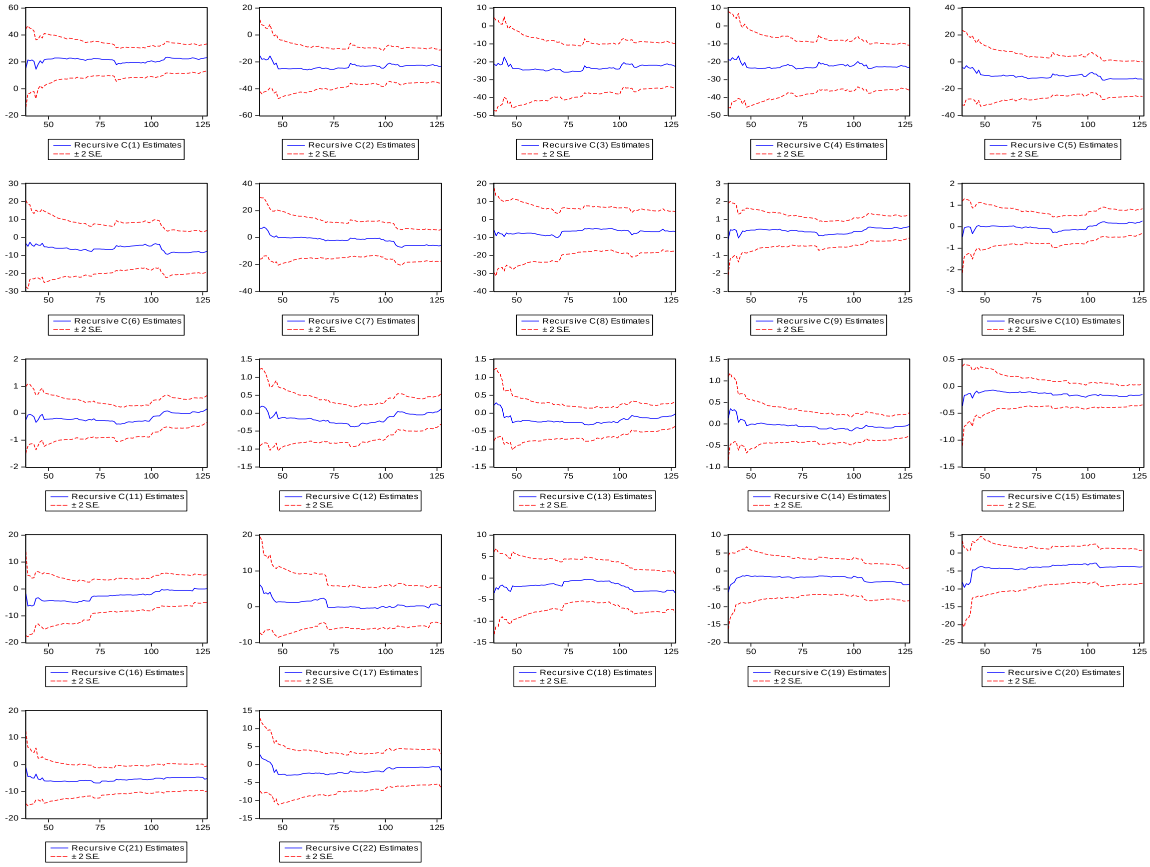


Figure 5.33: ***JORSPD / Inflation Rate / REPO Rate Recursive Coefficients–D(REPO) Equation***

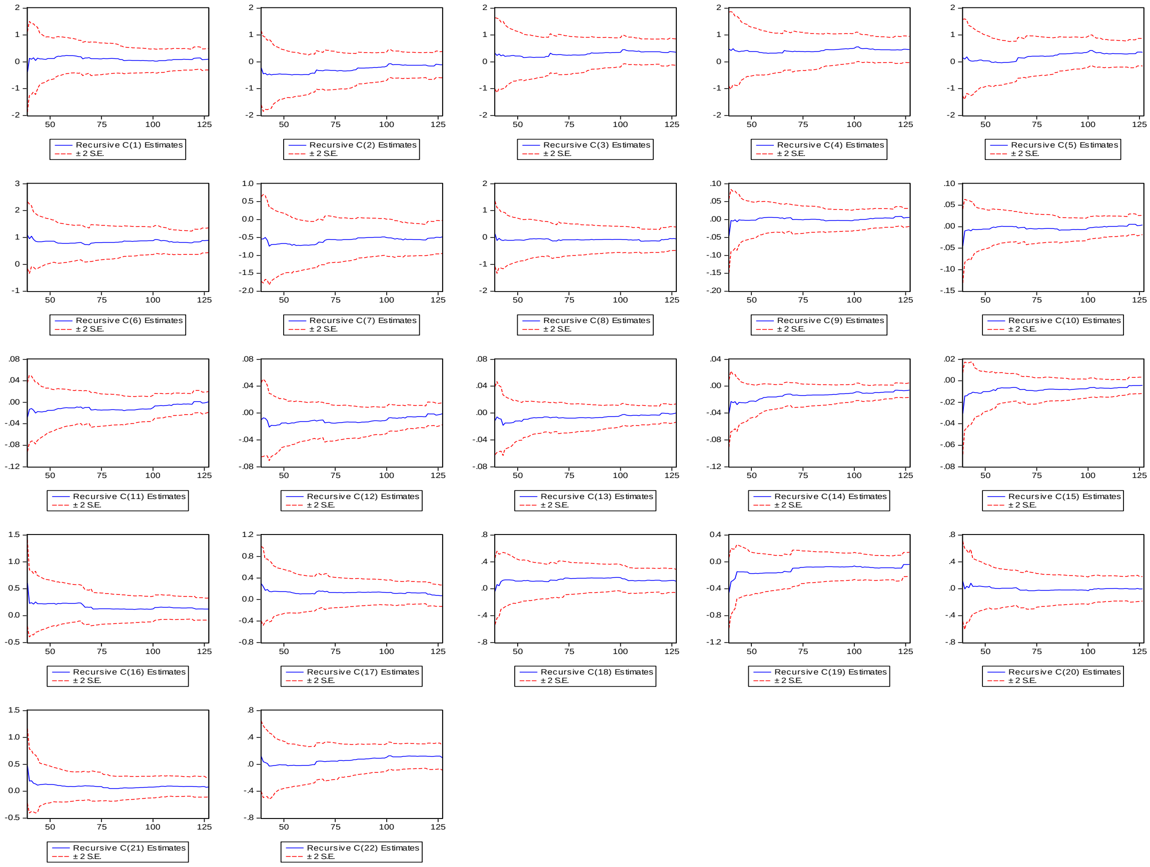


Figure 5.34: ***Impulse Response Under VAR System - (JORSPD And INFRATE)***

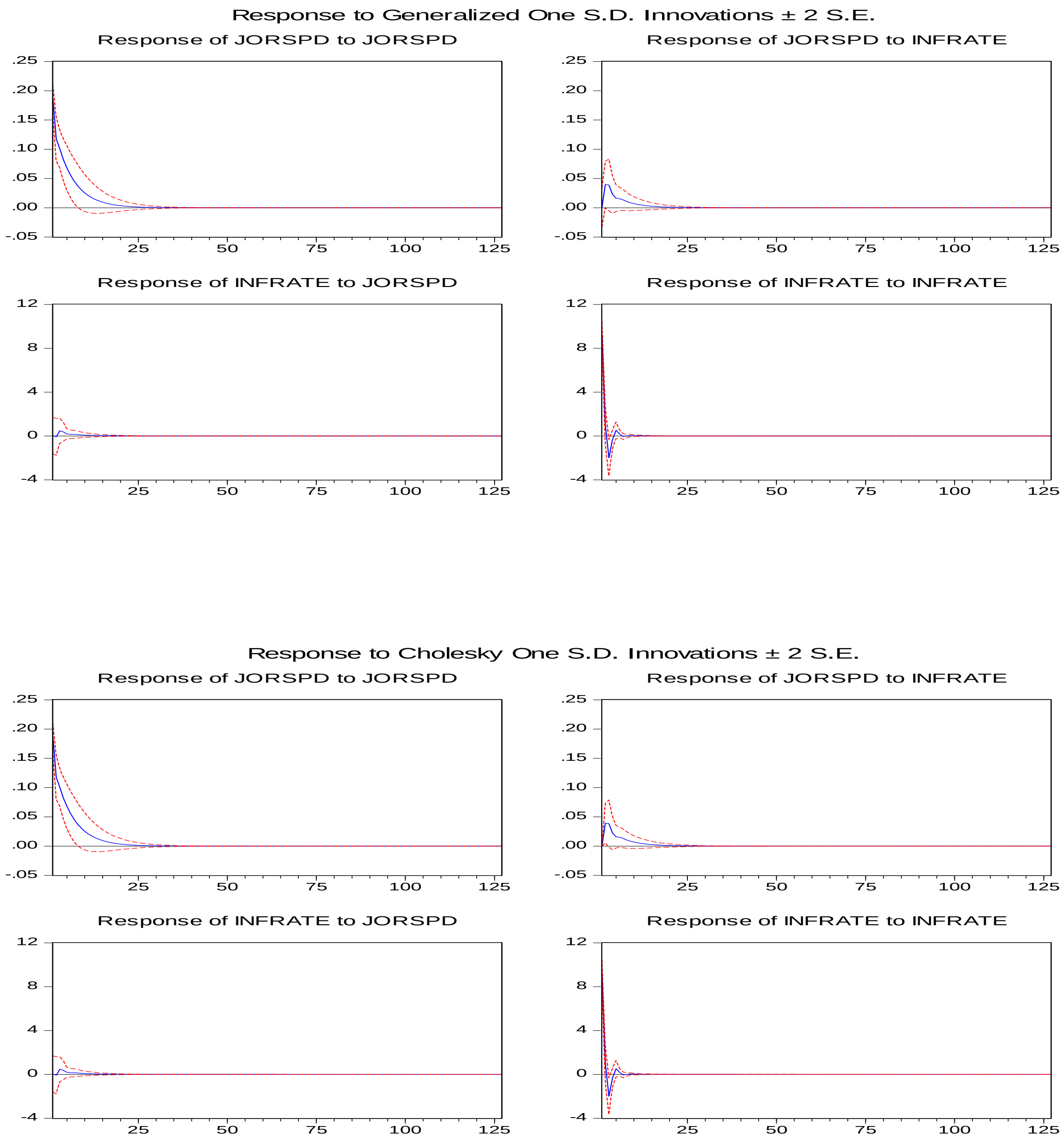


Figure 5.35: ***Impulse Response Under VAR System - (USTBSPD And INFRATE)***

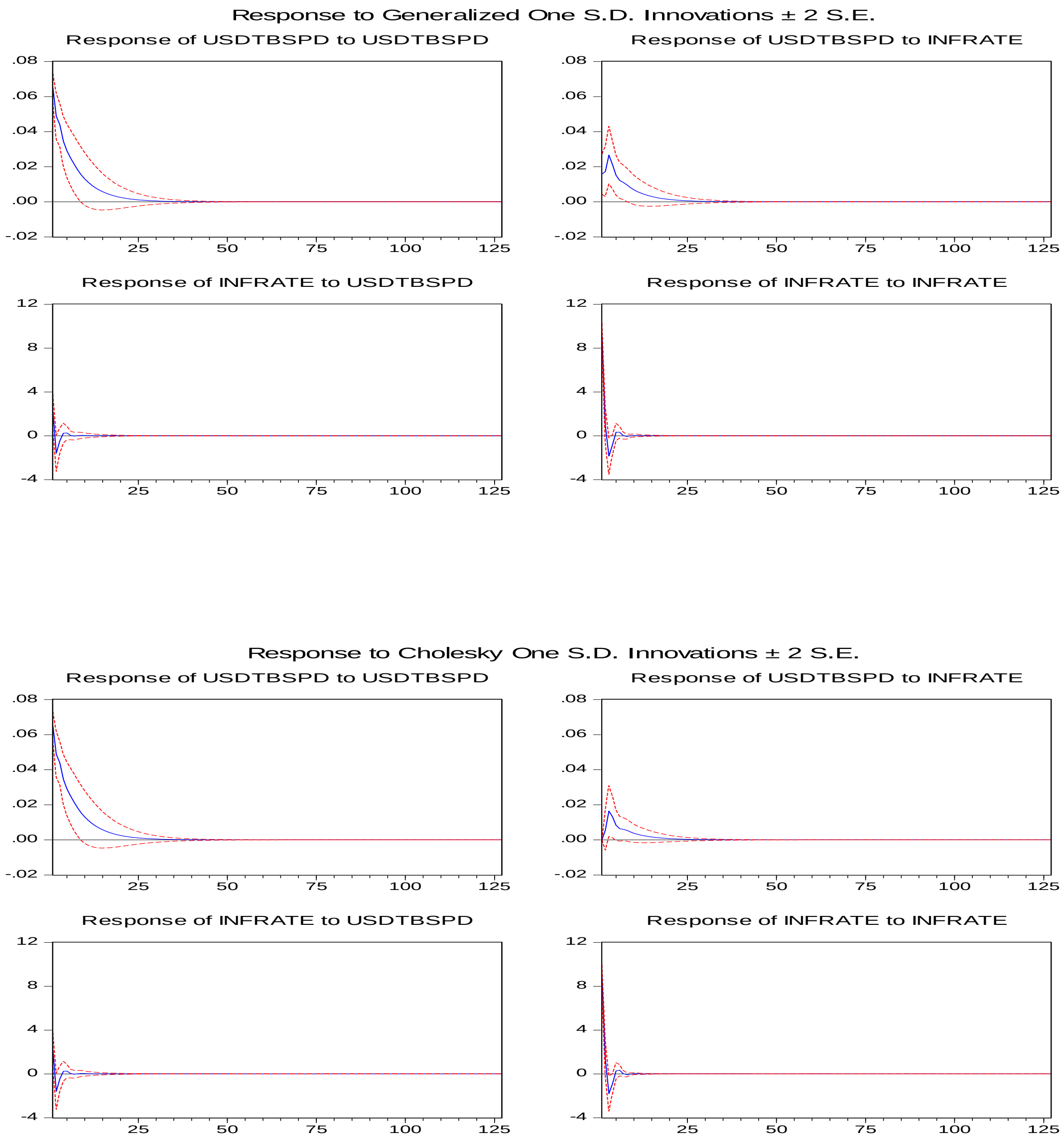
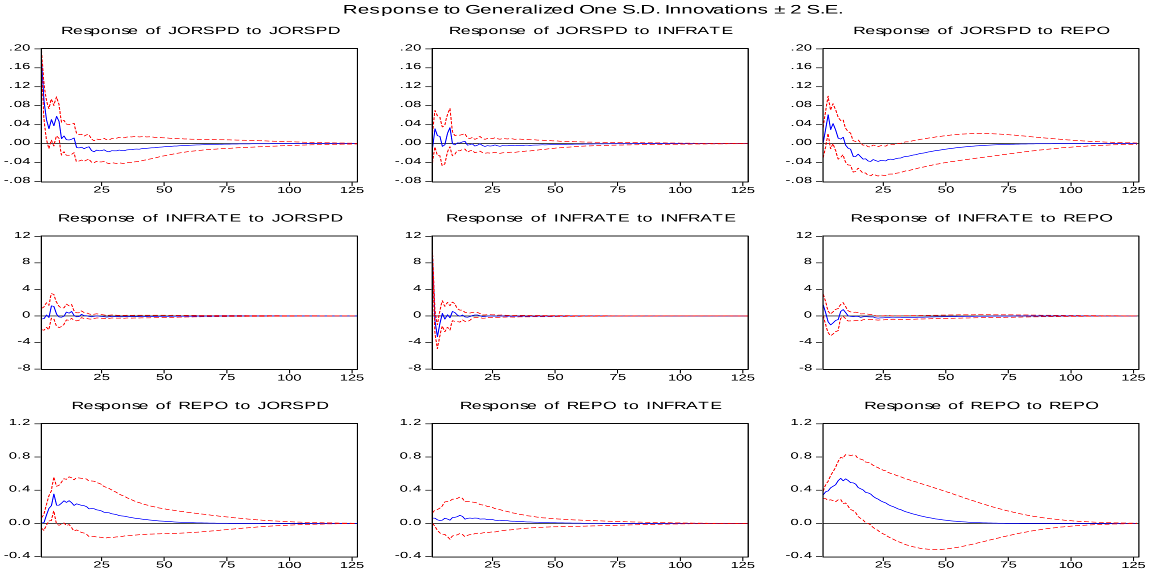


Figure 5.3 : ***Impulse Response Under VAR System - (JORSPD, INFRATE And REPO)***



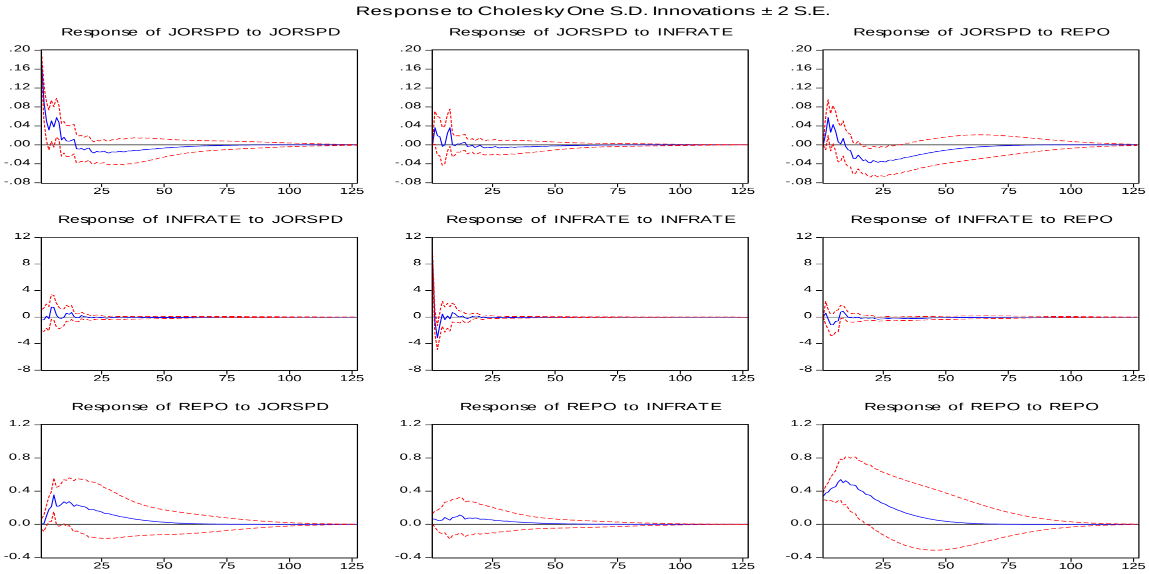


Table 5.1.1: ***Unit Root Test (ADF AIC), (Levels And First Differences)***

Test Of The Order Of Integration Using (AIC)	**Exogenous: Constant**	**Exogenous: Constant, Linear Trend**	**Exogenous: None**
Variables	**t-Statistics I(1) (No. Of Lags)**	**t-Statistics I(1) (No. Of Lags)**	**t-Statistics I(0) (No. Of Lags)**
Levels			
CDs (Three Month Rate)	*-1.660915(6)	*-1.785321(6)	
CDs (Six Month Rate)	*-1.824287(2)	*-1.695064(2)	
USTBILLS (Three Month Rate)	*-2.005293(10)	*-2.301176(10)	
USTBILLS (Six Month Rate)	*-1.955631(12)	*-2.077217(12)	
Repo Rate	*-1.412065(2)	*-1.212599(2)	
Smooth CDs (Three Month Rate)	*-1.720856(1)	*-1.427685(1)	
Smooth CDs (Six Month Rate)	*-1.814090(1)	*-1.587787(1)	
First Difference			
Δ CDs (Three Month Rate)			**-3.562698(5)
Δ CDs (Six Month Rate)			**-5.775701(1)
Δ USTBILLS (Three Month Rate)			**-2.238462(9)
Δ USTBILLS (Six Month Rate)			**-2.421192(11)
Δ Repo Rate			**-10.20930(0)
Δ Smooth CDs (Three Month Rate)			**-8.385052(0)
Δ Smooth CDs (Six Month Rate)			**-7.916715(0)

Notes:
-The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 6.0, (2007).
-Levels
*** Denote that the null hypothesis of non-stationarity cannot be rejected at (1%,5%,10%) significance levels.**
- First difference
**** Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

Table 5.1.2: ***Unit Root Test (ADF SIC), (Levels And First Differences)***

Test Of The Order Of Integration Using (SIC)	**Exogenous: Constant**	**Exogenous: Constant, Linear Trend**	**Exogenous: None**
Variables	**t-Statistics I(1) (No. Of Lags)**	**t-Statistics I(1) (No. Of Lags)**	**t-Statistics I(0) (No. Of Lags)**
Levels			
CDs (Three Month Rate)	*-1.660915(6)	*-1.785321(6)	
CDs (Six Month Rate)	*-1.824287(2)	*-1.695064(2)	
USTBILLS (Three Month Rate)	*-1.953704(3)	*-2.112442(3)	
USTBILLS (Six Month Rate)	*-2.087421 (10)	*-2.264889 (10)	
Repo Rate	*-1.412065(2)	*-1.212599(2)	
Smooth CDs (Three Month Rate)	*-1.720856(1)	*-1.427685(1)	
Smooth CDs (Six Month Rate)	*-1.814090(1)	*-1.587787(1)	
First Difference			
Δ CDs (Three Month Rate)			**-3.562698(5)
Δ CDs (Six Month Rate)			**-5.775701(1)
Δ USTBILLS (Three Month Rate)			**-2.744850(2)
Δ USTBILLS (Six Month Rate)			**-2.421192(11)
Δ Repo Rate			**-10.20930(0)
Δ Smooth CDs (Three Month Rate)			**-8.385052(0)
Δ Smooth CDs (Six Month Rate)			**-7.916715(0)

Notes:
-The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 6.0, (2007).
-Levels
*** Denote that the null hypothesis of non-stationarity cannot be rejected at (1%,5%,10%) significance levels.**
-First difference
**** Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

Table 5.2: ***Unit Root Test (PP), (Levels And First Differences)***

Test Of The Order Of Integration Using (PP)	**Exogenous: Constant**	**Exogenous: Constant, Linear Trend**	**Exogenous: None**
Variables	**t-Statistics I(1) (Bandwidth)**	**t-Statistics I(1) (Bandwidth)**	**t-Statistics I(0) (Bandwidth)**
Levels			
CDs (Three Month Rate)	*-1.913189(6)	*-1.579892(6)	
CDs (Six Month Rate)	*-2.012310(6)	*-1.738847(6)	
USTBILLS (Three Month Rate)	*-1.438436(8)	-*1.4033870(8)	
USTBILLS (Six Month Rate)	*-1.447820(8)	*-1.373904(8)	
Repo Rate	*-1.528564(6)	*-1.287074(5)	
Smooth CDs (Three Month Rate)	*-1.870871(5)	*-1.516635(5)	
Smooth CDs (Six Month Rate)	*-2.000623(6)	*-1.724705(6)	
First Difference			
Δ CDs (Three Month Rate)			**-11.04248(5)
Δ CDs (Six Month Rate)			**-9.340094(4)
Δ USTBILLS (Three Month Rate)			**-7.598994(6)
Δ USTBILLS (Six Month Rate)			**-7.160118(6)
Δ Repo Rate			**-10.37731(5)
Δ Smooth CDs (Three Month Rate)			**-8.402042(2)
Δ Smooth CDs (Six Month Rate)			**-7.921693(2)

Notes:
- The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 6.0, (2007).
- Levels
*** Denote that the null hypothesis of non-stationarity cannot be rejected at (1%,5%,10%) significance levels.**
- First difference
**** Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

Table 5.3.1: ***Unit Root Test (ADF AIC). (Term Spreads And Inflation Rates - Levels And First Differences)***

Test Of The Order Of Integration Using (AIC)	Exogenous: Constant	Exogenous: Constant, Linear Trend	Exogenous: None
Variables	**t-Statistics I(1) I(0) (No. Of Lags)**	**t-Statistics I(1) I(0) (No. Of Lags)**	**t-Statistics I(1) I(0) (No. Of Lags)**
Levels			
CDs Spread	*-2.095460(6)	*-2.734540(6)	
Smooth CDs Spread	*-2.530075(2)	*-2.880118(6)	
USTBILLS Spread	***-3.071327(1)	*-2.868476(2)	
Inflation Rate (H=1 Month)	**-9.368042(1)		*-0.949358(11)
Inflation Rate (H=12 Month)	*-0.899845(12)		*0.155363(12)
First Difference			
Δ CDs Spread			**-5.265822(5)
Δ Smooth CDs Spread			**-10.01763(1)
Δ USTBILLS Spread			**-9.645465(1)
Δ Inflation Rate (H=1 Month)			**-6.608706(10)
Δ Inflation Rate (H=12 Month)			**-4.452857(11)

Notes:

- The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 6.0, (2007).

***Denote that the null hypothesis of non-stationarity cannot be rejected at (1%,5%,10%) significance levels.**

****Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

***** Denote that the null hypothesis of non-stationarity cannot be rejected at (1%) significance level.**

Table 5.3.2: ***Unit Root Test (ADF SIC). (Term Spreads And Inflation Rates - Levels And First Differences)***

Test Of The Order Of Integration Using (SIC)	**Exogenous: Constant**	**Exogenous: Constant, Linear Trend**	**Exogenous: None**
Variables	**t-Statistics I(1) I(0) (No. Of Lags)**	**t-Statistics I(1) I(0) (No. Of Lags)**	**t-Statistics I(1) I(0) (No. Of Lags)**
Levels			
CDs Spread	*-2.756355(2)	*-3.322676(2)	
Smooth CDs Spread	*-2.530075(2)	*-2.960010(2)	
USTBILLS Spread	***-3.071327(1)	*-2.868476(2)	
Inflation Rate (H=1 Month)	**-9.368042(1)		*-0.949358(11)
Inflation Rate (H=12 Month)	*-0.899845(12)		*0.155363(12)
First Difference			
Δ CDs Spread			**-9.511755(2)
Δ Smooth CDs Spread			**-10.01763(1)
Δ USTBILLS Spread			**-9.645465(1)
Δ Inflation Rate (H=1 Month)			**-8.717664(6)
Δ Inflation Rate (H=12 Month)			**-4.452857(11)

Notes:

- The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 6.0, (2007).

***Denote that the null hypothesis of non-stationarity cannot be rejected at (1%,5%,10%) significance levels.**

****Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**

*****Denote that the null hypothesis of non-stationarity cannot be rejected at (1%) significance level.**

Table 5.4: ***Unit Root Test (PP). (Term Spreads And Inflation Rates - Levels And First Differences)***

Test Of The Order Of Integration Using (PP)	**Exogenous: Constant**	**Exogenous: Constant, Linear Trend**	**Exogenous: None**
Variables	**t-Statistics I(1) I(0) (Bandwidth)**	**t-Statistics I(1) I(0) (Bandwidth)**	**t-Statistics I(1) I(0) (Bandwidth)**
Levels			
CDs Spread	**-4.032043(4)	**-4.950682(5)	
Smooth CDs Spread	*-2.829582(5)	*-3.421230(5)	
USTBILLS Spread	**-3.496339(2)	***-3.732304(2)	
Inflation Rate (H=1 Month)	**-10.03905(8)		**-9.157681(2)
Inflation Rate (H=12 Month)	*-2.446016(8)		*-1.482697(12)
First Difference			
Δ CDs Spread			**-21.85679(25)
Δ Smooth CDs Spread			**-16.14059(63)
Δ USTBILLS Spread			**-13.92698(10)
Δ Inflation Rate (H=1 Month)			**-45.16774(52)
Δ Inflation Rate (H=12 Month)			**-11.92901(21)

Notes:
- The critical values are taken from MacKinnon (1996) as reported by Eviews program, version 6.0, (2007).
*** Denote that the null hypothesis of non-stationarity cannot be rejected at (1%,5%,10%) significance levels.**
**** Denote the rejection of the null hypothesis of non-stationarity at (1%, 5%,10%) significance levels.**
*****Denote that the null hypothesis of non-stationarity cannot be rejected for at (1%) significance level.**

Table 5.5: ***ARFIMA Model For US Term Spread***

			AR(p) COEFFECIENTS	MA(q) COEFFECIENTS		
ARMA	$\hat{\beta}_0$	$\hat{d}$	$\hat{\phi}_i$	Θ_i	**log-likelihood**	**AIC**
(0,0)	**0.1013 (0.384)**	**0.5 (34.9)***	**-**	**-**	**155.057**	**-2.395**

*** The t-statistics is significant at 5% level**

Table 5.6: ***The Percentage Of Rejection Under Dickey Fuller (DF) Test, (Monte Carlo Analysis)***

Replications =50,000	**The Percentage Of Rejection Of The Null Hypothesis Of Unit Root At 5% Level Of Significance Sample Sizes = 25, 50, 100, 150, And 200**				
	25	**50**	**100**	**150**	**200**
	t-Statistic<-2.99	**t-Statistic<-2.92**	**t-Statistic<-2.89**	**t-Statistic<-2.88**	**t-Statistic<-2.88**
Variance = 0	**5.04%**	**4.79%**	**5.01%**	**5.02%**	**4.96%**
Variance = 0.5	**9.90%**	**10.89%**	**11.73%**	**11.82%**	**11.85%**
Variance = 1	**25.10%**	**31.77%**	**34.92%**	**36.59%**	**36.67%**
Variance = 1.5	**44.00%**	**55.92%**	**61.39%**	**63.48%**	**63.86%**
Variance = 2	**60.00%**	**74.08%**	**79.38%**	**81.23%**	**81.96%**
Variance = 3	**79.47%**	**92.35%**	**95.27%**	**96.10%**	**96.43%**
Variance = 4	**88.78%**	**97.90%**	**99.11%**	**99.46%**	**99.54%**
Variance = 5	**93.18%**	**99.44%**	**99.87%**	**99.94%**	**99.96%**
Variance = 6	**95.23%**	**99.86%**	**99.98%**	**100.00%**	**100.00%**
Variance = 7	**96.45%**	**99.96%**	**100%**	**100.00%**	**100.00%**

Table 5.7: ***The Critical Values, (Monte Carlo Analysis)***

Replications =50,000	The Critical Values For All Samples' Sizes														
	25			50			100			150			200		
Critical Values	**1%**	**5%**	**10%**	**1%**	**5%**	**10%**	**1%**	**5%**	**10%**	**1%**	**5%**	**10%**	**1%**	**5%**	**10%**
Variance = 0	**-3.77**	**-2.99**	**-2.63**	**-3.56**	**-2.90**	**-2.59**	**-3.49**	**-2.89**	**-2.58**	**-3.48**	**-2.88**	**-2.57**	**-3.46**	**-2.88**	**-2.57**
Variance = 0.5	**-4.21**	**-3.36**	**-2.98**	**-4.02**	**-3.33**	**-2.97**	**-4.00**	**-3.34**	**-2.98**	**-4.02**	**-3.32**	**-2.97**	**-4.00**	**-3.32**	**-2.97**
Variance = 1	**-5.08**	**-4.15**	**-3.69**	**-5.12**	**-4.27**	**-3.83**	**-5.29**	**-4.41**	**-3.94**	**-5.36**	**-4.44**	**-3.97**	**-5.40**	**-4.45**	**-4.00**
Variance = 1.5	**-5.77**	**-4.80**	**-4.33**	**-6.12**	**-5.18**	**-4.70**	**-6.58**	**-5.57**	**-5.02**	**-6.78**	**-5.71**	**-5.13**	**-6.94**	**-5.79**	**-5.21**
Variance = 2	**-6.29**	**-5.26**	**-4.80**	**-6.87**	**-5.91**	**-5.41**	**-7.63**	**-6.57**	**-5.99**	**-8.05**	**-6.87**	**-6.24**	**-8.35**	**-7.06**	**-6.40**
Variance = 3	**-6.87**	**-5.84**	**-5.36**	**-7.80**	**-6.84**	**-6.36**	**-9.09**	**-8.04**	**-7.45**	**-9.87**	**-8.68**	**-8.03**	**-10.47**	**-9.13**	**-8.42**
Variance = 4	**-7.18**	**-6.16**	**-5.67**	**-8.34**	**-7.40**	**-6.91**	**-9.98**	**-8.97**	**-8.41**	**-11.03**	**-9.92**	**-9.29**	**-11.88**	**-10.62**	**-9.92**
Variance = 5	**-7.36**	**-6.36**	**-5.86**	**-8.70**	**-7.75**	**-7.28**	**-10.52**	**-9.56**	**-9.05**	**-11.80**	**-10.76**	**-10.18**	**-12.83**	**-11.66**	**-11.01**
Variance = 6	**-7.50**	**-6.49**	**-5.99**	**-8.93**	**-7.98**	**-7.52**	**-10.91**	**-9.99**	**-9.49**	**-12.32**	**-11.35**	**-10.81**	**-13.51**	**-12.41**	**-11.82**
Variance = 7	**-7.59**	**-6.57**	**-6.07**	**-9.11**	**-8.15**	**-7.70**	**-11.19**	**-10.30**	**-9.81**	**-12.72**	**-11.77**	**-11.26**	**-13.98**	**-12.95**	**-12.41**

Table 5.8: ***The Bivariate Cointegration Analysis, Testing The Validity Of Fisher Hypothesis (FH) Using Monthly Inflation Data***

Bivariate Cointegration	No Of Lags (No Serial Correlation)	λ Max		t-Statistic	Critical Value At 5%	λ Trace		t-Statistic	Critical Value At 5%	The Cointegrating Vector (Normalized)*
		Null	**Alt.**			**Null**	**Alt.**			
(CD3M , INFRATE)	**1**	**r = 0**	**r = 1**	**68.05**	**15.89**	**r = 0**	**r ≥ 1**	**71.18**	**20.26**	**(1, -38.08)**
(CD6M , INFRATE)	**2**	**r = 0**	**r = 1**	**49.29**	**15.89**	**r = 0**	**r ≥ 1**	**52.91**	**20.26**	**(1, -28.42)**

*** The cointegrating vector is identified at 5% level of significant.**

Table 5.9: ***The Cointegration Analysis, Testing The Validity Of Fisher Hypothesis (FH) Between The Three Month Interest Rate And The Monthly Inflation Rate***

Panel A			
Cointegration Equation	**Normalized Cointegration Coefficients**		
	CD3M	**INFRATE**	**CONSTANT**
	1	***-38.07823**	**111.8113**
SE t-Statistic [ ]		**4.05585** **[-9.38846]**	**30.3951** **[3.67860]**

Panel B			
Testing The Strong Form Of Fisher Effect **Imposing Restrictions (1, -1)**			
	CD3M	**INFRATE**	**LR Statistic (Probability)**
Restrictions Are Rejected At 5% (Fisher Hypothesis Does Not Hold)	**1**	**-1**	**6.529 (0.011)**

***Significant at level 5%.**

Table 5.10: ***The Cointegration Analysis, Testing The Validity Of Fisher Hypothesis (FH) Between The Six Month Interest Rate And The Monthly Inflation Rate***

Panel A			
Cointegration Equation	**Normalized Cointegration Coefficients**		
	CD6M	**INFRATE**	**CONSTANT**
	1	***-28.42081**	**81.4312**
SE t-Statistic [ ]		**3.73112** **[-7.61724]**	**22.2491** **[3.65998]**
Panel B			
Testing The Strong Form Of Fisher Effect **Imposing Restrictions (1, -1)**			
	CD6M	**INFRATE**	**LR Statistic (Probability)**
Restrictions Are Rejected At 5% (Fisher Hypothesis Does Not Hold)	**1**	**-1**	**6.879 (0.008)**

***Significant at level 5%.**

Table 5.11 : ***The Bivariate Cointegration Analysis, Testing The Validity Of Fisher Hypothesis (FH) Using The Yearly Inflation Rate***

Bivariate Cointegration	No Of Lags (No Serial Correlation)	λ Max		t-Statistic	Critical Value At 5%	λ Trace		t-Statistic	Critical Value At 5%	The Cointegrating Vector (Normalized)
		Null	Alt.			Null	Alt.			
(CD3M , INFRATE)	**5**	**r = 0**	**r = 1**	**6.54**	**15.89**	**r = 0**	**r ≥ 1**	**8.31**	**20.26**	**No Coint***
(CD6M , INFRATE)	**6**	**r = 0**	**r = 1**	**7.96**	**15.89**	**r = 0**	**r ≥ 1**	**9.45**	**20.26**	**No Coint***

*** No cointegrating vector is identified either at 5% or 10% level of significance.**

Table 5.12: ***The Bivariate Cointegration Analysis Between Each Term Spread (The Domestic And The US) And The Monthly Inflation Rate***

Bivariate Cointegration	No Of Lags (No Serial Correlation)	λ Max		t-Statistic	Critical Value At 5%	λ Trace		t-Statistic	Critical Value At 5%	The Cointegrating Vector (Normalized)*
		Null	Alt.			Null	Alt.			
(JORSPD , INFRATE)	**2**	**r = 0**	**r = 1**	**52.80**	**15.89**	**r = 0**	**r ≥ 1**	**59.64**	**20.26**	**(1,-0.173780)**
(USTBSPD , INFRATE)	**2**	**r = 0**	**r= 1**	**48.60**	**15.89**	**r = 0**	**r ≥ 1**	**54.62**	**20.26**	**(1,-0.107263)**

*** The cointegrating vector is identified at 5% level of significant.**

Table 5.13: ***The Cointegration Analysis And The Error Correction Model (ECM) For JORSPD And INFRATE***

Panel A				
Cointegration Equation	**Normalized Cointegration Coefficients**			
	JORSPD	**INFRATE**	**CONSTANT**	
	1	***-0.173780**	***0.424015**	
SE t-Statistic [ ]		**0.02181** **[-7.96624]**	**0.12886** **[3.29059]**	
Panel B				
Vector Error Correction Estimates (VECM)				
Coefficients Of The VECM	**D(JORSPD)**	**SE** **t-Statistic[ ]**	**D(INFRATE)**	**SE** **t-Statistic[ ]**
Cointegration Equation (ECT)	***-0.048584**	**0.01898** **[-2.55962]**	***6.935852**	**0.92427** **[7.50411]**
D(JORSPD (-1))	***-0.291881**	0.08726 **[-3.34484]**	****-7.137158**	4.24923 **[-1.67964]**
D(JORSPD (-2))	***-0.227060**	0.08740 **[-2.59786]**	****-7.131830**	4.25603 **[-1.67570]**
D(INFRATE (-1))	**-0.003551**	0.00254 **[-1.39683]**	***0.286466**	0.12381 **[2.31385]**
D(INFRATE (-2))	**-0.002268**	0.00190 **[-1.19388]**	**0.075895**	0.09249 **[0.82055]**
R – Squared	**0.172042**		**0.491637**	
Adjusted R – Squared	**0.144212**		**0.474549**	

***Significant at level 5%.**
**** Significant at level 10%.**

Table 5.14: ***The Constructed Error Correction Model (ECM) For JORSPD And INFRATE.***

Vector Error Correction Estimates Using OLS Estimator (Robust SE)				
Coefficients Of The VECM	**D(JORSPD)**	**SE** **t-Statistic[ ]**	**D(INFRATE)**	**SE** **t-Statistic[ ]**
Cointegration Equation (ECT)	***-0.048584**	**0.019041** **[-2.551517]**	***6.935844**	**0.869828** **[7.973809]**
D(JORSPD (-1))	****-0.291881**	**0.173895** **[-1.678494]**	***-7.137152**	**2.233478** **[-3.195533]**
D(JORSPD (-2))	****-0.227060**	**0.136701** **[-1.660999]**	***-7.131826**	**3.423861** **[-2.082978]**
D(INFRATE (-1))	****-0.003551**	**0.002009** **[-1.767409]**	***0.286466**	**0.104493** **[2.741494]**
D(INFRATE (-2))	**-0.002268**	**0.002080** **[-1.090366]**	**0.075895**	**0.068082** **[1.114754]**
R - Squared	**0.172042**		**0.491637**	
Adjusted R - Squared	**0.144212**		**0.474549**	

***Significant at level 5%.**
**** Significant at level 10%.**

Table 5.15: *Granger Causality Results For JORSPD And INFRATE*

Dependent Variables	Short-Run Effects		Long-Run Effects (Weak Exogeneity) ECT Only (Wald Test)	Strong Exogeneity (ECT&Explanatory Variables)	
	D(JORSPD) A_1=0, A_2=0	D(INFRATE) B_1=0, B_2=0		$\alpha_{INFRATE}$ = A_1 = A_2 =0	α_{JORSPD} =B_1=B_2=0
	WALD F-STATISTICS (P-VALUE)		F-STATISTIC (P-VALUE) OF α_{JORSPD} =0 & $\alpha_{INFRATE}$ =0	WALD F-STATISTICS (P-VALUE)	
D(JORSPD)	–	1.574 (0.2115)	*6.510 (0.0120)	–	**2.589 (0.0562)
D(INFRATE)	*5.108 (0.0074)	–	*63.582 (0.0000)	*26.465 (0.0000)	–

***Significant at level 5%.**
**** Significant at level 10%.**

Table 5.16: ***The Cointegration Analysis And The Error Correction Model (ECM) For USTBSPD And INFRATE.***

Panel A					
Cointegration Equation	**Normalized Cointegration Coefficients**				
	USTBSPD	**INFRATE**	**CONSTANT**		
	1	***-0.107263**	**0.233665**		
SE t-Statistic [ ]		**0.01438** **[-7.45953]**	**0.08240** **[2.83562]**		
Panel B					
Vector Error Correction Estimates (VECM)					
Coefficients Of The VECM	**D(USTBSPD)**	**SE** **t-Statistic[ ]**	**D(INFRATE)**	**SE** **t-Statistic[ ]**	
Cointegration Equation (ECT)	***-0.022154**	**0.01102** **[-2.01060]**	***9.868821**	**1.50347** **[6.56401]**	
D(USTBSPD (-1))	***-0.208743**	**0.09073** **[-2.30067]**	***-37.53485**	**12.3803** **[-3.03182]**	
D(USTBSPD (-2))	****-0.167059**	**0.09183** **[-1.81930]**	***-27.01473**	**12.5296** **[-2.15607]**	
D(INFRATE (-1))	****-0.001732**	**0.00090** **[-1.93014]**	**0.182290**	**0.12246** **[1.48851]**	
D(INFRATE (-2))	**-4.99E-05**	**0.00067** **[-0.07454]**	**0.024431**	**0.09137** **[0.26738]**	
R - Squared	**0.103434**		**0.510202**		
Adjusted R - Squared	**0.073298**		**0.493738**		

***Significant at level 5%.**
**** Significant at level 10%.**

Table 5.17: ***The Constructed Error Correction Model (ECM) For USTBSPD And INFRATE***

Vector Error Correction Estimates Using OLS Estimator (Robust SE)				
Coefficients Of The VECM	**D(USTBSPD)**	**SE** **t-Statistic[ ]**	**D(INFRATE)**	**SE** **t-Statistic[ ]**
Cointegration Equation (ECT)	****-0.022154**	**0.013449** **[-1.647216]**	***9.868849**	**1.120120** **[8.810525]**
D(USTBSPD) (-1))	****-0.208743**	**0.116861** **[-1.786257]**	***-37.53487**	**16.01857** **[-2.343210]**
D(USTBSPD) (-2))	***-0.167059**	**0.079486** **[-2.101737]**	***-27.01475**	**11.19731** **[-2.412611]**
D(INFRATE) (-1))	****-0.001732**	**0.000937** **[-1.849642]**	***0.182289**	**0.088571** **[2.058116]**
D(INFRATE) (-2))	**-4.99E-05**	**0.000601** **[-0.083087]**	**0.024431**	**0.065279** **[0.374252]**
R - Squared	**0.103434**		**0.510202**	
Adjusted R - Squared	**0.073298**		**0.493738**	

***Significant at level 5%.**
**** Significant at level 10%.**

Table 5.18: ***Granger Causality Results For USTBSPD And INFRATE***

Dependent Variables	Short-Run Effects		Long-Run Effects (Weak Exogeneity) ECT Only (Wald Test)	Strong Exogeneity (ECT&Explanatory Variables)	
	D(USTBSPD) $A_1=A_2=0$	**D(INFRATE)** $B_1=B_2=0$		$\alpha_{INFRATE}=A_1=A_2=0$	$\alpha_{USTBSPD}=B_1=B_2=0$
	WALD F-STATISTICS (P-VALUE)		**F-STATISTIC (P-VALUE) OF** $\alpha_{USTBSPD}=0$ **&** $\alpha_{INFRATE}=0$	**WALD F-STATISTICS (P-VALUE)**	
D(USTBSPD)	–	***3.541** **(0.0321)**	**2.713** **(0.1022)**	–	**2.686** **(0.0497)**
D(INFRATE)	***4.836** **(0.0096)**	–	***77.625** **(0.0000)**	***32.185** **(0.0000)**	–

*** Significant at level 5%.**

Table 5.19: ***The Multivariate Cointegration Test (The Domestic Spread, The Monthly Inflation Rate And The REPO Rate)***

(Multivariate Cointegration)	No of Lags (No Serial Correlation)	λ Max		t-statistic	Critical Value At 5%	λ Trace		t-statistic	Critical Value At 5%	The Cointegrating Vector (Normalized)*
		Null	**Alt.**			**Null**	**Alt.**			
(JORSPD,INFRATE,REPO)	**7**	**r = 0**	**r = 1**	**32.41**	**22.30**	**r = 0**	**r ≥ 1**	**46.53**	**35.19**	**(1, -0.072067, 0.016032, -0.036494)**
		r ≤ 1	**r = 2**	**11.01**	**15.89**	**r ≤ 1**	**r ≥ 2**	**14.13**	**20.26**	**–**
		r ≤ 2	**r = 3**	**3.12**	**9.16**	**r ≤ 2**	**r = 3**	**3.12**	**9.16**	**–**

*** The cointegrating vector is identified at 5% level of significant**

Table 5.20: The Cointegration Analysis, And The Error Correction Model (ECM) For JORSPD, INFRATE And REPO

Panel A				
Cointegration Equation	**Normalized Cointegration Coefficients**			
	JORSPD	**INFRATE**	**REPO**	**CONSTANT**
	1	***-0.072067**	**0.016032**	**-0.036494**
SE t-Statistic [ ]		0.01271 [-5.66961]	0.01418 [1.13056]	0.11870 [-0.30743]

Panel B						
Vector Error Correction Estimates (VECM)						
Coefficients Of The VECM	**D(JORSPD)**	**SE t-Statistic[ ]**	**D(INFRATE)**	**SE t-Statistic[ ]**	**D(REPO)**	**SE t-Statistic[ ]**
Co Integration Equation (ECT)	***-0.328796**	**0.10065 [-3.26674]**	***23.11915**	**5.06651 [4.56313]**	**0.096523**	**0.19813 [0.48717]**
D(JORSPD (-1))	**-0.109224**	0.12327 [-0.88609]	***-23.46992**	6.20500 [-3.78242]	**-0.106377**	0.24265 [-0.43839]
D(JORSPD (-2))	**-0.074961**	0.12433 [-0.60291]	***-22.66641**	6.25865 [-3.62161]	**0.356256**	0.24475 [1.45559]
D(JORSPD (-3))	**-0.031755**	0.12471 [-0.25464]	***-23.36744**	6.27744 [-3.72245]	****0.452214**	0.24549 [1.84212]
D(JORSPD (-4))	**0.113180**	0.12971 [0.87254]	***-13.30410**	6.52953 [-2.03753]	**0.351135**	0.25534 [1.37515]
D(JORSPD (-5))	**-0.014721**	0.11637 [-0.12650]	**-7.742235**	5.85764 [-1.32173]	***0.896947**	0.22907 [3.91562]
D(JORSPD (-6))	**0.094067**	0.11703 [0.80377]	**-5.726444**	5.89122 [-0.97203]	***-0.486320**	0.23038 [-2.11093]
D(JORSPD (-7))	**-0.049895**	0.11199 [-0.44553]	**-6.788234**	5.63741 [-1.20414]	**-0.049970**	0.22046 [-0.22666]
D(INFRATE (-1))	***-0.018522**	0.00649 [-2.85199]	****0.614208**	0.32692 [1.87879]	**0.006250**	0.01278 [0.48890]

Table 5.20: Continued

D(INFRATE (-2))	***-0.017852**	0.00574 [-3.11203]	**0.280156**	0.28877 [0.97018]	**0.004287**	0.01129 [0.37964]
D(INFRATE (-3))	***-0.013709**	0.00492 [-2.78518]	**0.161069**	0.24777 [0.65008]	**0.000862**	0.00969 [0.08902]
D(INFRATE (-4))	***-0.013827**	0.00419 [-3.29968]	**0.122368**	0.21094 [0.58010]	**-0.001074**	0.00825 [-0.13014]
D(INFRATE (-5))	***-0.012332**	0.00346 [-3.56802]	**-0.015476**	0.17398 [-0.08895]	**-3.95E-05**	0.00680 [-0.00580]
D(INFRATE (-6))	***-0.007191**	0.00267 [-2.69762]	**-0.007354**	0.13418 [-0.05481]	**-0.005773**	0.00525 [-1.10012]
D(INFRATE (-7))	***-0.004675**	0.00193 [-2.42414]	**-0.146800**	0.09709 [-1.51204]	**-0.004064**	0.00380 [-1.07043]
D(REPO (-1))	**0.053243**	0.05181 [1.02766]	**0.075014**	0.260801 [0.02876]	**0.123290**	0.10199 [1.20886]
D(REPO (-2))	***0.135292**	0.05065 [2.67137]	**0.396485**	2.54938 [0.15552]	**0.071619**	0.09970 [0.71837]
D(REPO (-3))	**-0.029360**	0.04446 [-0.66036]	**-3.501876**	2.23810 [-1.56466]	**0.110312**	0.08752 [1.26037]
D(REPO (-4))	****0.088342**	0.04561 [1.93697]	**-3.693260**	2.29584 [-1.60867]	**-0.035850**	0.08978 [-0.39931]
D(REPO (-5))	**0.003310**	0.04650 [0.07120]	**-3.695394**	2.34049 [-1.57890]	**0.001236**	0.09153 [0.01351]
D(REPO (-6))	**-0.030429**	0.04660 [-0.65296]	***-5.216454**	2.34586 [-2.22369]	**0.077182**	0.09174 [0.84134]
D(REPO (-7))	**-0.003563**	0.04733 [-0.07528]	**-1.781204**	2.38266 [-0.74757]	**0.098763**	0.09318 [1.05996]
R - Squared	**0.415463**		**0.594146**		**0.427034**	
Adjusted R - Squared	**0.288913**		**0.506281**		**0.302989**	

*** Significant at level 5%.**
**** Significant at level 10%.**

Table 5.21: ***The Constructed Error Correction Model (ECM) For JORSPD, INFRATE And REPO***

Vector Error Correction Estimates (VECM)						
Coefficients Of The VECM	**D(JORSPD)**	**SE t-Statistic[ ]**	**D(INFRATE)**	**SE t-Statistic[ ]**	**D(REPO)**	**SE t-Statistic[ ]**
Co Integration Equation (ECT)	***-0.328797**	**0.120591 [-2.726550]**	***23.11919**	**4.646465 [4.975653]**	**0.096524**	**0.222316 [0.434176]**
D(JORSPD (-1))	**-0.109224**	0.158815 [-0.687741]	***-23.46996**	4.995358 [-4.698354]	**-0.106378**	0.250521 [-0.424626]
D(JORSPD (-2))	**-0.074960**	0.119078 [-0.629506]	***-22.66644**	6.458090 [-3.509775]	***0.356255**	0.162962 [2.186124]
D(JORSPD (-3))	**-0.031754**	0.080484 [-0.394540]	***-23.36747**	4.716785 [-4.954109]	***0.452213**	0.209378 [2.159793]
D(JORSPD (-4))	**0.113180**	0.097523 [1.160555]	***-13.30411**	6.199337 [-2.146054]	**0.351134**	0.237628 [1.477665]
D(JORSPD (-5))	**-0.014720**	0.074074 [-0.198726]	**-7.742245**	5.279039 [-1.466601]	***0.896947**	0.206757 [4.338165]
D(JORSPD (-6))	**0.094067**	0.085747 [1.097034]	**-5.726445**	4.610351 [-1.242085]	**-0.486321**	0.389069 [-1.249962]
D(JORSPD (-7))	**-0.049895**	0.084649 [-0.589438]	**-6.788239**	4.169026 [-1.628255]	**-0.049970**	0.178785 [-0.279498]
D(INFRATE (-1))	***-0.018522**	0.007754 [-2.388698]	****0.614207**	0.315360 [1.947636]	**0.006250**	0.014489 [0.431378]
D(INFRATE (-2))	***-0.017852**	0.008469 [-2.107998]	**0.280155**	0.274126 [1.021993]	**0.004287**	0.011972 [0.358088]
D(INFRATE (-3))	***-0.013709**	0.006658 [-2.059069]	**0.161068**	0.252668 [0.637470]	**0.000863**	0.010281 [0.083896]
D(INFRATE (-4))	****-0.013827**	0.007545 [-1.832743]	**0.122368**	0.223037 [0.548643]	**-0.001074**	0.008357 [-0.128455]

Table 5.21: ***Continued***

D(INFRATE (-5))	**-0.012332	0.007046 [-1.750191]	-0.015476	0.166343 [-0.093037]	-3.94E-05	0.005386 [-0.007322]
D(INFRATE (-6))	-0.007191	0.004781 [-1.504088]	-0.007354	0.121330 [-0.060614]	-0.005773	0.004842 [-1.192218]
D(INFRATE (-7))	-0.004675	0.003092 [-1.512070]	**-0.146800	0.078225 [-1.876632]	-0.004064	0.003793 [-1.071515]
D(REPO (-1))	0.053243	0.058192 [0.914955]	0.075008	1.827303 [0.041049]	0.123290	0.091582 [1.346229]
D(REPO (-2))	**0.135292	0.075282 [1.797141]	0.396480	2.189084 [0.181117]	0.071619	0.066017 [1.084862]
D(REPO (-3))	-0.029360	0.031572 [-0.929951]	-3.501882	2.491139 [-1.405736]	**0.110312	0.058872 [1.873746]
D(REPO (-4))	**0.088342	0.045754 [1.930828]	*-3.693266	1.367785 [-2.700181]	-0.035851	0.092505 [-0.387553]
D(REPO (-5))	0.003310	0.028220 [0.117307]	*-3.695400	1.684702 [-2.193503]	0.001236	0.065270 [0.018940]
D(REPO (-6))	-0.030429	0.047277 [-0.643625]	*-5.216461	1.610972 [-3.238083]	0.077182	0.095972 [0.804214]
D(REPO (-7))	-0.003563	0.026767 [-0.133111]	-1.781211	2.252214 [-0.790871]	0.098763	0.092912 [1.062976]
R - Squared	0.415463		0.594146		0.427034	
Adjusted R - Squared	0.288913		0.506281		0.302990	

*** Significant at level 5%.**
**** Significant at level 10%.**

Table 5.22: ***Granger Causality Results For JORSPD, INFRATE And REPO***

Dependent Variables	Short-Run Effects						***Long-Run Effects (Weak Exogeneity) ECT Only (Wald Test)	Strong Exogeneity (ECT&Explanatory Variables)		
	D(JORSPD)	D(INFRATE)	D(REPO)	A_1=A_2=A_3=A_4=A_5=A_6=A_7=C_1=C_2=C_3=C_4=C_5=C_6=C_7=0	B_1=B_2=B_3=B_4=B_5=B_6=B_7=C_1=C_2=C_3=C_4=C_5=C_6=C_7=0	A_1=A_2=A_3=A_4=A_5=A_6=A_7=B_1=B_2=B_3=B_4=B_5=B_6=B_7=0		$\propto_{JORSPD}$ = B_1=B_2=B_3=B_4=B_5=B_6=B_7=C_1=C_2=C_3=C_4=C_5=C_6=C_7=0	$\propto_{INFRATE}$ = A_1=A_2=A_3=A_4=A_5=A_6=A_7=C_1=C_2=C_3=C_4=C_5=C_6=C_7=0	$\propto_{REPO}$ = A_1=A_2=A_3=A_4=A_5=A_6=A_7=B_1=B_2=B_3=B_4=B_5=B_6=B_7=0
	A_1=A_2=A_3=A_4=A_5=A_6=A_7=0	B_1=B_2=B_3=B_4=B_5=B_6=B_7=0	C_1=C_2=C_3=C_4=C_5=C_6=C_7=0							
	WALD F-STATISTICS (P-VALUE)						F-STATISTIC (P-VALUE) OF α_{JORSPD} =0, $\alpha_{INFRATE}$ =0 & α_{REPO} =0	WALD F-STATISTICS (P-VALUE)		
D(JORSPD)	-	1.056 (0.3978)	1.515 (0.1713)	-	**1.660 (0.0770)	-	*7.434 (0.0076)	*2.294 (0.0079)	-	-
D(INFRATE)	*6.581 (0.0000)	-	*5.017 (0.0001)	*5.074 (0.0000)	-	-	*24.757 (0.0000)	-	*5.137 (0.0000)	-
D(REPO)	*5.982 (0.0000)	0.711 (0.6627)	-	-	-	*3.830 (0.0000)	0.189 (0.6651)	-	-	*3.575 (0.0001)

* Significant at level 5%.
** Significant at level 10%.

Table 5.23 ***The Results Of The Stability Tests***

ECM	The Equations Under Each ECM	CUSUM	CUSUMSQ	Figures
First ECM	JORSPD	STABLE*	UNSTABLE	13 & 15
	INFRATE**	STABLE*	STABLE*	14 & 16
Second ECM	USTBSPD	STABLE*	STABLE*	17 & 19
	INFRATE**	STABLE*	STABLE*	18 & 20
Third ECM	JORSPD	STABLE*	UNSTABLE	21 & 24
	INFRATE**	STABLE*	STABLE*	22 & 25
	REPO RATE	STABLE*	UNSTABLE	23 & 26

*** The stability is recognized within 5% significance boundaries**
****The equation of the inflation rate shows stability under each ECM.**

Table 5.24.1 : ***Variance Decomposition Of The JORSPD***

Horizon	Std. Error (SE)	JORSPD	INFRATE
12 M	0.289349	94.64718	5.352823
24 M	0.290449	94.63412	5.365878
36 M	0.290459	94.63401	5.365992
48 M	0.290459	94.63401	5.365993

Table 5.24.2 : ***Variance Decomposition Of The INFRATE***

Horizon	Std. Error (SE)	JORSPD	INFRATE
12 M	9.595942	0.536132	99.46387
24 M	9.596275	0.542531	99.45747
36 M	9.596278	0.542587	99.45741
48 M	9.596278	0.542587	99.45741

Table 5.25.1: ***Variance Decomposition Of The USTBSPD***

Horizon	Std. Error (SE)	USTBSPD	INFRATE
12 M	0.115362	94.70518	5.294821
24 M	0.116404	94.66039	5.339608
36 M	0.116424	94.65954	5.340457
48 M	0.116425	94.65953	5.340473

Table 5.25.2: ***Variance Decomposition Of The INFRATE***

Horizon	Std. Error (SE)	USTBSPD	INFRATE
12 M	9.587693	8.471855	91.52815
24 M	9.587712	8.472193	91.52781
36 M	9.587712	8.472200	91.52780
48 M	9.587712	8.472200	91.52780

Table 5.26.1 : ***Variance Decomposition Of The JORSPD***

Horizon	Std. Error (SE)	JORSPD	INFRATE	REPO
12 M	0.251737	81.47417	6.238189	12.28764
24 M	0.278946	68.38463	5.387670	26.22770
36 M	0.303214	60.69204	4.898997	34.40896
48 M	0.311985	58.61434	4.783539	36.60212

Table 5.26.2: ***Variance Decomposition Of The INFRATE***

Horizon	Std. Error (SE)	JORSPD	INFRATE	REPO
12 M	10.09556	5.348550	89.28259	5.368861
24 M	10.15690	5.852429	88.39303	5.754536
36 M	10.20405	5.955884	87.59613	6.447983
48 M	10.22745	6.029749	87.20793	6.762317

Table 5.26.3: ***Variance Decomposition Of The REPO***

Horizon	Std. Error (SE)	JORSPD	INFRATE	REPO
12 M	1.788274	18.24758	2.029162	79.72326
24 M	2.326075	19.91682	2.285600	77.79758
36 M	2.445903	20.46861	2.363792	77.16760
48 M	2.466848	20.60766	2.382666	77.00967

CONCLUSIONS

6.1 GENERAL DISCUSSION

Investigating whether the short end of the term structure has the ability to predict the future movements in short term interest rates and the inflation rate has been the main objective of this thesis. The subsidiary objective is to explore the efficiency and the potential of the Jordanian interbank market of different maturities and the primary market for the Central Bank of Jordan Certificates of Deposits.

In order to examine the ability of the term structure to predict the future movements in short term interest rates, the validity of the Expectations Hypothesis (EH) is tested. A number of econometrics techniques are employed for the empirical testing of the EH and two sets of data are used for the same purpose.

The first data set represents the term structure in the Jordanian interbank market of different maturities; that is, the JODIBOR term structure. Despite the main shortcoming of this data set which is the data are available for a very short period; i.e. for just two years, the empirical testing provides evidence that the EH holds for the extreme short end of the JODIBOR term structure and accordingly the interbank market for the very short term interest rates such as the overnight, one week and one month is considered efficient.

Although the single equation regression and the VAR methodology fail to provide support for the Pure Expectations Hypothesis (PEH), except for the correlation coefficient and the standard deviation ratio statistics under the VAR methodology which provide some support, the cointegration analysis on the contrary provides robust evidence that the EH holds for the extreme short end of the JODIBOR term structure; i.e. the EH holds for the spreads that include the very short term interest rates such as the overnight, one week and one month interest rates.

The rejection under the single equation regression and the VAR methodology is not a surprising result because both methods depend on specific assumptions. The rejection under the single equation regression may occur because daily data are used to construct the perfect foresight spread (PFS) which implies that the degree of overlapping is high; and although the Newey West correction is applied under both the OLS and GMM estimators, the effect of the overlapping data may not be resolved completely. While the rejection under the VAR methodology can be attributed to the fact that the Jordanian interbank market of different maturities is a newly established market, it is therefore expected that the market players are still learning and they may not use the VAR methodology for forecasting. On the other hand, if they do use the VAR methodology, then their set of information is different from the one that is used in this study and this complies with the main interpretation of Cuthbertson, Hayes and Nitzsche (1996) that the VAR approach requires that both agents and econometricians use the same set of information, and if the information set that is used by econometricians is different from the one that is used by agents then the estimated coefficients of the VAR will be biased and accordingly the EH will be rejected.

Regarding the rejection of the EH for the spreads that include longer term interest rates under the cointegration analysis, it can be attributed to the fact that the data set covers a very short period, only two years; accordingly the behaviour of the longer term interest rates may not be adequately observed; i.e. long term interest rates need more time to reflect their real behaviour.

The findings of the cointegration analysis that indicate that the extreme short end of the JODIBOR term structure has predictive power are supported by the evidence obtained from studying the evolution of the market players' behaviour. The results of the time varying parameter (TVP) test indicate that the estimated time varying parameter (β_t) approaches the theoretical value one for the spreads that include the very short term interest rates such as the spreads between the overnight and one week rates and between the overnight and one month rates. Therefore, the results of the TVP test confirm strongly that market players' expectations are moving toward rationality, at least for the very short term interest rates.

Regarding the longer term interest rates in the JODIBOR term structure, the results of the TVP comply with those of the cointegration analysis; that is, the EH does not hold for the longer term interest rates, although the upward trending of the estimated time varying parameter (β_t) in the cases of the three and six months' maturities can be considered as an indication that there is a potential for this part of the interbank market to be developed, whereas all the signals indicate that the interbank market of twelve months' maturity; i.e. the longest term in the JODIBOR term structure, does not exist yet.

The empirical investigation achieves its main goal because important facts are revealed about the relationship between the interest rates in the JODIBOR term structure; that is, the very short term interest rates are driven by one common stochastic trend and the EH holds. The non rejection of the EH in the extreme short end of the JODIBOR term structure can be considered as an indicator of the efficiency of the Jordanian interbank market.

Moreover, another attempt has been carried out to test the empirical validity of the EH using a risk-free rate term structure; that is, the CDs' term structure. The main advantage of the CDs’ term structure is that the data of the CDs' interest rates are available for a ten year period which makes it suitable for examining the long run equilibrium relationship between interest rates of different maturities. However, the main limitation is that the data set consists of two maturities only, the three and six months' interest rates, and the six month interest rate series contains many missing values.

The empirical evidence provides support for the EH. The findings of the cointegration analysis for the whole sample period indicate strongly that both interest rates have long run equilibrium relationship; i.e. they share a common trend, and the EH holds. Furthermore, the results of the Granger Causality test indicate that the direction of causality is unidirectional where the long run interest rate; i.e. the six month interest rate, is the strong force of attraction that drives the movement of the three month interest rate while the reverse is not true; i.e the three month interest rate does not cause the six month interest rate.

The results of the causality direction do not comply with the common belief under the EH; that is, short term rate causes long term rate. Therefore further investigation is carried out to check the robustness of the causality results. The findings of the forward recursive cointegration analysis confirm the same original fact about the causality direction and indicate that the Spline function has no significant effect on the causality results, although the absence of cointegration in the first three recursive periods necessitates further analysis. In order to explain the absence of cointegration, the effects of the structural breaks and the learning process particularly at the beginning of the sample period have been addressed. The results of the causality direction have been changed dramatically after accounting for the structural breaks; i.e. the direction of the causality becomes bidirectional which provides additional support for the EH, whereas the findings of the time varying parameter test show no strong evidence of learning at the beginning of the sample period.

The empirical investigation reveals important facts about the relationship between the interest rates in the CDs' term structure. The fact that the EH holds indicates that the spread between the six and three months' interest rates has a predictive power for the future changes in the three month interest rate and this is clear evidence of the efficiency of the primary market. In addition, having bidirectional causality is a very important fact for policy makers because it has an important empirical application, particularly the forecasting application.

The last empirical investigation is related to the ability of the short end of the term structure to predict the inflation rate. The cointegration analysis is used as the main econometrics technique to identify the long run relationship among the variables. The existence of the long run equilibrium relationship is clear evidence that the short term nominal interest rates and/or the term spread contain useful information about the inflation rate. Before employing the cointegration analysis, the order of integration for all the involved variables is proven to be non stationary I(1).

Furthermore, a Monte Carlo experiment is designed to show that the results of the standard unit root tests, particularly the Dickey Fuller (DF) test, are misleading when the data set contains noise within, such as the monthly inflation rate. The Monte Carlo simulation provides robust evidence that the size distortion of the DF test becomes larger as the noise increases in the data and faster as the sample size becomes bigger; and this evidence supports the literature that discusses the size distortion of the DF test.

The empirical evidence indicates that short term nominal interest rates have no predictive power while the domestic spread has. The long run equilibrium relationship between the domestic term spread and the inflation rate is clear evidence that the domestic term spread contains some information about the inflation rate. In addition an investigation is carried out to examine the influence of additional variables, particularly the variables that reflect the monetary policy stance, on the predictability of the domestic term spread. The results of the cointegration analysis show that the estimated coefficients of the domestic term spread remain highly significant despite the fact that an additional variable has been included in the analysis, which indicates that the spread contains information beyond that explained by the monetary policy variables. Furthermore, given that the exchange regime in Jordan has been pegged to the US dollars since 1995, the cointegration analysis findings verify that there is a long run relationship between the US term structure and the Jordanian inflation rate which means that the US term spread contains useful information about the Jordanian inflation rate.

6.2 *CONCLUDING REMARKS*

6.2.1 *THE DATA*

Several econometrics techniques are employed to deal with the main limitations of the data sets that are used for testing. The Spline smoothing function is used to estimate the missing values in the six month CDs' interest rates series in a way that retains the main properties of the original data. Moreover, identifying the true order of integration of the monthly inflation rate becomes an issue in this thesis. A Monte Carlo experiment has been conducted to prove that the standard unit root tests are not adequate when the data contain noise within. It has been proven that the distribution of the t-statistic when the data contain noise within is different from the distribution of the t-statistic under the DF test. Therefore using the DF normal critical values can be misleading and implausible; so instead, new sets of critical values are proposed in this thesis.

6.2.2 *THE EXPECTATIONS HYPOTHESIS (EH)*

A number of methodologies have been used to test the validity of the EH. However, in this thesis, the findings of the cointegration analysis have been adopted because this technique does not have the same major shortcomings as the single equation regression and the VAR methodology. The empirical evidence shows that the EH holds for the extreme short end of the JODIBOR term structure and for the CDs' term structure and this gives an indication about the predictability of the two terms' structure and the efficiency of both the interbank market of short term interest rates and the primary market for the CDs.

The fact that the CDs' term structure has predictive power is a valuable piece of information and it can be the main motivator for the policy designers to consider building the CDs' term structure by introducing other maturities of the CDs to the market like one month, nine month and twelve month maturities. In the case that the Jordanian financial market continues to experience an absence of regular issuance of the Government securities of different maturities and the secondary market for both the CDs and the Government securities remains very thin; then to provide the market with a risk-free rate term structure that extends up to one year, will play an important role in developing the financial market in Jordan and enhancing the pricing of other financial instruments.

In addition, it is worth mentioning that in response to the consequences of the global financial crises that emerged in the third quarter of 2008, and in order to deal with the expectations of the slowdown in economic growth, the Central Bank of Jordan (CBJ) has begun to gradually inject more liquidity into the market by continuing its issuance of the CDs in volumes less than the CDs' matured volumes, and since October 2008, the CBJ ceased the issuance of the CDs. This action is an indicator of the flexibility of the CBJ's monetary policy. However, the CDs are and will remain the main instrument of the monetary policy; therefore it is expected that the CBJ will continue to use this instrument in the future for the domestic liquidity management unless other alternatives become available.

6.2.3 THE INFORMATION CONTENTS OF THE TERM STRUCTURE ABOUT FUTURE INFLATION RATE

The empirical evidence clearly shows that the short term nominal interest rates have no predictive power while the domestic term spread and the US term spread contain some information about the inflation rate.

Although the evidence indicates that the domestic term spread contains some information about the inflation rate, the term spread which represents the slope of the short end of the term structure may not be a better measurement of the steepness of the term structure and accordingly it is not an optimal indicator that reflects the overall market's expectations about future expected inflation. This remark complies with empirical evidence in the literature; that is, when the term spread represents the slope of the very short end of the term structure then it does not normally contain useful information about the changes in the inflation rate, while if the term spread represents the slope of the medium term or the long term segments of the term structure - that is it represents the overall steepness of the term structure - then the term spread is found to contain useful information for the prediction of inflation.

In conclusion, all the objectives of this thesis have been achieved. The predictability of the short end of the term structure has been identified, the efficiency of the newly established market and the primary market has been explored, the limitations of the involved data sets have been dealt with, and the Monte Carlo simulation provides evidence that the size distortion of the DF test increases when the data set contains noise.

6.3 *AREAS OF FURTHER RESEARCH*

This study is the first attempt at understanding the relationship between interest rates of different maturities in the Jordanian financial market. The potential areas for further research are:

- Re-Investigating whether the EH holds for the other segments of the JODIBOR term structure particularly the parts that include longer term interest rates when more data become available, because in this case the true behaviour of the longer term interest rates can be adequately observed .

-Further research about the relationship between the domestic term spread and the inflation rate will be more valuable when longer maturities of interest rates become available, because in this case the term spread will be a better measurement of the overall steepness of the term structure.

-Studying the degree of the linkage between the US term structure and the Jordanian term structure and whether they can substitute for one another.

APPENDIX TO CHAPTER ONE

The following is a detailed example of how the eight perfect foresight spreads (PFS) are calculated using historical data.

1- The PFS Between One Week And Overnight Rates:

$$\text{PFS} = \sum_{i=1}^{7-1} \left(1-\frac{i}{7}\right) \Delta^1 R^1_{t+i(1)} \quad \text{, n= 7 days, m = 1 day so k=} \ \frac{7}{1} = 7.$$

$$\text{PFS} = \Big[\left(1-\frac{1}{7}\right)(\text{r}^1_{t+1} - \text{r}^1_{t}) + \left(1-\frac{2}{7}\right)(\text{r}^1_{t+2} - \text{r}^1_{t+1}) + \left(1-\frac{3}{7}\right)(\text{r}^1_{t+3} - \text{r}^1_{t+2}) +$$

$$\left(1-\frac{4}{7}\right)(\text{r}^1_{t+4} - \text{r}^1_{t+3}) + \left(1-\frac{5}{7}\right)(\text{r}^1_{t+5} - \text{r}^1_{t+4}) + \left(1-\frac{6}{7}\right)(\text{r}^1_{t+6} - \text{r}^1_{t+5})\Big]$$

2- The PFS Between One Month And Overnight Rates:-

$$\text{PFS} = \sum_{i=1}^{28-1} \left(1-\frac{i}{28}\right) \Delta^1 R^1_{t+i(1)} \quad \text{, n= 28 days, m = 1 day so k=} \ \frac{28}{1} = 28.$$

$$\text{PFS} = \Big[\left(1-\frac{1}{28}\right)(\text{r}^1_{t+1} - \text{r}^1_{t}) + \left(1-\frac{2}{28}\right)(\text{r}^1_{t+2} - \text{r}^1_{t+1}) + \left(1-\frac{3}{28}\right)(\text{r}^1_{t+3} - \text{r}^1_{t+2}) +$$

$$\left(1-\frac{4}{28}\right)(\text{r}^1_{t+4} - \text{r}^1_{t+3}) + \left(1-\frac{5}{28}\right)(\text{r}^1_{t+5} - \text{r}^1_{t+4}) + \left(1-\frac{6}{28}\right)(\text{r}^1_{t+6} - \text{r}^1_{t+5}) +$$

$$\left(1-\frac{7}{28}\right)(\text{r}^1_{t+7} - \text{r}^1_{t+6}) + \left(1-\frac{8}{28}\right)(\text{r}^1_{t+8} - \text{r}^1_{t+7}) + \left(1-\frac{9}{28}\right)(\text{r}^1_{t+9} - \text{r}^1_{t+8}) +$$

$$\left(1-\frac{10}{28}\right)(\text{r}^1_{t+10} - \text{r}^1_{t+9}) + \left(1-\frac{11}{28}\right)(\text{r}^1_{t+11} - \text{r}^1_{t+10}) + \left(1-\frac{12}{28}\right)(\text{r}^1_{t+12} - \text{r}^1_{t+11}) +$$

$$\left(1-\frac{13}{28}\right)(\text{r}^1_{t+13} - \text{r}^1_{t+12}) + \left(1-\frac{14}{28}\right)(\text{r}^1_{t+14} - \text{r}^1_{t+13}) + \left(1-\frac{15}{28}\right)(\text{r}^1_{t+15} - \text{r}^1_{t+14}) +$$

$$\left(1-\frac{16}{28}\right)(r^{1}_{t+16} - r^{1}_{t+15})+\left(1-\frac{17}{28}\right)(r^{1}_{t+17} - r^{1}_{t+16}) +\left(1-\frac{18}{28}\right)(r^{1}_{t+18} - r^{1}_{t+17})+$$

$$\left(1-\frac{19}{28}\right)(r^{1}_{t+19} - r^{1}_{t+18})+\left(1-\frac{20}{28}\right)(r^{1}_{t+20} - r^{1}_{t+19}) +\left(1-\frac{21}{28}\right)(r^{1}_{t+21} - r^{1}_{t+20})+$$

$$\left(1-\frac{22}{28}\right)(r^{1}_{t+22} - r^{1}_{t+21}) +\left(1-\frac{23}{28}\right)(r^{1}_{t+23} - r^{1}_{t+22})+\left(1-\frac{24}{28}\right)(r^{1}_{t+24} - r^{1}_{t+23})+$$

$$\left(1-\frac{25}{28}\right)(r^{1}_{t+25} - r^{1}_{t+24}) +\left(1-\frac{26}{28}\right)(r^{1}_{t+26} - r^{1}_{t+25})+\left(1-\frac{27}{28}\right)(r^{1}_{t+27} - r^{1}_{t+26})]$$

3- The PFS Between Three Month And One Month Rates.

$$\text{PFS} = \sum_{i=1}^{3-1}\left(1-\frac{i}{3}\right)\Delta^{28}R^{28}_{t+i(28)} \text{ , n= 84 days, m = 28 day so k= } \frac{84}{28} = 3.$$

$$\text{PFS} = [\left(1-\frac{1}{3}\right)(r^{28}_{t+28} - r^{28}_{t}) +\left(1-\frac{2}{3}\right)(r^{28}_{t+56} - r^{28}_{t+28})]$$

4- The PFS Between Six Month And One Month Rates.

$$\text{PFS} = \sum_{i=1}^{6-1}\left(1-\frac{i}{6}\right)\Delta^{28}R^{28}_{t+i(28)} \text{ , n= 168 days, m = 28 day so k= } \frac{168}{28} = 6.$$

$$\text{PFS} = [\left(1-\frac{1}{6}\right)(r^{28}_{t+28} - r^{28}_{t}) +\left(1-\frac{2}{6}\right)(r^{28}_{t+56} - r^{28}_{t+28})+\left(1-\frac{3}{6}\right)(r^{28}_{t+84} - r^{28}_{t+56})+$$

$$\left(1-\frac{4}{6}\right)(r^{28}_{t+112} - r^{28}_{t+84})+\left(1-\frac{5}{6}\right)(r^{28}_{t+140} - r^{28}_{t+112})]$$

5- The PFS Between The Twelve Month And One Month Rates.

$$\text{PFS} = \sum_{i=1}^{12-1} \left(1-\frac{i}{12}\right) \Delta^{28} R^{28}_{t+i(28)}\ ,\ \text{n= 336 days, m = 28 day so k=}\ \frac{336}{28} = 12.$$

$$\text{PFS} =[\left(1-\frac{1}{12}\right)(r^{28}_{t+28} - r^{28}_{t}) + \left(1-\frac{2}{12}\right)(r^{28}_{t+56} - r^{28}_{t+28}) + \left(1-\frac{3}{12}\right)(r^{28}_{t+84} - r^{28}_{t+56}) +$$

$$\left(1-\frac{4}{12}\right)(r^{28}_{t+112} - r^{28}_{t+84}) + \left(1-\frac{5}{12}\right)(r^{28}_{t+140} - r^{28}_{t+112}) + \left(1-\frac{6}{12}\right)(r^{28}_{t+168} - r^{28}_{t+140}) +$$

$$\left(1-\frac{7}{12}\right)(r^{28}_{t+196} - r^{28}_{t+168}) + \left(1-\frac{8}{12}\right)(r^{28}_{t+224} - r^{28}_{t+196}) + \left(1-\frac{9}{12}\right)(r^{28}_{t+252} - r^{28}_{t+224}) +$$

$$\left(1-\frac{10}{12}\right)(r^{28}_{t+280} - r^{28}_{t+252}) + \left(1-\frac{11}{12}\right)(r^{28}_{t+308} - r^{28}_{t+280})\ ]$$

6- The PFS Between The Six Month And Three Month Rates.

$$\text{PFS} = \sum_{i=1}^{2-1} \left(1-\frac{i}{2}\right) \Delta^{84} R^{84}_{t+i(84)}\ ,\ \text{n= 168 days, m = 84 day so k=}\ \frac{168}{84} = 2.$$

$$\text{PFS} = [\left(1-\frac{1}{2}\right)(r^{84}_{t+84} - r^{84}_{t})]$$

7- The PFS Between Twelve Month And Three Month Rates.

$$\text{PFS} = \sum_{i=1}^{4-1} \left(1-\frac{i}{4}\right) \Delta^{84} R^{84}_{t+i(84)}\ ,\ \text{n= 336 days, m = 84 day so k=}\ \frac{336}{84} = 4.$$

$$\text{PFS} =[\left(1-\frac{1}{4}\right)(r^{84}_{t+84} - r^{84}_{t}) + \left(1-\frac{2}{4}\right)(r^{84}_{t+168} - r^{84}_{t+84}) + \left(1-\frac{3}{4}\right)(r^{84}_{t+252} - r^{84}_{t+168})\ ]$$

8- The PFS Between The Twelve Month And The Six Month Rates.

PFS = $\sum_{i=1}^{2-1} \left(1-\frac{i}{2}\right) \Delta^{168} R_{t+i(168)}^{168}$, n= 336 days, m = 168 day so k= $\frac{336}{168}$ = 2.

PFS =[$\left(1-\frac{1}{2}\right)$(r$_{t+168}^{168}$ - r$_{t}^{168}$)]

BIBLIOGRAPHY

1- ABU NURUDEEN, B.O. and WAFURE, O.G., 2009. An empirical investigation of the Fisher Effect in Nigeria: A Co-Integration and Error Correction Approach", International Review of Business Research Papers, 5(5). 96-109.

2- AGIAKLOGLOU, C. and NEWBOLD, P., 1992. Empirical evidence on Dickey-Fuller-Type Tests. Journal of Time Series Analysis, 13(6), 471-483.

3- ALFRED, A.M., 1968. Business economics. 1 edn. London: Macmillan.

4- AL-KHAZALI, O., 1999. Nominal interest rates and inflation in the Pacific-Basin countries. Management Decision Journal, 37 6), 491-498.

5- AMSLER, C.E., 1986. The Fisher Effect: Sometimes Inverted, Sometimes Not? *Southern Economic Journal*, 52(3), 832.

6- ANDERSON, N., BREEDON, F., DEACON, M., DERRY, A. and MURPHY, G., 1997. Estimating and Interpreting the Yield Curve. Series in financial economics and quantitative analysis. Wiley 1997.

7- ANG, A., PIAZZESI, M. and WEI, M., 2006. What does the yield curve tell us about GDP growth? *Journal of Econometrics*, 131(1-2), 359-403.

8- ANG, J.B. and MCKIBBIN, W.J., 2007. Financial liberalization, financial sector development and growth: Evidence from Malaysia. *Journal of Development Economics*, 84(1), 215-233.

9- ASAFU-ADJAYE, J., 2000. The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries. *Energy Economics*, 22(6), 615-625.

10- ASTERIOU, D. and HALL, S.G., 2007. Applied Econometrics: A Modern Approach Using Eviews and Microfit Revised Edition. Palgrave Macmillan.

11- ATKINS, F.J., 1989. Co-integration, error correction and the Fisher effect. *Applied Economics*, 21(12), 1611.

12- BEKAERT, G. and HODRICK, R.J., 2001. Expectations hypotheses tests. *Journal of Finance*, 56(4), 1357-1394.

13- BERNANKE, B., 2006. Reflections on the yield curve and monetary policy, remarks before the economic club of New York, Federal Reserve Board.

14- BERNARD, H. and GERLACH, S., 1998. Does the Term Structure Predict

Recessions? The International Evidence. *International Journal of Finance and Economics,* 3(3), 195-215.

15- BERUMENT, H. and JELASSI, M.M., 2002. The Fisher hypothesis: A multi-country analysis. *Applied Economics,* 34(13), 1645-1655.

16- BHAR, R., 1996. Modelling Australian Bank Bill Rates: a Kalman Filter Approach. *Accounting & Finance,* 36(1), 1-14.

17- BOERO, G. and TORRICELLI, C., 2002. The information in the term structure of German interest rates. *European Journal of Finance,* 8(1), 21-45.

18 BONHAM, C.S., 1991. Correct cointegration tests of the long-run relationship between nominal interest and inflation. *Applied Economics,* 23(9), 1487.

19- BOOTH, G.G. and CINER, C., 2001. The relationship between nominal interest rates and inflation: International evidence. *Journal of Multinational Financial Management,* 11(3), 269-280.

20- BOX-STEFFENSMEIER, J.M. and TOMLINSON, A.R., 2000. Fractional integration methods in political science. *Electoral Studies,* 19(1), 63-76.

21- BREMNES, H., GJERDE, Ø. and SÆTTEM, F., 2001. Linkages among interest rates in the United States, Germany and Norway. *Scandinavian Journal of Economics,* 103(1), 127-145.

22- BROWN, C.R., CYREE, K.B., GRIFFITHS, M.D. and WINTERS, D.B., 2008. Further analysis of the expectations hypothesis using very short-term rates. *Journal of Banking and Finance,* 32(4), 600-613.

23- BROWN, R.L., DURBIN, J. and EVANS, J.M., 1975. Techniques for Testing the Constancy of Regression Relationships over Time. *Journal of the Royal Statistical Society.Series B (Methodological),* 37(2), 149-192.

24- BUDINA, N., MALISZEWSKI, W., DE MENIL, G. and TURLEA, G., 2006. Money, inflation and output in Romania, 1992-2000. *Journal of International Money and Finance,* 25(2), 330-347.

25- CAMPBELL, J.Y. and SHILLER, R.J., 1991. Yield Spreads and Interest Rate Movements: A Bird's Eye View. *The Review of Economic Studies,* 58(3, Special Issue: The Econometrics of Financial Markets), 495-514.

26- CAMPBELL, J.Y. and SHILLER, R.J., 1987. Cointegration and Tests of Present Value Models. *The Journal of Political Economy,* 95(5), 1062-1088.

27- CARMICHAEL, J. and STEBBING, P.W., 1983. Fisher's Paradox and the Theory of Interest. *The American Economic Review,* 73(4), 619-630.

28- CARNEIRO, F.G., DIVINO, J.A.C.A. and ROCHA, C.H., 2002. Revisiting the Fisher hypothesis for the cases of Argentina, Brazil and Mexico. *Applied Economics Letters*, 9(2), 95-98.

29- CHAREMZA, W.W. and DEADMAN, D.F., 1992. New Directions in Econometric Practice: General to Specific Modelling Cointegration and Vector Autoregression. Edward Elgar, Aldershot 1992.

30- CHEUNG, Y.W. and LAI, K.S., 1998. Power of the Augmented Dickey-Fuller test with information-based lag selection. *Journal of Statistical Computation and Simulation*, 60(1), 57-65.

31- CHOUDHRY, T., 1997. Cointegration analysis of the inverted Fisher effect: Evidence from Belgium, France and Germany. *Applied Economics Letters*, 4(4), 257-260.

32- CHRISTIANSEN, C., ENGSTED, T., JAKOBSEN, S. and TANGGAARD, C., 2002. An empirical study of the term structure of interest rates in Denmark, 1993-2002". Department of Finance, the Aarhus School of Business.

33- COOK, S. and MANNING, N., 2004. Lag optimisation and finite-sample size distortion of unit root tests. *Economics Letters*, 84(2), 267-274.

34- COOK, T. and HAHN, T., 1990. Interest Rate Expectations and the Slope of the Money Market Yield Curve. *Economic Review (00946893)*, 76(5), 3.

35- COORAY, A., 2003. The fisher effect: A survey. *Singapore Economic Review*, 48(2), 135-150.

36- COORAY, A., 2003. A test of the expectations hypothesis of the term structure of interest rates for Sri Lanka. *Applied Economics*, 35(17), 1819-1827.

37- COORAY, A., 2002. Interest Rates and Inflationary Expectations: Evidence on the Fisher Effect in Sri Lanka. *South Asia Economic Journal*, 3(2), 201-216.

38- CROWDER, W.J., 1997. The long-run Fisher relation in Canada. *Canadian Journal of Economics*, 30(4 SUPPL. B), 1124-1142.

39- CROWDER, W.J. and HOFFMAN, D.L., 1996. The long-run relationship between nominal interest rates and inflation: The fisher equation revisited. *Journal of Money, Credit and Banking*, 28(1), 102-118.

40- CROWDER, W.J. and WOHAR, M.E., 1999. Are Tax Effects Important in the Long-Run Fisher Relationship? Evidence from the Municipal Bond Market. *The Journal of Finance*, 54(1), 307-317.

41- CULBERTSON, J.M., 1958. Culbertson on Interest Structure: Reply. *The Quarterly Journal of Economics*, 72(4), 607-613.

42- CUTHBERTSON, K., 1988. Expectations, learning and the Kalman filter. The Manchester School, 1988 Blackwell Publishers Ltd and the Victoria University of Manchester,Volume 56, Issue 3,223 – 246.

43- CUTHBERTSON, K., 1996. The expectations hypothesis of the term structure: The UK interbank market. *Economic Journal*, 106(436), 578-592.

44- CUTHBERTSON, K. and BREDIN, D., 2000. The expectations hypothesis of the term structure: the case of Ireland. The Economic and Social Review, 31(3), 267-281.

45- CUTHBERTSON, K., HALL, S.G. and TAYLOR, M.P., 1992. Applied Econometric Techniques. Harvester Wheatsheaf, Hemel Hemstead 1992.

46- CUTHBERTSON, K., HAYES, S. and NITZSCHE, D., 2000. Are German money market rates well behaved? *Journal of Economic Dynamics and Control*, 24(3), 347-360.

47- CUTHBERTSON, K., HAYES, S. and NITZSCHE, D., 1998. Interest rates in Germany and the UK: Cointegration and error correction models. *Manchester School*, 66(1), 27-43.

48- CUTHBERTSON, K., HAYES, S. and NITZSCHE, D., 1996. The behaviour of certificate of deposit rates in the UK. *Oxford Economic Papers*, 48(3), 397-414.

49- CUTHBERTSON, K. and NITZSCHE, D., 2005. Quantitative Financial Economics. Second edition, John Wiley and Sons, Ltd.

50- CUTHBERTSON, K. and NITZSCHE, D., 2003. Long rates, risk premia and the over-reaction hypothesis. *Economic Modelling*, 20(2), 417-435.

51- DARBY, M.R., 1975. The financial and tax effects of monetary policy on interest rates. Economic Inquiry, Vol. XIII, pp. 266-276.

52- DEJONG, D.N., NANKERVIS, J.C., SAVIN, N.E. and WHITEMAN, C.H., 1992. The power problems of unit root test in time series with autoregressive errors. *Journal of Econometrics*, 53(1-3), 323-343.

53- DEJONG, D.N., NANKERVIS, J.C., SAVIN, N.E. and WHITEMAN, C.H., 1992. Integration Versus Trend Stationary in Time Series. *Econometrica*, 60(2), 423-433.

54- DELLA CORTE, P., SARNO, L. and THORNTON, D.L., 2008. The expectation hypothesis of the term structure of very short-term rates: Statistical tests and economic value. *Journal of Financial Economics*, 89(1), 158-174.

55- DICKEY, D.A. and FULLER, W.A., 1981. Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica*, 49(4), 1057-1072.

56- DICKEY, D.A. and FULLER, W.A., 1979. Distribution of the Estimators for Autoregressive Time Series With a Unit Root. *Journal of the American Statistical Association*, 74(366), 427-431.

57- DIEBOLD, F.X. and RUDEBUSCH, G.D., 1991. On the Power of Dickey-Fuller tests against fractional alternatives. Economics Letters, 35. 155-160.

58- DIEBOLD, F.X. and RUDEBUSCH, G.D., 1989. Long memory and persistence in aggregate output. *Journal of Monetary Economics*, 24(2), 189-209.

59- DIEBOLD, F.X., RUDEBUSCH, G.D. and BORAǦAN ARUOBA, S., 2006. The macroeconomy and the yield curve: A dynamic latent factor approach. *Journal of Econometrics*, 131(1-2), 309-338.

60- DOTSEY, M., 1998. The predictive content of the interest rate term spread for future economic growth. Economic Quarterly, Federal Reserve Bank of Richmond, issue Sum, 31-51.

61- DRAKOS, K., 2002. A daily view of the term structure dynamics: Some international evidence. *Economist*, 150(1), 41-52.

62- DRAKOS, K., 2001. Monetary policy and the yield curve in an emerging market: The Greek case. *Emerging Markets Review*, 2(3), 244-262.

63- DUTT, S.D. and GHOSH, D., 1995. The Fisher hypothesis: Examining the Canadian experience. *Applied Economics*, 27(11), 1025.

64- ELLIOTT, G., ROTHENBERG, T.J. and STOCK, J.H., 1996. Efficient Tests for an Autoregressive Unit Root. *Econometrica*, 64(4), 813-836.

65- ELSHAREIF, E.E. and TAN, H.B., 2009. Term structure and inflation dynamics: Evidence from three South Eastern Asian countries. *European Journal of Scientific Research*, 34(2), 204-211.

66- ENDERS, W., 2003. Applied Econometric Time Series. Second edition. Wiley Series in Probability and Statistics 2003.

67- ENGLE, R.F. and GRANGER, C.W.J., 1987. Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 55(2), 251-276.

68- ENGSTED, T. and TANGGAARD, C., 1995. The Predictive Power of Yield Spreads for Future Interest Rates: Evidence from the Danish Term Structure. *Scandinavian Journal of Economics*, 97(1), 145.

69- ESTRELLA, A. and MISHKIN, F.S., 1997. The predictive power of the term structure of interest rates in Europe and the United States: Implications for the European Central Bank. *European Economic Review*, 41(7), 1375-1401.

70- ESTRELLA, A. and HARDOUVELIS, G.A., 1991. The Term Structure as a Predictor of Real Economic Activity. *The Journal of Finance*, 46(2), 555-576.

71- FAHMY, Y.A.F. and KANDIL, M., 2003. The Fisher effect: New evidence and implications. *International Review of Economics and Finance*, 12(4), 451-465.

72- FAMA, E.F. and GIBBONS, M.R., 1982. Inflation, real returns and capital investment. *Journal of Monetary Economics*, 9(3), 297-323.

73- FAMA, E.F., 1986. Term premiums and default premiums in money markets. *Journal of Financial Economics*, 17(1), 175-196.

74- FAMA, E.F., 1984. The information in the term structure. *Journal of Financial Economics*, 13(4), 509-528.

75- FAMA, E.F., 1975. Short-Term Interest Rates as Predictors of Inflation. *The American Economic Review*, 65(3), 269-282.

76- FAMA, E.F. and BLISS, R.R., 1987. The Information in Long-Maturity Forward Rates. *The American Economic Review*, 77(4), 680-692.

77- FANG, V. and LEE, V.C.S., 2003. Testing the expectations hypothesis for interest rate term structure: Some Australian evidence. V. Kumar et al. (Eds), ICCSA 2003, LNCS 2669, 189-198

78- FELDSTEIN, M., 1980. Tax Rules and the Mismanagement of Monetary Policy. *The American Economic Review*, 70(2, Papers and Proceedings of the Ninety-Second Annual Meeting of the American Economic Association), 182-186.

79- FRANKEL, J.A. and LOWN, C.S., 1994. An Indicator of Future Inflation Extracted from the Steepness of the Interest Rate Yield Curve Along Its Entire Length. *The Quarterly Journal of Economics*, 109(2), 517-530.

80- FROOT, K.A., 1990. New hope for the expectations hypothesis of the term structure of interest rates. NBER working papers 2363, National Bureau of Economic Research, Inc.

81- GANDOLFI, A.E., 1982. Inflation, Taxation, and Interest Rates. *The Journal of Finance*, 37(3), 797-807.

82- GARCIA, M.G.P., 1993. The Fisher effect in a signal extraction framework The recent Brazilian experience. *Journal of Development Economics*, 41(1), 71-93.

83- GARGANAS, E., 2002. Testing the rational expectations hypothesis of the term structure for unstable emerging market interest rates with interbank data from Greece and the Czech Republic. PHD Thesis.

84- GARRATT, A. and HALL, S.G., 1997. E-equilibria and adaptive expectations: Output and inflation in the LBS model. *Journal of Economic Dynamics and Control*, 21(7), 1149-1171.

85- GERLACH, S., 1997. The information content of the term structure: evidence for Germany. *Empirical Economics*, 22(2), 161-179.

86- GERLACH, S. and SMETS, F., 1997. The term structure of Euro-rates: Some evidence in support of the expectations hypothesis. *Journal of International Money and Finance*, 16(2), 305-321.

87- GHAZALI, N.A. and LOW, S.W., 2002. The expectation hypothesis in emerging financial markets: The case of Malaysia. *Applied Economics,* 34(9), 1147-1156.

88- GHAZALI, N.A. and LOW, S.W., 1999. On the predictive power of the Malaysian T Bills term spread in predicting real economic activity. Malaysian Management Journal, 3 (2), 73-92.

89- GONZALEZ, J., SPENCER, R. and WALZ, D., 1999. The information in the Mexican term structure of interest rates: Capital market implications. *Journal of International Financial Markets, Institutions and Money*, 9(2), 149-161.

90- GOODFRIEND, M., 1998. Using the term structure of interest rates for monetary policy. Federal Reserve Bank of Richmond Economic Quarterly Volume 84/3 Summer 1998.

91- GRAHAM, F.C., 1988. The Fisher Hypothesis: A Critique of Recent Results and Some New Evidence. Southern Economic Journal, 54(4), 961.

92- GRANGER, C.W.J., 1993. What are We Learning About the Long-Run? The Economic Journal, 103(417), 307-317.

93- GRANGER, C.W.J., 1988. Some recent development in a concept of causality. Journal of Econometrics, 39(1-2), 199-211.

94- GRANGER, C.W.J., 1986. Developments in the Study of Cointegrated Economic Variables. Oxford Bulletin of Economics & Statistics, 48(3), 213-228.

95- GRANGER, C.W.J., 1966. The Typical Spectral Shape of an Economic Variable. Econometrica , Vol. 34 (1966), pp. 150-61. Essays in Econometrics, Collected Papers of Clive W. J. Granger, Econometric Society Monographs No. 32. Edited by Ghysels, E., Swanson, N.R. and Watson, M.W., 2001.

96- GRANGER, C.W.J. and HALLMAN, J., 1991. Nonlinear transformations of integrated time series. Journal of Time Series Analysis. 12(3), 207-224.

97- GRANGER, C.W.J. and MORGENSTERN, O., 1963. Spectral Analysis of New York Stock Market Prices. Kyklos, Vol. 16 (1963), pp. 1-27. Reprinted in the Random Character of Stock Market Prices, edited by P.H. Cootner, MIT Press. 1964. Essays in Econometrics, Collected Papers of Clive W. J. Granger, Econometric Society Monographs No. 32. Edited by Ghysels, E., Swanson, N.R. and Watson, M.W., 2001.

98- GRANVILLE, B. and MALLICK, S., 2004. Fisher hypothesis: UK evidence over a century. Applied Economics Letters, 11(2), 87-90.

99- GREENSPAN, A., 2005. Letter to the honourable Jim Saxton, Chairman of the Joint Economic Committee, 28 November 2005.

100- GUEST, R. and MCLEAN, A., 1998. New evidence on the expectations theory of the term structure of Australian Commonwealth Government Treasury yields. Applied Financial Economics, 8(1), 81-87.

101- GUTHRIE, G., WRIGHT, J. and YU, J., 1999. Testing the Expectations Theory of the Term Structure for New Zealand.(Statistical Data Included).

102- HALL, A.D., ANDERSON, H.M. and GRANGER, C.W.J., 1992. A Cointegration Analysis of Treasury Bill Yields. The review of economics and statistics, 74(1), 116-126.

103- HALL, S.G., 1998b. "Reg-X User guide" .

104- HALL, S. G. and GARRATT, A., 1992. Expectations and learning in economic models. Economic Outlook,1992 Oxford Economic Forecasting Ltd,16(5),52 – 53.

105- HALL, S.G. and MILNE, A., 1994. The Relevance of P-Star Analysis to UK Monetary Policy. The Economic Journal, 104(424), 597-604.

106- HALL, S. G. and URGA, G.U., 2002. Testing for ongoing efficiency in the Russian stock market. Working paper.

107- HAMILTON, J.D. and KIM, D.H., 2002. A reexamination of the predictability of economic activity using the yield spread. Journal of Money, Credit and Banking, 34(2), 340-360.

108- HAMORI, S. and TOKIHISA, A., 1997. Testing for a unit root in the presence of a variance shift. Economics Letters, 57(3), 245-253.

109- HANSEN, B.E., 1992. Testing for parameter instability in linear models. Journal of Policy Modelling, 14(4), 517-533.

110- HARDOUVELIS, G.A., 1994. The term structure spread and future changes in long and short rates in the G7 countries: Is there a puzzle? Journal of Monetary Economics, 33(2), 255-283.

111- HARVEY, C.R., 1997. The relation between the term structure of interest rates and Canadian economic growth. Canadian Journal of Economics, 30(1), 169-193.

112- HARVEY, C.R., 1989. Forecasts of Economic Growth from the Bond and Stock Markets. Financial Analysts Journal, 45(5), 38.

113- HAWTREY, K.M., 1997. The Fisher effect and Australian interest rates. Applied Financial Economics, 7(4), 337-346.

114- HONDROYIANNIS, G., LOLOS, S. and PAPAPETROU, E., 2005. Financial markets and economic growth in Greece, 1986-1999. Journal of International Financial Markets, Institutions and Money, 15(2), 173-188.

115- HONDROYIANNIS, G. and PAPAPETROU, E., 2000. Do demographic changes affect fiscal developments? Public Finance Review, 28(5), 468-488.

116- HSU, C. and KUGLER, P., 1997. The revival of the expectations hypothesis of the US term structure of interest rates. Economics Letters, 55(1), 115-120.

117- HUANG, B.N., YANG, C.W. and HU, J.W.S., 2000. Causality and cointegration of stock markets among the United States, Japan and the South China Growth Triangle. International Review of Financial Analysis, 9(3), 281-297.

118- HUIZINGA, J. and MISHKIN, F.S., 1986. Monetary policy regime shifts and the unusual behavior of real interest rates. Carnegie-Rochester Confer.Series on Public Policy, 24(C), 231-274.

119- HURN, A.S., MOODY, T. and V. ANTON MUSCATELLI, 1995. The Term Structure of Interest Rates in the London Interbank Market. Oxford Economic Papers, 47(3), 418-436.

120- INTERNATIONAL MONETARY FUND, 1984. Taxation, Inflation, and Interest Rates. Edited by Tanzi, V. 1984.

121- ISLAM, A.M. and AHMED, S.M., 1999. The purchasing power parity relationship: causality and cointegration tests using Korea-U.S. exchange rate and prices. Journal of Economics Development, 24(2), 95-111.

122- JOHANSEN, S. and JUSELIUS, K., 1990. Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money. Oxford Bulletin of Economics & Statistics, 52(2), 169-210.

123- JOHANSEN, S., 1988. Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12(2-3), 231-254.

124- JOHNSON, P.A., 1997. Estimation of the specification error in the expectations theory of the term structure. Applied Economics, 29(9), 1239.

125- JORGENSEN, J.J. and TERRA, P.R.S., 2003. The Fisher Hypothesis in a VAR framework: Evidence from advanced and emerging markets, 2003, pp609-614.

126- JORION, P. and MISHKIN, F., 1991. A multicountry comparison of term-structure forecasts at long horizons. Journal of Financial Economics, 29(1), 59-80.

127- KANAGASABAPATHY, K. and GOYAL, R., 2002. Yield Spread as a Leading Indicator of Real Economic Activity: An Empirical Exercise on the Indian Economy. IMF Working Paper, WP 02 91.

128- KIM, K.A. and LIMPAPHAYOM, P., 1997. The effect of economic regimes on the relation between term structure and real activity in Japan. Journal of economics and business, 49(4), 379-392.

129- KIM, T., LEYBOURNE, S. and NEWBOLD, P., 2004. Behaviour of Dickey-Fuller unit-root tests under trend misspecification. Journal of Time Series Analysis, 25(5), 755-764.

130- KING F.L., 2007. An Empirical Study of the Fisher Effect and the Dynamic Relation between Nominal Interest Rate and Inflation in Singapore. Munich Personal RePEc Archive, Working paper , June 2007.

131- KLASRA, M.A., 2009. Cointegration, causality and the transmission of shocks across wheat market in Pakistan. Quality and Quantity, 43(2), 305-315.

132- KOEKEMOER, R., 2001. Variable parameter estimation of consumer price expectations for the South African economy. South African Journal of Economics, 69(1), 1-39.

133- KONSTANTINOU, P.T., 2005. The expectations hypothesis of the term structures: A look at the polish interbank market. Emerging Markets Finance and Trade, 41(3), 70-91.

134- KOOL, C.J.M. and THORNTON, D.L., 2004. A note on the expectations hypothesis at the founding of the Fed. Journal of Banking and Finance, 28(12), 3055-3068.

135- KRAMER, W. and DAVIES, L., 2002. Testing for unit roots in the context of misspecified logarithmic random walks. Economics Letters, 74(3), 313-319.

136- LANGE, R., 1999. The expectations hypothesis for the longer end of the term structure: some evidence for Canada. Working papers 99-20, Bank of Canada.

137- LEVY, D. and DEZHBAKHSH, H., 2003. On the typical spectral shape of an economic variable. Applied Economics Letters, 10(7), 417-423.

138- LEYBOURNE, S.J. and NEWBOLD, P., 2000. Behavior of Dickey-Fuller t-tests when there is a break under the alternative hypothesis. Econometric Theory, 16(5), 779-786.

139- LONGSTAFF, F.A., 2000. The term structure of very short-term rates: New evidence for the expectations hypothesis. Journal of Financial Economics, 58(3), 397-415.

140- LUTHMAN, U., 2004. Testing the expectations hypothesis with survey data with an introduction of an analysis of surveyed interest rates. Working papers 2004:11, Örebro University, Swedish Business School.

141- LÜTKEPOHL, H. and REIMERS, H.E., 1992. Impulse response analysis of cointegrated systems. Journal of Economic Dynamics and Control, 16(1), 53-78.

142- MACDONALD, R. and MURPHY, P.D., 1989. Testing for the long run relationship between nominal interest rates and inflation using cointegrated techniques. Applied Economics, 21(4), 439.

143- MANKIW, N.G., GOLDFELD, S.M. and SHILLER, R.J., 1986. The Term Structure of Interest Rates Revisited. Brookings Papers on Economic Activity, 1986(1), 61-110.

144- MANKIW, N.G. and MIRON, J.A., 1986. The Changing Behavior of the Term Structure of Interest Rates. The Quarterly Journal of Economics, 101(2), 211-228.

145- MANKIW, N.G., MIRON, J.A., and WEIL, D.N., 1987. The Adjustment of Expectations to a Change in Regime: A Study of the Founding of the Federal Reserve. The American Economic Review77, 358-374.

146- MANKIW, N.G., SUMMERS, L.H. and WEISS, L., 1984. Do Long-Term Interest Rates Overreact to Short-Term Interest Rates? Brookings Papers on Economic Activity, 1984(1), 223-247.

147- MASIH, A.M. and RYAN, V., 2005. The term structure of interest rates in Australia: an application of long run structural modelling. Applied Financial Economics, 15(8), 557-573.

148- MASIH, A.M.M. and MASIH, R., 1996. Empirical tests to discern the dynamic causal chain in macroeconomic activity: new evidence from Thailand and Malaysia based on a multivariate cointegration/vector error-correction modelling approach. Journal of Policy Modelling, 18(5), 531-560.

149- MASIH, M., Al-HAJJI, M. and UMAR, Y., 2008. Empirical Test of the Long-Run Fisher Effect: An Application of the ARDL Bounds Technique to Saudi Arabia. Journal of International Finance and Economics, 8, 53-64.

150- MASIH, R. and MASIH, A.M.M., 1996. Macroeconomic activity dynamics and Granger causality: New evidence from a small developing economy based on a vector error-correction modelling analysis. Economic Modelling, 13(3), 407-426.

151- MEHL, A., 2006. The Yield Curve as a Predictor and Emerging Economies. European Central Bank, Working Paper series, No. 691, November 2006

152- MISHKIN, F.S., 1992. Is the Fisher effect for real?. A reexamination of the relationship between inflation and interest rates. Journal of Monetary Economics, 30(2), 195-215.

153- MISHKIN, F.S., 1991. A multi-country study of the information in the shorter maturity term structure about future inflation. Journal of International Money and Finance, 10(1), 2-22.

154- MISHKIN, F.S., 1990. What does the term structure tell us about future inflation? Journal of Monetary Economics, 25(1), 77-95.

155- MISHKIN, F.S., 1990. The Information in the Longer Maturity Term Structure About Future Inflation. The Quarterly Journal of Economics, 105(3), 815-828.

156- MISHKIN, F.S., 1984a. The real interest rate: a multi-country empirical study. Canadian Journal of Economics, 17(2), 283-311.

157- MISHKIN, F.S., 1984b. Are Real Interest Rates Equal Across Countries? An Empirical Investigation of International Parity Conditions. The Journal of Finance, 39(5), 1345-1357.

158- MISHKIN, F.S. and SIMON, J., 1995. An empirical examination of the Fisher effect in Australia. National Bureau of Economic Research (NBER). working paper series, working paper No. 5080, 227-239.

159- MITCHELL-INNES, H.A., AZIAKPONO, M.J. and FAURE, A.P., 2007. Inflation targeting and the fisher effect in South Africa: An empirical investigation. South African Journal of Economics, 75(4), 693-707

160- MONT , A. and REYES, M., 1998. Effect of a shift in the trend function on Dickey-Fuller unit root tests. Econometric Theory, 14(3), 355-363.

161- MOSCONI, R. and GIANNINI, C., 1992. Non-Causality in Cointegrated Systems: Representation Estimation and Testing. Oxford Bulletin of Economics & Statistics, 54(3), 399-417.

162- MUNDELL, R., 1963. Inflation and Real Interest. The Journal of Political Economy, 71(3), 280-283.

163- MUSTI, S. and D'ECCLESIA, R.L., 2008. Term structure of interest rates and the expectation hypothesis: The euro area. European Journal of Operational Research, 185(3), 1596-1606.

164- MYLONIDIS, N., and NIKOLAIDOU, E., 2002. The Interest Rate Term Structure in the Greek Money Market. University of Loannina, Department of Economics, Greece 2002.

165- NAGAYASU, J., 2002. On the term structure of interest rates and inflation in Japan. Journal of economics and business, 54(5), 505-523.

166- NAKAOTA, H., 2005. The term structure of interest rates in Japan: The predictability of economic activity. Japan and the World Economy, 17(3), 311-326.

167- NELSON, C.R. and PLOSSER, C.R., 1982. Trends and random walks in macroeconomic time series. Some evidence and implications. Journal of Monetary Economics, 10(2), 139-162.

168- NELSON, C.R. and SCHWERT, G.W., 1977. Short-Term Interest Rates as Predictors of Inflation: On Testing the Hypothesis that the Real Rate of Interest is Constant. The American Economic Review, 67(3), 478-486.

169- NG, S. and PERRON, P., 2001. Lag Length selection and the Construction of Unit Root Tests with Good Size and Power. Econometrica, 69(6), 1519-1554.

170- ODA, N., 1996. A Note on the Estimation of Japanese Government Bond Yield Curves. Institute for Monetary and Economic Studies , Bank of Japan, IMES Discussion Paper 96-E-27, August 1996.

171- OLEKALNS, N., 1996. Further evidence on the Fisher effect. Applied Economics, 28(7), 851-856.

172- OxMetrics Reference, 2004. "Pc Give program 2.3".

173- PATTERSON, K., 2000. An Introduction to Applied Econometrics, A Time Series Approach. Palgrave Macmillan 2000.

174- PAYNE, J.E. and EWING, B.T., 1997. Evidence from lesser developed countries on the fisher hypothesis: A cointegration analysis. Applied Economics Letters, 4(11), 683-687.

175- , R.F., 1995. The Fisher effect: Reprise. Journal of Macroeconomics, 17(2), 333-346.

176- PENG, W., 1995. The Fisher Hypothesis and Inflation Persistence-Evidence from Five Major Industrial Countries. IMF Working Paper, WP 95 118.

177- PERRON, P., 1989. The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. Econometrica, 57(6), 1361-1401.

178- PERRON, P. and NG, S., 1996. Useful Modifications to some Unit Root Tests with Dependent Errors and their Local Asymptotic Properties. The Review of Economic Studies, 63(3), 435-463.

179- PESARAN, M.H. and PESARAN, B.,1997. Working with Microfit 4.0: - Interactive Econometric Analysis Oxford: Oxford University Press.

180- PHILLIPS, P.C.B. and PERRON, P., 1988. Testing for a Unit Root in Time Series Regression. Biometrika, 75(2), 335-346.

181- PLOSSER, C.I. and GEERT ROUWENHORST, K., 1994. International term structures and real economic growth. Journal of Monetary Economics, 33(1), 133-155.

182- ROSSI, M., 1996. The Information content of the short end of the term structure of interest rates", Bank of England, Working paper series No. 55.

183- RUDEBUSCH, G.D., 1992. Trends and Random Walks in Macroeconomic Time Series: A Re-Examination. International Economic Review, 33(3), 661-680.

184- SARNO, L., THORNTON, D.L. and VALENTE, G., 2007. The empirical failure of the expectations hypothesis of the term structure of bond yields. Journal of Financial and Quantitative Analysis, 42(1), 81-100.

185- SATAKE, M., 2005. An empirical Study on Testing the Fisher Hypothesis in Japan. Journal of International Economic Studies, No. 19, pp. 63-75.

186- SATHYE, M., SHARMA, D. and LIU, S., 2008. The Fisher in an Emerging Economy: The Case of India. CCSE, International Business Research, Vol. 1, No. 2, pp. 99-104.

187- SCHWERT, G.W., 1989. Tests for unit roots: A Monte Carlo investigation. Journal of Business and Economic Statistics, 7(2), 147-159.

188- SEN, A., 2008. Behaviour of Dickey-Fuller tests when there is a break under the unit root null hypothesis. Statistics and Probability Letters, 78(6), 622-628.

189- SEN, A., 2003. On unit-root tests when the alternative is a trend-break stationary process. Journal of Business and Economic Statistics, 21(1), 174-184.

190- SEN, A., 2001. Behaviour of Dickey-Fuller F -tests under the trend-break stationary alternative. Statistics and Probability Letters, 55(3), 257-268.

191- SHEA, G.S. 1992. Benchmarking the expectations hypothesis of the interest-rate term structure: An analysis of cointegration vectors. Journal of Business & Economic Statistics, 10(3), 347-66.

192- SHEN, C., 1998. The term structure of the Taiwan money market rates and rational expectation. International Economic Journal, 12(1), 105-119.

193- SHILLER, R.J., 1979. The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure. The Journal of Political Economy, 87(6), 1190-1219.

194- SHILLER, R.J., CAMPBELL, J.Y., SCHOENHOLTZ, K.L. and WEISS, L., 1983. Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates. Brookings Papers on Economic Activity, 1983(1), 173-223.

195- SHIVAM, M. and JAYADEV, M. 2004. The interest rate term structure in the Indian money market. Six Annual Conference on 'Money and Finance in the Indian Economy', organized by the India Gandhi Institute of Development Research (IGIDR), Mumbai, March 25-27.

196- SMETS, F. and TSATSARONIS, K., 1997. Why does the Yield Curve Predict Economic Activity? Dissecting the Evidence for Germany and the United States. Bank for International Settlements (BIS), Working Papers No. 49.

197- STOCK, J.H. and WATSON, M.W., 1989. New Indexes of Coincident and Leading Economics Indicators. In O. Blanchard and S. Fischer, eds., NBER Macroeconomics Annual, Cambridge, Mass.:MIT Press, pp. 351-94.

198- TANZI, V., 1980. Inflationary Expectations, Economic Activity, Taxes, and Interest Rates. The American Economic Review, 70(1), 12-21.

199- TAYLOR, M.P., 1992. Modelling the Yield Curve. The Economic Journal, 102(412), 524-537.

200- TEASE, W.J., 1988. The Expectations Theory of the Term Structure of Interest Rates in Australia. Economic Record, 64(185), 120.

201- THORNTON, D.L., 2006. Tests of the expectations hypothesis: Resolving the Campbell-Shiller paradox. Journal of Money, Credit and Banking, 38(2), 511-542.

202- THORNTON, D.L., 2005. Tests of the expectations hypothesis: Resolving the anomalies when the short-term rate is the federal funds rate. Journal of Banking and Finance, 29(10), 2541-2556.

203- THORNTON, J., 1996. The adjustment of nominal interest rates in Mexico: A study of the fisher effect. Applied Economics Letters, 3(4), 255-257.

204- TOBIN, J., 1965. Money and Economic Growth. Econometrica, 33(4), 671-684.

205- WAGGONER, D.F., 1997. Spline methods for extracting interest rate curves from coupon bond prices. Federal Reserve Bank of Atlanta. Working paper series 97-10, 1997(10).

206- WALLACE, M.S. and WARNER, J.T., 1993. The Fisher Effect and the Term Structure of Interest Rates: Tests of Cointegration. The review of economics and statistics, 75(2), 320-324.

207- WESSO, G.R., 2000. Long-Term Yield Bonds and Future Inflation in South Africa: A Vector Error-Correction Analysis. South African Reserve Bank, June 2000.

208- WOODWARD, G.T., 1992. Evidence of the Fisher Effect from U.K. Indexed Bonds. The review of economics and statistics, 74(2), 315-320.