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RANDOM WALKS IN DAILY FOREIGN EXCHANGE RATES?

The case of Lebanon (2010-2015)

By

TAMAR VARTKES KOHILIAN

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AN ABSTRACT OF THE THESIS

Tamar Vartkes Kohilian for Master of Business Admisnistration emphasis Accounting

Title: Random Walk in Foreign Exchange Market? The Case of Lebanon (2010-2015)

The purpose of this study is find evidence against Random Walk theory in Lebanese Foreign Exchange Market. The study was done on 6 foreign exchange currencies from January 2010 till 8 April, 2015 with a daily frequency with 1279 observations per series. The six currencies are Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), European Currency Unit (EURO), British Pound (GBP), and Japanese Yen (JPY). The data is taken from Bank of Lebanon's official website, and the currencies are chosen upon availability and convenience.

Empirical evidence from this study showed that Lebanese Foreign exchange market follows Weak Form Efficiency and does not follow a Random Walk.

The study recommends the Lebanese banks, to focus on the special departments that are entrusted with undertaking technical analysis, and finding best forecasts of the foreign exchange rates, in order to take trading positions based upon this forecast and maximize profits.

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CHAPTER ONE

INTRODUCTION

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Financial market is market that used to raise finance; for long term finance we use the term Capital Market, for short term finance we use Money Market. Accordingly financial market consists of the following:

1. Capital markets has 2 subdivisions: Stock markets and Bond Markets
2. Commodity markets
3. Money markets
4. Derivatives markets
5. Futures markets
6. Insurance markets
7. Foreign exchange markets

All these constitute the financial market which is the most important market in economy to finance a country. Accordingly a lot of studies and researches have been done in order to find ways to maximize the outcome and increase the flow of capital to a country. One of these studies has revealed the Efficient Market Hypothesis.

Efficient Market Hypothesis states that a market is said to be efficient if all available information can be used to set the price of a stock. Information includes not only what is

currently known about a stock, but also any future expectations, such as earnings or dividend payments. The concept of Efficient Market Hypothesis is developed independently by Paul A. Samuelson and Eugene F. Fama in the 1960s.

They both set specifications and characteristics for Efficient Market Hypothesis; they can be summarized as following:

Weak form efficiency: only past market trading information, such as stock prices, trading volume, and short interest rates are considered, accordingly even the weak form efficiency implies that technical analysis cannot work, since technical analysis relies exclusively on past trading data to forecast price movements.

Semi-strong form extends the information further to public information other than market data, such as news, accounting reports, company management, patents, products of the company, and analyst's recommendation.

Strong form extends the information further to include not only public information, but also private information, typically held by corporate insiders, such as officers and executives of the corporation.

The weak form as stated above, discusses only the independency of the price of a stock, but there are other characteristics that weak form does not talk about like the identicality and normality of the distribution of the prices, hence a new theory was introduces in 1973 by Burton Malkiel, when he wrote "A Random Walk Down Wall Street" which was known as Random Walk theory.

This theory takes into consideration the characteristic of Weak Form Efficiency and goes deeper into testing the identicality and the normality distributions' of the prices; meaning the past movement or direction of the price of a stock or overall market cannot be used to predict

its future movements. According to Kednall (1953), stock price fluctuations are independent of each other and have the same probability distribution, but that over a period of time, prices maintain an upward trend, called an upward lift. While according to Fama (1970) where he defined random walk model with its 2 hypothesizes and then tested the empirical validity of the model.

Starting with definition of random walk model and its hypotheses; in his paper, Fama (1970) defined the theory of random walk model that has 2 hypotheses first price changes are independent and have an identical probability distribution. And accordingly the price of stock cannot be predicted from past stock activities.

Price independence: the changes in prices are not affected from previous price changes, so the probability distribution for the price changes in present are independent from price changes in previous periods. Knowing the changes in prices of previous periods is not useful to predict the price changes of present; even though random walk theory cannot really describe the reality, but it is acceptable as long as the dependency of prices is not above some "minimum acceptable" level. According to his research, independence theory best describes the reality when the actual degree of dependence cannot help to predict the future prices. Sometimes there are noises generated as well as new information can be dependent but due to the presence of sophisticated traders eventually the changes in stock market will be independent. From point of view of investors the shape of the price changes is important, so that they can know the risk of the investment in the stock, the form is also important to identify the nature of the process generating price changes. In his paper he also talked about Bachelier and Osborne model which states that price changes in stock are independent and identically distributed random variables. They also

implied in their model that the changes in prices have a finite variance, and if the transactions are too large, then the variation in price will have normal or Gaussian distribution. And therefore the variance will be proportional to the respective time interval.

Distribution of price changes: there is no specific shape for the distribution of the price changes, but the shape should reflect the development creating the price changes.

In his article he used 3 techniques to test for dependency: Auto correlation, the run test and the third test includes Alexander's filter technique.

In implication of dependency, he found out that if successive price changes are independent that implies the stock market is efficient and found out 2 factors that help to have independent price changes were sophisticated chart readers and second sophisticated analysts.

As mentioned earlier, one of the components of financial market is the foreign exchange market. The foreign exchange market (forex, FX, or currency market) is a global decentralized market for the trading of currencies. In terms of volume of trading, it is by far the largest market in the world. The main participants in this market are the larger international banks. With increasing globalization, nations are exposed to the international community, and trading in both goods and services will be affected to a large extent by movements in exchange rates, accordingly the foreign exchange markets is relevant not only to academics, but to central bankers and policy makers as well, because a clear understanding of the functioning of the market will translate into better decision making in terms of trade policy. For instance, an appreciation of the local currency results in a loss of national competitiveness as exports become more expensive and trading partners switch to relatively cheaper sources but at the same time,

traders benefit since imports become cheaper. The modern foreign exchange market began forming during the 1970s after three decades of government restrictions on foreign exchange transactions: The Bretton Woods system of monetary management established the rules for commercial and financial relations among the world's major industrial states after World War II. The foreign exchange market is unique because of the following characteristics:

- its huge trading volume representing the largest asset class in the world leading to high liquidity;
- its geographical dispersion;
- its continuous operation: 24 hours a day except weekends, i.e., trading from 22:00 GMT on Sunday (Sydney) until 22:00 GMT Friday (New York);
- the variety of factors that affect exchange rates;
- the low margins of relative profit compared with other markets of fixed income;
- The use of leverage to enhance profit and loss margins and with respect to account size.

Foreign exchange market has an important role in every country, and it is important to know how the market functions and how to exchange rates move and react, accordingly my thesis will be on testing if Lebanese Foreign Exchange market follows a random walk, because as I have mentioned before, Efficient Market Hypothesis concentrated on independency of price changes without taking into consideration the identical and normal distribution of the rates.

Foreign exchange market in Lebanon is picking a lot of pace and many people in Lebanon have got into foreign exchange market. The main concept lying behind foreign exchange market trading is the free floating currencies. These currencies are the ones which are not supported by

gold, silver or any certain material. Any profit or loss generating out of forex trading is basically due to the changes or differences in valuation of currencies. The Lebanese foreign exchange market is a free foreign exchange market, full currency convertibility policies, no restrictions on the inward or outward movement of capital.

The Lebanese Pound is convertible and its exchange rate is generally determined on the basis of demand and supply conditions in the exchange market. Bankers are allowed to engage in spot transactions in any currency. However, they are prohibited from engaging in forward transactions in Lebanese Pounds for speculative purposes. BDL intervenes when necessary in order to maintain orderly conditions in the foreign exchange market. There are no taxes or subsidies on purchases or sales of foreign exchange.

Foreign exchange rate stability is a primary policy objective of the Government and of BDL. BDL's exchange rate policy since October 1992 has been to anchor the Lebanese Pound nominal exchange rate to the U.S. Dollar. This appreciation was limited to 0.03% in 1999 and the Lebanese Pound exchange rate has remained unchanged since 2000. Since September 1999, BDL has maintained its policy of pegging the value of the Lebanese Pound to the U.S. Dollar at a fixed average closing rate of LL 1,507.5 per U.S. $1.00.

The participants in the foreign exchange market are the banks and the exchange institutions

CHAPTER TWO

LITERATURE REVIEW

Foreign exchange market has an important role in every country, and it is important to know how the market functions and how to exchange rates move and react, as I have indicated, EMH has three forms (Fama 1970); weak, semi-strong and strong. Each version reflects a different degree of information in the prices of financial assets. The concentration will be on the weak form of EMH and going deeper in understanding the weak form to identify the characteristics of Random Walk Hypothesis. The weak form of EMH asserts that prices of financial assets reflect all the information contained in past prices. Therefore, no market participant can use past data on the prices of financial assets to predict the future values of such assets, in other words, the prices of financial assets behave randomly, with or without any identifiable pattern.

There have been a lot of research studies to identify the pattern of foreign exchange market using different tests to reach to their conclusions.

A research was done by Guneratne (2004) who tested weak and semi-strong form efficiency of foreign exchange market in Seri Lanka for six currencies. Weak form efficiency is tested by using unit root test. He based his research on the average monthly exchange rates for Japanese Yen, UK pound, US dollar, French franc, Indian rupee and German mark for the period January 1986 to November 2000. He used the Augmented Dickey –Fuller (1979, 1981) known as ADF test (is a test for a unit root in a time series sample. It is an augmented version of the Dickey–Fuller test for a larger and more complicated set of time series models. The augmented Dickey–Fuller (ADF) statistic, used in the test, is a negative number. The more negative it is, the stronger the rejections of the hypothesis that there is a unit root at some level of confidence), while doing the test he found out that all exchange rates under consideration are no-stationary in their levels and become stationary when they are first differenced. The level of significance of ADF

statistics for all currencies is 1%, which implies that financial time series behave as a random walk and the results show consistence with the weak form of Efficient Market Hypothesis. Meaning past exchange rates cannot predict the future exchange rates, they are unpredictable.

Another research was done by Lean and Russell (2005), about Asian exchange rate whether they follow a Random Walk. They studied the PPP hypothesis (Purchasing Power Parity) states that exchange rates adjust to reflect price differences across countries, PPP hypothesis states that real exchange rate reverts to a constant mean, accordingly they have used unit root to test the PPP hypothesis. They have applied ADF unit root test and univariate and panel LM (Lagrange Multiplier) unit root tests with one and two structural breaks by using the natural log of monthly exchange rates of US dollar for 15 Asian countries. The results of the test were as following: for ADF unit root test, null Hypothesis states that the variables on which the tests are based have a unit root, so they have found evidence of PPP for one-third of the countries, which were as following: Philippines: the null hypothesis of unit root null was rejected at 1% significance level, while for India at 5% and for Pakistan and Thailand at 10% significance. The results of LM unit root test with one break in the intercept were as following: 60% of the sample have evidence of PPP meaning the unit root null hypothesis was rejected for almost nine countries, the structural break was significant for each of the 15 countries, except for 3 countries, while the structural break for 6 countries were associated with Asian financial crisis and for 4 countries the structural break occurs during 2001-02, where there was a global downturn which was affected by s lowdown of US economy(terrorist attack ,war in Afghanistan, the Enron and WorldCom collapses. While the results of 2 structural breaks were as following: the unit root null is rejected for 10 countries out of 15 at a 10% significance level.

Another research was done by Juliana, Yasmiza, Hartini, Safrul and Mohd (2011), about Weak-Form Efficiency of Foreign Exchange Market in the Organization for Economic Cooperation and Development Countries, the paper examines the weak form efficiency of foreign exchange market in thirty Organizations for Economic Cooperation and Development (OECD) countries, they used daily foreign exchange rates from 2000 till 2007. In order to prove their theory they have used Augmented Dickey-Fuller (ADF), Philip-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin analysis to examine for the unit root and come up with their conclusion.

In order to prove the co-integration between the time series, the integration level should be tested, accordingly they have done the unit root test in order to determine the order of integration of the series. In order to have a unit root, and find out the relationship between the co-integration properties of the variables 3 test has been conducted to reach to their conclusion and find out the order of integration, starting with Augmented Dickey Fuller test; ADF test is conducted by 'augmenting" the proceedings equation by adding the lagged values of the dependent variables, the ADF test corrects for higher order serial correlation by adding lagged differenced terms the right-hand side while the PP test makes a correction to the t-statistic of the coefficient.

After conducting the test they came up to the following results to investigate the relationship with the co-integration properties of foreign exchange rates in OECD countries.

In order to reject the null hypothesis (existence of unit root), t-test statistic is negatively less than the critical value (5 %significance level), the ADF and PP tests results show that all variables exceed the critical value except for CHF, CZK, DKK, MXN, SEDK and TRY, which implies that unit root hypothesis cannot be rejected for almost all of the variables, therefore the variables of foreign exchange rates are non-stationary, while the test results of KPSS showed as well the same as ADF and PP test results, implying that all variables exceed the critical value,

therefore they are non-stationary , the second part of the tests was conducted for first difference of the series, the ADF and PP test results show that all values are less than the critical value 5% which implies that all variables do not have a unit root and are fist difference stationary, while KPSS test results showed that not all variables fail to reject the null hypothesis at 95% significance level.

So the conclusion of their research was as following: the unit root test showed that variables are integrated at level I (1) except for few currencies that are integrated at level I (0), which meet the requirement of weak form efficient market hypothesis, meaning financial time series behave as a random walk.

Another study was done by Biswajit (2012); where in his research he tested whether Indian Rupee- US Dollar exchange rate follows a Random Walk. His study was based on the daily data of India rupee- US Dollars exchange rate for a period of 1 January 2003 to 31 December 2010. He has conducted several tests to reach to his conclusions the tests were unit root and variance ratio tests. Ljung-Box statistics is used to test for independency, and according to test results it showed that there is no random walk, rejected the null hypothesis, this implies there is serial autocorrelation in the data. Another test was done for stationary which is ADF test and according to the results, he fail to reject the null hypothesis; hence there is random walk, while according to Phillip Perron test results, it showed there is no random walk in the data series while KPSS test showed a conflicting result meaning, the results showed that there is a random walk, in order to solve the conflict he did variance ratio tests, one of the tests is Chow-Dennig Variance ratio test statistics, and the result of the test showed that there is no random walk, another variance ration test was conducted, Wald test, the test statistics are all significant and enables him to reject the null hypothesis, which implies there is no random walk a final test was done in order

to confirm the results that he got; it was spectral shape tests, which uses test statistics like Anderson-Darling statistics and Cramer-von Misses statistics to test the null hypothesis and the test statistics reject the presence of random walk in the data series under study. The test results do not support the Random Walk Hypothesis, therefore market is not efficient.

Another research as well is done by Ngougi, Sifunjo, Pokhariyal and Wainaina (2012) about analyzing the efficiency of foreign exchange market in Kenya. This study tests the Efficiency Market hypothesis through a data from January 1997 till June 2007, by examining the behavior of foreign Exchange returns in Kenya.

In their study, they have applied the following tests: Run Test that checks whether the Exchange Rates are independent or identically distributed. It counts the actual and expected number of runs and their corresponding signs. The unit root test tests whether the spot rates are difference stationary or trend stationary. Ljung-Box (LB) Q-statistics checks for the presence of autocorrelation in the series, thus testing the Market Efficiency. The mean returns are negative for sampling intervals; therefore the exchange rate is appreciative on average. The variance, on the other hand, is the lowest on a daily basis and highest on a weekly basis, which implies that the volatility will be at the highest level when measured on a weekly interval.

The returns are negatively skewed only on a monthly basis, thus giving the exchange rate an appreciating tendency on long intervals. This implies that exchange rates have extreme movements when distributed normally and on shorter intervals. According to LB statistics, returns are highly serially correlated. The results of the run test shows that the difference between the actual numbers of total runs is much greater than that of the expected, at all different intervals. Thus that difference is negative for plus and positive for minus runs, implying that

changes of the exchange rate are nonlinear and asymmetrical. This means that the depreciation and appreciation of the exchange rate is more than the expected.

The returns are auto-correlated. The distribution of runs according to their sign and length is different from the normal distribution. The deviation magnitude between actual and expected number of runs is decreasing with an increasing run length. The magnitude differences have also a pattern.

The result of the study shows that the actual number of runs has a three time greater standard deviation than that of the expected and the mean of deviation between actual and expected number of runs is different than zero. As the intervals and the run length changes the deviations from the mean increase. This implies that if the signs are generated randomly, than there will be a considerable variation between the actual and expected breakdown of runs and proves the existence of patterns in foreign exchange rate returns. Thus, giving investors chances for making profits. Therefore, the results of this study show the inefficiency of foreign market exchanges.

A study was done by Mbululu, Auret and Chiliba (2013) about whether exchange rates in Zambia follow a random walk. They used daily exchange rates of the Zambian Kawacha against U.S. Dollar for a period from August 2003 till December 2012. In order to reach to their conclusion they have conducted several tests like ADF test for unit root, Ljung-Box Q statistics for autocorrelation , variance ratio test and as well as Jarque-Bera test to find out if the exchange rates are normally distributed. The test results showed that the Zambian exchange market reject the Random Walk Hypothesis; according to ADF test results, it showed that the daily exchange rates are not stationary, which implies the rejection of null hypothesis of unit root, according to variance ratio test, it turned out that the null hypothesis of homoscedasticity is rejected because of auto correlation in daily exchange rates, while the results of Jarque-Bera test results also

confirm the rejection of Random Walk Hypothesis, because the Zambian daily exchange rates are not normally distributed, as well as the results of Ljung- Box Q statistics rejects the null hypothesis of Random walk due to the fact that the daily exchange rates are serially correlated. All these imply that the Zambian exchange market does not follow a random walk.

Another study was done by Sheik and Shakila (2014) about the weak form efficiency of foreign exchange markets of developing economies; they made their study for monthly exchange rates for three major currencies (China, Indonesia, US) vis the Indian Rupee, by doing several tests like ADF test for unit root, Jarque-Bera test for goodness of fit, VAR (Vector Auto Regression). The result of the tests were as following: the 3 currencies are normally distributed at 1% level, as well as they are stationery over a period of time at 5% significant level; hence the three exchange rates studied follow a random walk and therefore support the validity of weak form of Efficient market hypothesis.

Another research was done by Azar (2014) where he tested whether the Lebanese foreign exchange market is a weak form efficient by studying statistical behavior of six daily foreign exchange currencies against Lebanese pounds, to test whether these 6 currencies follow each a martingale. In definition, Martingale is a model of fair game, where knowledge of past events never helps to predict the mean of future winnings. a martingale is a sequence of random variables (i.e., a stochastic process) for which, at a particular time in the realized sequence, the expectation of the next value in the sequence is equal to the present observed value even given knowledge of all prior observed values.

To prove his theory, there are any requirements for such a process, among them is verifying that currencies include one unit root(is a feature of processes that evolve through time that can

cause problems in statistical inference involving time series models), percentage increase are random, shocks are very persistent, samples do not suffer from any calendar breaks and finally the currency rates are not predictable from the past of bilateral relations. In his paper he tests comprehensively the stochastic process of foreign exchange rates. (Stochastic process: is a collection of random variables, representing the evolution of some system of random values over time. This is the probabilistic counterpart to a deterministic process (or deterministic system). Instead of describing a process which can only evolve in one way, in a stochastic or random process there is some indeterminacy: even if the initial condition or starting point is known, there are several often infinitely many directions in which the process may evolve.) He used the following test in his paper: unit root tests, tests on uncorrelated increments, variance ratio test, non-linear dependencies, normality test, tests for breaks, Granger Causality test (is a statistical hypothesis test for determining whether one time series is useful in forecasting another), test for GARCH effects, cross correlation tests. The data that was used in his paper were daily exchange rates for six currencies from January 4, 2010 till January 31, 2014 taken from the web site of the Bank of Lebanon. He took all series were logged and log returns were calculated by taking the first difference of the natural log.

In order to meet the requirements of martingale, first a unit root test was done and confirmed the presence of one unit root in the arranged series, second test was done to see if there are serial correlation for all the 6 currencies, using the Ljung-Box Q statistics (is a type of statistical test of whether any of a group of autocorrelations of a time series are different from zero. Instead of testing randomness at each distinct lag, it tests the "overall" randomness based on a number of lags) and Runs test, accordingly he fail to reject the null hypothesis for the 6 currencies at a

marginal significance level of 1 %, so the evidence in support of serial correlation in log return is quite weak, which supports weak for efficiency and martingale process, because when there is no serial correlation therefore the variables are random. After running the Run test, the result was fail to reject the null hypothesis, which means the 6 log returns are random and not auto-correlated, implying that the returns are orthogonal to any information available previously which supports weak form efficiency and a martingale process. Another test was done Variance ratio test which tests the long run martingale or a stochastic process that is highly determined, in this test also the results fail to reject the null of martingale at marginal significance level of 10%.

Another test was done as well to show the non-linear dependencies, and the result of the test also as the previous tests, fails to reject the null hypothesis, which states that non- linear dependence does not invalidate a martingale process, which states heteroscedasticity conditional evidence but it is still an unwanted stochastic behavior. Another test was done for normality test (normality tests are used to determine if a data set is well-modeled by a normal distribution and to compute how likely it is for a random variable underlying the data set to be normally distributed) the test results show significant departure from normality, but this result also as the previous one does not invalidate the martingale process; another test was done as well to see if there are structural breaks in the time span of the data, even though the time span was not that long, when there are structural breaks they lead the series look like there is a unit root process in fact there is no unit root, therefore suspicion of breaks in very important to determine for martingale hypothesis, he used 2 test to prove that there are no breaks in the data series; one was The Bai-Perron test and the other Quandt-Andrews unknown break test, both test implied the

same conclusion no breaks found in the data series, therefore the sample is homogenous and the martingale process is an inherent feature of the data.

In order to test for orthogonally and unpredictability is to run a Granger Causality test and is showed that the series are not predictable and the martingale process is well held. As mentioned earlier there is evidence for conditional heteroscedasticity it is normal to model it and see if such modeling can eliminate the non-linear dependence. The models he used to test are the GARCH and EGARCH models and the successfully remove heteroscedasticity in the standardized residuals. The last test was done to see if there exist cross dependencies and he found out that all the currencies at 1 % two tailed marginal significance level all pairwise correlations are significantly zero and positive except for Japanese Yen, it has marginally significant cross correlation with the euro and British pound but insignificant correlation with AUD and Canadian dollar. Therefore cross correlation between currencies do not invalidate the martingale hypothesis, in fact cross correlation between currencies are accepted because Lebanese pounds is the reference point of all six currencies.

CHAPTER THREE

METHODOLOGY

Accordingly the focus of my research will be to test whether the Lebanese foreign exchange rate market follow a random walk. In order to find out whether the six exchange rates follow a random walk, I will have to test three characteristics of the random walk theory which are normal distribution, identical and independent. Six daily foreign exchange rates against the Lebanese pounds, with 1279 observations per series, are studied. Log returns are calculated. Accordingly I will conduct the following tests on log returns to reach to my conclusion. (Except for item 1 which is applied on the log levels):

1. Augmented Dickey-Fuller tests (ADF) for random walks on the log levels of the six series. Taking logs stabilizes usually the variance. It is expected that all series in log levels follow a lognormal distribution or follow a random walk, or are deemed integrated of order one, and that log returns are stationary, or integrated of order zero. The null hypothesis of the ADF test is a random walk. If there is a random walk in log levels this means past information is already incorporated in prices and does not help in predicting future prices.
2. Calendar breaks test and other tests as may arise in the literature. If there are breakpoints, the series do not follow a stable distribution and hence are not identically distributed. Four tests are available:
    - Least squares with calendar breakpoints
    - Quandt-Andrews breakpoint tests
    - Bai-Perron Multiple breakpoint tests
3. Runs tests on the mean and on the median. If the series are not random this is weak-form inefficient because speculators can take advantage of the non-randomness
4. Normality tests. If the series are skewed to the right speculation can be profitable by holding the currency long, otherwise hold the currency short. If the distribution is leptokurtic, speculation can be profitable by holding a butterfly position in a combination of foreign exchange rates:
    - Kolmogorov-Smirnov normality test
    - Chi-square test for normality

- Eviews normality tests: Lilliefors (D); Cramer-von Mises (W2); Watson (U2); Anderson-Darling (A2).
- Jarque-Bera normality test

5. Ljung-Box Q-statistics for serial correlation and orthogonality: tests on the raw data, on the absolute values, and on the squares of the log returns. If autocorrelation is present on the raw data this is supportive of weak-form inefficiency because it implies predictability by historical prices. If autocorrelation is present in the absolute values and the squares of these values then the series are not identically distributed.
6. Descriptive statistics and tests on the mean log returns. If the mean log return is statistically significantly different from zero then the exchange rate is consistently appreciating, or consistently depreciating, which introduces unwanted predictability. It is expected that the six mean log returns are equal to each other and equal to zero. It is also expected that the six variances are equal to each other otherwise options of high-variance currencies will be pricier and more valuable.

Data

The study will be done on 6 currencies from January 2010 till 8 April, 2015 with a daily frequency with 1279 observations per series. The six currencies are Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), European Currency Unit (EURO), British Pound (GBP), and Japanese Yen (JPY). The data is taken from Bank of Lebanon's official website,

and the currencies are chosen upon availability and convenience. The rates that will be studied are spot cross foreign exchange rates, I did not include US dollars in my thesis because the exchange rate is fixed by Bank of Lebanon, and 1 U.S. Dollar is equal to 1,507.50 Lebanese Pounds. The six currencies are quoted indirectly in terms of the number of units of the Lebanese pound per one unit of foreign exchange currency. All series are logged as all the variables in the survey of literature use, log returns are calculated by taking the first difference of natural logs and the first difference of the logs is a very close approximation to a proportionate change. Accordingly if the foreign exchange rate follows a lognormal distribution, stated as a random walk in log levels, then this implies that the change in logs is identically, independently and normally distributed.

HYPOTHESIS AND SUB-HYPOTHESES

The general null hypothesis is that the log returns are statistically independent, identically and normally distributed. In order for a random walk to hold, there are 7 statistical requirements to be fulfilled. Each sub-hypothesis tests for a given part of the general null hypothesis.

Accordingly the sub hypotheses to be tested in my research will be:

I. The first null hypothesis will be: the series are non-stationary (unit root).all exchange rates in log-levels have a unit root, if the null

hypothesis is not rejected, this will imply that the series follow a lognormal distribution.

II. The second null hypothesis will be: there are no calendar breaks in the data series. It is known that a random and stationary series with a break will look like a non-stationary process or a random walk

III. The third null hypothesis to be tested is that: all log returns have the same zero mean and the same variance

IV. The forth null hypothesis: All log returns are random, if the null hypothesis is not rejected, than the series are independently distributed.

V. The fifth null hypothesis: All log returns follow a normal distribution

VI. The sixth null hypothesis: All log returns are not serially correlated, failure to reject the null hypothesis, means the series are identically distributed.

VII. The seventh null hypothesis: The absolute values of all log returns are not auto-correlated, if we fail to reject the null hypothesis; this means the series are identically distributed.

VIII. The eight null hypothesis: the square of the values of all log returns are not auto-correlated, if we fail to reject the null hypothesis; this means the series are identically distributed

CHAPTER FOUR

STATSITICAL ANALYSES

4.1 DESCRIPTIVE STATISTICS

Table 1. Descriptive statistics on Δ log X, i.e. the log returns.

Currency X	mean	median	max	min	Standard deviation	Annual st. dev.	Skewness test	Kurtosis test
AUD	-0.000125	0.0000958	0.030186	-	0.007485	0.11835	-5.103	16.92
CAD	-0.000140	0.000000	0.027628	0.04226	0.005548	0.08772	-4.397	17.85
CHF	0.0000577	0.000113	0.149415		0.008093	0.12796	-15.833	119.41

EURO	-0.000220	0.000000	0.020842	-	0.006037	0.09545	-6.382	12.29
GBP	-	0.000000	0.024694	0.03281	0.005125	0.08103	-5.103	16.44
JPY	0.0000643	0.000000	0.027992	-	0.006038	0.09547	-7.118	32.55
	-0.000199			0.07587				
				-				
				0.03430				
				-				
				0.02902				
				-				
				0.03714				

Notes: The actual z-statistics are reported for the skewness and kurtosis tests. The null hypotheses are absence of skewness and absence of kurtosis. The critical values for these two tests at the 5% marginal significance level are ±1.96. The annual standard deviation is equal to the daily standard deviation multiplied by the square root of 250 days a year.

Table 1 reproduces descriptive statistics on the log returns of the six foreign currencies that includes the arithmetic mean, standard deviation, kurtosis and skewness of daily exchange rate of 6 currencies. If a data series is exactly normally distributed, values of skewness and excess kurtosis are zero. Skewness measures the spread of returns around the mean. Negative skewness implies that the actual returns are likely to deviate further downwards from the mean returns, while positive skewness implies that actual mean returns are likely to deviate further upwards from the mean returns. A normal distribution has a skewness value of zero. Kurtosis measures the peakedness of a distribution compared to a normal distribution.

Skewness test is done by calculating the actual z and compare it with the critical Z, at α 0.05 two tailed, the critical 1.96 in absolute value. In order to calculate the actual z, we divide the skewness statistics by the standard error and compare it with the critical Z, if the actual Z is in the rejection zone meaning greater than 1.96, then we reject the symmetry.

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Table 2 and 3 show the actual z values for both skewness and kurtosis tests.

table 2: actual Z for skewness test

	Skewness			
	Statistic	Std. Error	actual Z	absolute value
dlaud	-0.347	0.068	-5.10294	5.10294
dlcad	-0.299	0.068	-4.39706	4.39706
dlchf	4.222	0.068	62.08824	62.088
dleuro	-0.434	0.068	-6.38235	6.38235

dlgbp	-0.347	0.068	-5.10294	5.10294
dljpy	-0.484	0.068	-7.11765	7.11765

As the results of the skewness test show that all actual Z levels are greater than the critical value 1.96, this implies that the null hypothesis is rejected, all 6 currencies do not follow a normal distribution, and all 5 currencies are negatively skewed, except CHF.

table 3: actual Z for kurtosis test

	Kurtosis		
	Statistic	Std. Error	actual Z
dlaud	2.318	0.137	16.91971
dlcad	2.445	0.137	17.84672
dlchf	98.76	0.137	720.8759
dleuro	1.684	0.137	12.29197
dlgbp	2.252	0.137	16.43796
dljpy	4.459	0.137	32.54745

The results of the kurtosis tests show that all 5 currencies have actual Z greater than the critical Z, thereby indicating leptokurtic distribution; which means the points along the X-axis are clustered, resulting in a higher peak (higher kurtosis) than the curvature found in a normal distribution. This high peak and corresponding fat tails means the distribution is more clustered around the mean

4.2 UNIT ROOT TEST

The first sub hypothesis to be tested in my research is the existence of unit root in the logged data series. A unit root is a requirement of week form efficiency as discussed by Fama (1965, 1970, and 1991). The null hypothesis to be tested in ADF unit root test is whether the data are non-stationary, have a unit root, while the alternative hypothesis is whether the data under study are stationary. In order to do the test the log returns are first calculated and then the first difference of natural logs is calculated. in order to know what to include in the ADF test, first I have graphed the six variables, in order to know if they are involved around a constant mean and follow a trend out that the variables do not evolve around a constant mean, accordingly the test is conducted by including a constant α and a time trend t. If Z is the foreign exchange rate, α is a constant, the equation will be as following:

This is in levels: $\text{Log}(Z_{t+1}) = \alpha + \log(Z_t)$ (1)

When we take the first difference of logs the formula will be: $\text{Log}(Z_{t+1}) - \log(Z_t)$ (2)

Table 4. Individual unit root tests with the Augmented Dickey-Fuller (ADF) test statistic. The null hypothesis is a unit root.

Currency X	log X	Δ log X
AUD	-1.404169 (0.8597)	-36.96506 (0.0000)
CAD	-1.806112 (0.7015)	-37.94578 (0.0000)
CHF	-2.242003 (0.4652)	-34.93936 (0.0000)
EURO	-1.081583 (0.9303)	-36.09557 (0.0000)
GBP	-2.452424 (0.3521)	-37.76019 (0.0000)
JPY	-1.800587 (0.7042)	-37.84230 (0.0000)

Notes: The tests include a constant and a trend. The ADF t-statistics are reported. In parenthesis are the actual p-values.

According to the results that are shown in table 4, in order to reject the null hypothesis, the actual p-value must be greater than the critical p- value at 10 % significance lever, which will be actual p> 0.1, as the results of the ADF test on levels shows that all six currencies reject the null hypothesis, therefore the six currencies when tested in levels are stationary which implies there is no unit root. Since the data is logged, and it is of daily frequency, the first difference of the logs is a very close approximation to a proportionate change, and the stationary process of the latter that expected returns are stable. The test results of first difference of logs as shown in table 4, all actual p-values are greater than the critical p-value; which means we fail to reject the null hypothesis; therefore, the currencies under study become non-stationary in first difference. The presence of a unit root, and of only one unit root, is strongly supported for logs of all six currencies.

4.3 CALENDAR BREAK TEST

The data may suffer from structural breaks although the time span is not that long (between 2010 and 8 April 2015). Structural breaks may force a series to look like a unit root process while in fact there is no unit root. Accordingly 3 calendar breakpoint tests applied in my research, the least square with break points, Quandt –Anderson unknown breakpoint test and Bai-Perron Multiple breakpoint tests. The Bai-Perron test is applied on the six demeaned log returns, and in order to be more certain about the inexistence of breaks Quandt-Andrews unknown break point tests is conducted as well as the least squared with no breaks test is applied. In total, and

for each currency, 895 break points are compared. The actual p-values are reported in Table 5. Since the null hypothesis is the absence of breaks, the first test of least squares with breaks shows there are no break points in the data series, while in the Quandt-Andrews unknown break points test the test results of maximum, exponential and average show that all currencies fail to reject the null hypothesis of no breakpoints, except for Japanese Yen, as the results of Quandt-Andrews test show, the maximum p-value of Japanese Yen is greater than the critical p-value, while the exponential and the average p-values are less than the critical value. Since the null hypothesis is the absence of breakpoint, and since all p-values are larger than 10% the conclusion is strong that there are no breaks and that the samples are homogenous.

Table 5. Tests for calendar breakpoints on $\Delta \log X$, i.e. the log returns.

Currency	Least squares with breaks	Quandt-Andrews unknown breakpoint test (Wald F-statistic)			Bai-Perron Multiple breakpoint tests (5% critical value of F-statistic: 8.58)
		Maximum	Exp	Ave	
AUD	No breakpoints selected	0.3600	0.1586	0.0988	4.097838
CAD	No breakpoints selected	0.5837	0.2666	0.1864	2.859598
CHF	No breakpoints selected	0.1456	0.5354	0.5967	6.227464
EURO	No breakpoints selected	0.1667	0.2202	0.3267	5.917699
GBP	No breakpoints selected	0.4875	0.7519	0.8115	3.335263
JPY	No breakpoints selected	0.0542	0.0215	0.0171	8.432660

Notes: Actual p-values for the Quandt-Andrews test are reported, its null hypothesis is no breakpoint, and 895 breaks are compared. The actual F-value is reported for the Bai-Perron test, and its null hypothesis is no breakpoint.

4.4 INDEPENDENCY TEST FOR MEAN AND VARIANCE

The third sub hypothesis to be tested in my research is whether the average log returns of 6 foreign exchange rates are zero, in order to find out, independent sample t-test is conducted, according to the test results shown in table 6. The results of the test show that all means are insignificantly different from zero; this means that the constant α in equation 1 and 2 are all zero

Table 6. Independent sample t-tests. The null hypothesis is that the average log return is zero:

AUD	-0.000125 (0.5427)
CAD	-0.000140 (0.3078)
CHF	0.0000577 (0.7962)
EURO	-0.000220 (0.1988)
GBP	-0.0000643 (0.6441)
JPY	-0.000199 (0.2259)

Notes: two-tailed actual p-value in parenthesis.

While table 7, shows the results of F-test of equality of the variance, as long as all 6 currencies are compared to one single currency which is the Lebanese pounds, the variances must be equal, in this test the null hypothesis is equality of variance, in all currencies the actual p-values are higher than the critical values. Only the two variances of Euro and Japanese yen are equal to each other statistically, while all the remaining currencies have unequal variances.

Table 7. F-tests of equality of variance. Actual F-values are reported.

	AUD	CAD	CHF	EURO	GBP
CAD	1.820				
	1.169	2.128			

CHF	1.537	1.184	1.797		
EURO	2.133	1.172	2.493	1.388	
GBP	1.537	1.184	1.797	1.000	1.388
JPY					

Notes: The critical values are 1.10 (5%), 1.12 (2.5%), and 1.14 (1%).

4.5 RUNS TEST

The forth sub hypothesis to be tested in my research is test for randomness, runs tests is a non-parametric statistical test that checks a randomness hypothesis for a two-valued data sequence. More precisely, it can be used to test the hypothesis that the elements of the sequence are mutually independent. If the number of runs is significantly higher or lower than expected, the hypothesis of statistical independence of the elements may be rejected. Accordingly I have conducted runs tests for mean and median for two tails at 10% level of significance, if the actual p-value is greater than the critical p-value; i.e. we fail to reject the null hypothesis and therefore the 6 foreign exchange rates are random. Table 8 and 9 show the results of the runs test. As the results of the runs test for mean and median show, all 6 currencies has asymptotic significance (2-tailed) greater that the critical value 0.05 this implies that we fail to reject the null hypothesis, than the series are independently distributed, therefore all 6 currencies are random.

Note: the variables are tested for the log diffrenece.

Table 8. Runs Test on median

	dljpy	dlgbp	dleuro	dlaud	dlcad	dlchf
Test Value[a]	.00	.00	.00	.00	.00	.00
Cases < Test Value	600	633	631	639	625	639
Cases >= Test Value	678	645	647	639	653	639

Total Cases	1278	1278	1278	1278	1278	1278
Number of Runs	635	642	637	647	641	609
Z	-.147	.115	-.162	.392	.073	-1.735
Asymp. Sig. (2-tailed)	.883	.908	.871	.695	.942	.083

Table 9. Runs Test on mean

	dljpy	dlgbp	dleuro	dlaud	dlcad	dlchf
Test Value[a]	-.0002	-.0001	-.0002	-.0001	-.0001	.0001
Cases < Test Value	600	628	611	614	614	629
Cases >= Test Value	678	650	667	664	664	649
Total Cases	1278	1278	1278	1278	1278	1278
Number of Runs	635	648	639	641	651	615
Z	-.147	.458	.013	.111	.671	-1.391
Asymp. Sig. (2-tailed)	.883	.647	.990	.912	.502	.164

4.6 TEST FOR AUTO-CORRELATION IN LOG RETURNS

There are 3 sub hypotheses whether the series under study are independent and random, which tests the log returns, the absolute value of the log returns and the third the square of the values of all log returns. In order to accept or reject the 3 null hypotheses, I have conducted a test for orthogonality and serial correlation which is the Ljung-Box Q statistics test, which tests whether the series are random and independent.

The null hypothesis is that there is no auto-correlation, i.e. the correlation in the populations from which the sample is taken are zero, so that any correlation in the data results from randomness of the sampling process, the alternative hypothesis is that the data are serially correlated, meaning the data exhibits serial correlation and one variable is correlated with

another variable, accordingly the P value is compared with the actual results of the tests and if the p actual is greater than the p critical, we reject the null hypothesis and accept the alternative hypothesis meaning there is auto correlation in the data, auto-correlation can decrease the accuracy of the data. The Ljung-Box Q statistics is done on 3 levels, first on log returns for serial correlation(results shown in table 10), second on the absolute value of log returns for auto-correlation(results shown in table 11) and on the square of the values of all log returns for auto-correlation(results shown in table 11). We will take into consideration 3 intervals: Lag 5, Lag 10 and Lag 15. The test results for all 5 currencies at the 3 lags taken into consideration for the 3 sets of returns (log returns, absolute value of log returns, as well as square of the values of all log returns) show that the significance level are greater than the critical value, meaning that we fail to reject the null hypothesis and all currencies are independent and not serially correlated. As well as the runs test for randomness can have two test values, the mean and the median, again the null for randomness fails to be rejected for both tests and for all 6 values.

Table 10. Tests of randomness and serial independence on Δ log X, i.e. the log returns.

			Ljung-Box Q-statistic		
Currency X	Runs test on the mean	Runs test on the median	K=5	K=10	K=15
AUD	0.912	0.695	0.918	0.535	0.073
CAD	0.502	0.942	0.086	0.101	0.032
CHF	0.164	0.083	0.178	0.053	0.204
EURO	0.990	0.871	0.621	0.476	0.430
GBP	0.647	0.908	0.349	0.710	0.623
JPY	0.883	0.883	0.388	0.398	0.377

Notes: Actual p-values are reported for all tests. The null of the runs tests is randomness. The null of the Ljung-Box Q-statistic is independent increments. The symbol k stands for the lag length in the computation of the Q-statistic.

4.7 TEST FOR AUTO-CORRELATION IN SQUARES AND ABSOLUTE VALUE OF LOGG RETURNS.

The absence of serial correlation is evidence against linear dependence. Accordingly, a Ljung-Box Q-statistics test is carried out on the squares of the demeaned log returns. In addition, as the test results show, all p values are less than the critical value; therefore, we reject the null hypothesis of linear dependency, meaning all values at three lags are independent. .as well as the absolute value of all log returns are calculated and the results of the test supports the conclusion that I have reached with the first 2 test results which is the series are random and independent.

Table11. Tests for conditional heteroscedasticity and non-linear dependence of Δ log X, i.e. the log returns.

Currency X	Ljung-Box Q-statistic on the absolute value of Δ log X			Ljung-Box Q-statistic on the square of Δ log X		
	K=5	K=10	K=15	K=5	K=10	K=15
AUD	0.000	0.000	0.000	0.000	0.000	0.000
CAD	0.000	0.000	0.000	0.000	0.000	0.000
CHF	0.000	0.000	0.000	0.000	0.000	0.000
EURO	0.000	0.000	0.000	0.000	0.000	0.000
GBP	0.000	0.000	0.000	0.000	0.000	0.000
JPY	0.000	0.000	0.000	0.000	0.000	0.000

4.8 TESTS FOR NORMALITY

The fifth sub hypothesis to be tested in my research is whether all log returns follow a normal distribution, in table 12 six normality tests are carried out on the six series of log returns, Chi-Square test, Kolmogorov-Smirnov, Jarque-Bera, Lilliefors(D), Cramer-von Mises, Watson(U2), and Anderson-Darling(A2), all the computations use the Eviews. The critical p-value to will be compared to is 0.05 and as the test results shown in table 12, all are less than 0.05, which means that all six foreign exchange rates are not normally distributed. All six series show significant departure from normality.

Table 12. Normality tests on Δ log X, i.e. the log returns.

Currency X	Jarque-Bera	Lilliefors (D)	Cramer-von Mises (W2)	Watson (U2)	Anderson-Darling (A2)	Chi-square test	KS test
AUD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.006
CAD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
CHF	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
EUR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
GBP	0.0000	0.0000	0.0000	0.0000	0.0000	0.0031	0.004
JPY	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000

Notes: The KS test is the Kolmogorov-Smirnov non-parametric test. Actual p-values for all tests are reported. The null is normality for all tests.

CHAPTER FIVE

FINDINGS

The test results showed supporting evidence for weak form efficiency, because the data under study are independent, but did not validate the 2 requirements of random walk which were identicality and normality distribution of the data, hence the series do not follow a random walk. therefore All six currencies under study are random and independent, but not normally and identically distributed, which meets the requirement of Weak form efficiency but they do not follow a random walk; hence this means there is evidence of non-linear relations in the Lebanese foreign exchange market, which implies that non-linear trading rules may be profitable.

RECOMMENDATIONS

This as well would explain the fact why banks worldwide, and among them Lebanese banks, have special departments that are trusted with undertaking technical analysis, and finding best forecasts of the foreign exchange rates, in order to take trading positions based upon this forecast. If a random walk holds then technical analysis is futile. Accordingly, banks are right in spending money and resources on technical analysis, because foreign exchange market in Lebanon is not normally and identically distributed, therefore traders and investors can make profits by technical analysis or applying some types of filter rules.

LIMITATIONS

- Data is only for 5 years
- Availability of the rates of the exchange currencies.

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