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Testing the Fair Game Hypothesis for US Dollar/Albanian Lekë Exchange Rate Over the Period January 1994- December 2012

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ABSTRACT:
The purpose of the paper is to test the fair game hypothesis for exchange rate process US Dollar / Albanian Lekë over the period January 1994 – December 2012.
The results of this study include: The fair game hypothesis is rejected for mean monthly exchange rate US Dollar/Albanian Lekë over the period January 1994 – December 2012 at 99.99% level of confidence. Day – to –day fluctuations of the nominal exchange rate US Dollar/ Albanian Lekë during the period 1 January 2008 – 31 December 2008 follow an unfair game process at 99.99% level of confidence. The fair game hypothesis is rejected for mean monthly exchange rate over the period January 2008 – December 2012 at 95% level of confidence. Day – to-day fluctuations of nominal exchange rate US Dollar/Albanian Lekë during the period 1 January 2004 – 31 December 2012 follow an unfair game at 99.99% level of confidence. A similar result holds for relative first differences of the daily exchange rate US Dollar/Albanian Lekë at 99.99% level of confidence. These findings are noteworthy because it has long been thought of that the movements in the US dollar / Albanian lekë nominal exchange rate must be a fair game.

Key Words: exchange rates, fair game, Kolmogorov – Smirnov- Lilliefors Test, Shapiro – Wilk Test.

1. Introduction

The efficient market hypothesis relies on the efficient exploitation of information by economic actors. Foreign exchange market efficiency (or foreign exchange market hypothesis) as well as fair game exchange process are important considerations for all currency market participants. Fama (1984) states that a foreign exchange market is efficient if fully reflect all available information. A weaker-form efficient market, proposed by Jensen (1978), states that a foreign exchange market is efficient if the marginal benefit of information does not exceed (is less or equal to) the marginal cost of collecting information. The role

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of foreign exchange market is to ensure that information is available to all participants. There are three types of currency market efficiency: weak form efficiency, semi-strong form efficiency, and strong form efficiency. Weak form efficiency requires that exchange rates move randomly, at least in the short term. Semi-strong efficiency and strong efficiency both refer to the disclosure of information. Semi-string efficiency requires that exchange rates reflect all published information; strong form efficiency requires that exchange rate reflect all public and private information (or inside , hidden information). The strong form of the efficient market hypothesis encompasses both semi-strong and weak forms of the efficiency. Especially, foreign exchange market efficiency implies zero serial correlation in exchange rate changes (fluctuations). If exchange rates were influenced by private (inside, hidden) information, then currency market participants would feel that the exchange market is unfair, as they would lose profits to other participants who had such information, see Madura and Fox (2007), p 84. The efficient market hypothesis, also referred as "Informational efficiency", asserts that currency market is "informationally efficient", see Hallwood and MacDonald (1994). The efficient market hypothesis requires that currency market participants have rational expectations, see Giannellis and Papadopoulos (2009). Robert Lucas Jr. (1975) interpreted the rational expectations hypothesis as an assumption that available information is optimally utilized by every participant in forming expectations. Lucas supposed that individual agents or firms form their forecasts by minimizing the square mean of the forecast error, conditional on the information available to them.

Foreign exchange market may or may not be efficient and some participants may or may not be rational. Either situation is acceptable to most of academics or practitioners. Whether or not a foreign exchange market is efficient has been extensively investigated, using different econometric techniques. Grossman and Stiglitz (1980), and Slezak (2003) argue that perfect informationally efficient markets are impossible because if markets are perfectly efficient then the profit from trading on information would be equal to zero, while the cost of gathering and trading on information is positive. Fama (1984) investigates the efficiency in nine currencies against US dollar and shows the efficient market hypothesis is rejected, because of a time-dependent risk premium. Hakkio and Rush (1989) test the efficiency hypothesis for the UK pound and the Deutsche mark. They find a consistency with efficient market hypothesis. Wu and Chen (1998) test the foreign exchange market efficiency for nine OECD countries and they find the support of the efficiency. Zivot (2000) tests the foreign exchange market efficiency for British pound, Japanese yen, and Canadian dollar against US dollar. He strongly rejects the efficiency hypothesis in all exchange rates, at 96% level of confidence. Aroskar, Sarkar, and Swanson (2004) investigate the impact of the European financial market crisis on foreign

exchange market hypothesis during pre-crisis, crisis, and post-crisis periods. They show that foreign exchange market inefficiency is strong in specific periods. Lee and Sodoikhuu (2012) report the validity (acceptance) of the weak-form efficient market hypothesis for foreign exchange markets in Japan, South Korea, and Philippines, but the rejection in Taiwan. In conclusion, several studies provide mixed evidence in efficient market hypothesis.

There might be three reasons why the currency markets are inefficient (Azad, 2009). First, the exchange rates in these markets do not quickly adjust to new information. Second, the exchange rates in these markets are not set at the equilibrium (Bayes-Nash-Harsanyi equilibrium) level, see Smith, Jefferis, and Ryoo (2002). Third the emergence of a parallel black market, due to the existence of exchange rate controls, and divergence between the equilibrium exchange rate and the official exchange rate, see Diamandis, Kouretas, and Zarangas (2007). If a foreign exchange market is inefficient, a mathematical model that best predicts the exchange rate movements can be developed. Therefore, an inefficient foreign exchange market provides opportunities for profitable foreign exchange transactions (Madura and Fox, 2007). Further, in an inefficient currency market the Monetary Authority (Central Bank) can determine the optimal strategy to influence exchange rates, to reduce the exchange rate validity, and to evaluate the consequences of economic policies. Participants in the inefficient foreign exchange market can devise and use various trading rules or techniques to make abnormal profits from transactions. Let us describe the exchange rate arrangements in Albania:

Currency	: Albanian lekë,
Exchange rate structure	: Unitary,
Classification	: Free floating,
Monetary authority	: Bank of Albania,

see IMF Annual Report on Exchange Arrangement and Exchange Restrictions, 2011. The Bank of Albania calculates and announces the daily exchange rates for US dollar, euro, and other major currencies. Albanian Government transactions are conducted rarely at exchange rates.

Exchange tax	: No
Exchange subsidy	: No
Forward exchange market	: No

The rest of the paper is organized as follows: Section 2 contains the mathematical apparatus, Section 3 provides the investigation of daily exchange rate US dollar / Albanian lekë; Section 4 presents the statistical analysis of monthly exchange rate US dollar / Albanian lekë; Section 5 concludes the paper (encloses the paper with conclusions).

2. Mathematical apparatus

Historically, there exists a very close link between efficient market hypothesis and martingales. Nominal and real exchange rates are well approximated by a discrete martingale. Academic economists have accumulated a mountain of evidence in the last twenty years to the effect that the mean exchange rates at the 1 or 3 month horizons follow a martingale. The forecast of exchange rates has never been significantly better that the martingale, see Meese and Rogoff (1983), Frankel (1993), Frankel and Rose (1995), MacDonald (1999), etc. Let us briefly explain the concept "discrete martingale". Consider a complete probability space (Ω, F, P) equipped with an increasing family $\{ F_t \}$, $t \in N$, of sub – σ algebras of F, called a filtration. In other words, (Ω, F, P, F_t), $t \in N$, denotes a filtered probability space. A real valued stochastic process X(t), integrable and adapted to $\{ F_t \}$ is said to be a discrete martingale if the conditional expectation satisfies the condition

$$E[X(t) \mid F_s] = X(s), \ P - a.s.,$$
$$\forall \ s, t \in N \text{ and } s \leq t.$$

In other words,

$$\int_A X(s)dP = \int_A X(t)dP \ , \forall \ s, t \in N, s \leq t, \text{ and } \forall \ A \subset F.$$

Of course, the filtration $\{ F_t \}$ is very important in this definition. When we want to stress this fact, we will speak of F_t – martingale. Any stochastic process X(t) is adapted to its natural filtration. $F_t^0 = \sigma$ (X(s), s ≤ t), and $\{ F_t^0 \}$ is the minimal filtration to which X(t) is adapted. In other words, $\{F_t^0\}$ is the minimal σ - algebra containing all sets of the form { w ∈ Ω | x(1) ∈ B_1, X(2) ∈ B_2, …, X(t) ∈ B_t}, where B_1, B_2, …, B_t ⊂ R are arbitrary Borel sets. To say that X(t) is adapted to $\{F_t\}$ is to say that $F_t^0 \subset F_t$, ∀ t ∈ N. Heuristically speaking , the σ-algebra F_t^0 is the collection of all random events which may occur before or at the time t. in other words, F_t^0 is the set of all possible posts up to time t. One often thinks of F_t^0 as the history of the stochastic process X(t) up to time t, or as the information set available at time t. note that F_t^0 is complete: all sets of P-measure zero are included in F_t^0;

$F_s^0 \subset F_t^0$ for s <t, and $F_t^0 \subset F$, ∀ t ∈ N.

We need the following statements:

Theorem 1._ If a stochastic process X(t) is F_t^0 – martingale, then E[X(t)] = constant, $\forall$ t $\in$ N.

Theorem 2. If a stochastic process is not F_t^0 – martingale, then it is not also F_t – martingale.

Definition (according to Jerome L. Stein and N.N. Vorobiev, 1980). A stochastic process with discrete time X(t), t $\in$ N, is said to be a fair game if the process Z(t) = X(t+1) – X(t), t $\in$ N, admits normal distribution with expectation zero , for all t $\in$ N:

Z(t) $\sim$ N (μ_t = 0, σ_t^2), see Gihman and Skorohod (1974 - 1979), Revuz and Yor (1991), Lipster and Shiryaev (1996), Shiryaev (2002), and Stein(2012) for an advanced treatement of martingale and fair game processes. The Kolmogorv – Smirnov test, like the Chi-squared test, can be used for any probability distribution. The Kolmogorov – Smirnov – Lilliefors test, however, is a supremum distance test specifically designed to test normal distribution. The Shapiro – Wilk test for normality compares a random sample against the normal distribution; this is a very powerful test. The Shapiro – Wilk test is of regression type and exhibits sensitivity to non-normality over a wide range of alternative distributions. The Shapiro – Wilk test is also sensitive to both skewness (asymmetry) and kurtosis (excess of the probability density function). The Shapiro – Wilk test provides a generally more accurate measure of non-normality that Kolmogorov – Smirnov – Lilliefors test, Cramer- Von Mises test, Durbin test, Chi-squared test, or b_1 test, see Hogg (2009), Field (2009). The Shapiro – Wilk test seems great: in one easy procedure it tells us whether a given random sample is selected or not from a normal population.

3. Investigation of the daily exchange rate US dollar / Albanian lekë

We are primarily concerned on the day-to-day fluctuations in the spot exchange rate

x(t) = s(t +1) – s(t), t $\in$ N.

We use the following concept of the **foreign exchange market efficiency**, introduced by Levich (1989).

Definition

The foreign exchange market is **efficient** if s(t) follows a **fair game** process. In other words, the foreign exchange market is efficient if x(t) follows a normal distribution with expectation equal to zero. The **normal distribution** of the day-to-day fluctuations in spot exchange rate provides the participants equal chance

to profit in foreign exchange market. If the foreign exchange market is **efficient (in Levich's sense),** then x(t) follows no pattern that might be exploited to **produce (generate)** profits. The data set consists of daily nominal exchange rate, quoted in term of Albanian lekë, for US dollar during the 1 January 1994 – 31 December 2012 in Albanian's exchange market. The data source is **Bank of Albania (http://wwwbankofalbania.org).**We develop a statistical analysis of the daily changes in the spot exchange rate

$$x(t) = s(t + 1) – s(t), \quad (1)$$

as well as of the relative daily changes in the spot exchange rate

$$r(t) = \frac{s(t+1)- s(t)}{s(t)} \quad (2)$$

Table 1 lists summary statistics for the x(t). We use SPSS (version 2009), see Field (2009)

Table 1. Statistical parameters for x(t)

Sample size	n = 2244
Sample mean	-0.000018
95% confidence interval for mean	-0.02433;0.02429
Median	-0.02000
Variance	0.345
Standard deviation	0.58722
Coefficient of variation	-32623.3
Maximum	2.88
Minimum	-4.17
Range	7.05
Interquartile range	0.635
Skewness	0.086
Kurtosis	3.278

Test the hypothesis

H_0 : The successive differences (changes) of the daily nominal exchange rate US dollar / Albanian lekë over the period 1 January 2004 – 31 December 2012 follow a normal distribution.

H_1 : The successive differences of the daily nominal exchange rate US dollar/Albanian lekë over the specified period follow a non normal distribution.

We apply Kolmogorov – Smirnov – Lilliefors test as well as the Shapiro – Wilk test for normality. The observed (computed) value of the KSL test is 0.061 and the observed value of the SW test is 0.966.

Decision Rule. Reject the null hypothesis H_0 at the confidence level 99.99%.

In other words, at the confidence 99.99%, the Albanian foreign exchange market was inefficient and the daily nominal exchange process rate s(t) was an unfair game, during the period 1 January 2004 – 31 December 2012.

Now, we consider the relative daily changes in the nominal exchange rate, denoted by **r(t),** quoted in terms of Albanian lekë, for US dollar during the period 1 January 2004 – 31 December 2012 in Albania's exchange market. Table 2 lists summary statistics for the **r(t)**.We use SPSS (version 2009), see Field (2009).

Table 2. Statistical parameters for r(t) during the period 1 January 2004 – 31 December 2012

Sample size	n = 2244
Sample mean	0.000019
95% confidence interval for mean	-0.00023; 0.00027
Median	-0.0002
Variance	0.000
Standard deviation	0.006
Coefficient of variation	315.8
Maximum	0.0340
Minimum	-0.0456
Range	0.0796
Interquartile range	0.0065
Skewness	0.127
Kurtosis	3.920

Test the hypothesis

H_0 : The relative daily changes **r(t)** in the nominal exchange rate US dollar/ Albanian lekë over the period 1 January 2004 – 31 December 2012 follow a normal distribution.

H_1 : The relative daily changes **r(t)** in the nominal exchange rate US dollar / Albanian lekë over the specified period follow a non-normal distribution.

We use KSL as well as SW test for normality. The observed value of the KSL test is 0.060 and the observed value of the SW test is 0.961.

Decision Rule. At the confidence level 99.99, reject the null hypothesis H_0 . That is, the Albanian foreign exchange market was inefficient regarding to the relative changes in the daily nominal exchange rate US dollar / Albanian lekë during the period 1 January – 31 December 2012.

Consider the relative daily changes in the nominal exchange rate, denoted by **r(t)**, quoted in terms of Albanian lekë, for US dollar during the period 1 January 2008 – 31 December 2008 in Albanian's exchange market. Table 3 lists summary statistics for the r(t).

Table 3. Statistical parameters for r(t) during the period 1 January 2008 – December 2008

Sample size	n = 247
Sample mean	0.000287
95% confidence interval for mean	0.000806; 0.001381
Median	0.000000
Variance	0.000
Standard deviation	0.0087249
Coefficient of variation	30.4
Maximum	0.0340
Minimum	-0.0460
Range	0.8000
Interquartile range	0.0080
Skewness	-0.334
Kurtosis	4.355

Test of normality for **r(t)** during the period 1 January 2008 – 31 December 2008

The observed value of the KSL test is 0.107 and the observed value of the SW test is 0.942.

Decision Rule. At the confidence level 99.99, the Albanian foreign exchange market was inefficient regarding to the daily US dollar/ Albanian lekë minimal exchange rate over the period 1 January 2008 – 31 December 2008. Equivalently, the **exchange process** was un **unfair game** over the period 1 January 2008 – 31 December 2008, regarding to the daily US dollar / Albanian lekë nominal exchange rate.

4. Statistical analysis of the monthly exchange rate US dollar / Albanian lekë

The data set consists of the successive differences of the monthly exchange rate US dollar / Albanian lekë during the period 1 January1994 – 31 December 2012 in Albania's exchange market. The source of the data is Bank of Albania. Table 4 contains statistical parameters for this data set.

Table 4. Statistical parameters for successive differences of the monthly exchange rate US dollar / Albanian lekë during the period 1 January 1994– 31 December 2012.

Sample size	n = 227
Sample mean	0.0523
95% confidence interval for mean	-0.4291; 0.5337
Median	-0.17
Variance	13.548
Standard deviation	3.681
Coefficient of variation	70.382
Maximum	19.10
Minimum	-13.24
Range	32.34
Interquartile range	3.17
Skewness	1.242
Kurtosis	6.891

The symbol **r(t)** denotes the successive differences of the monthly exchange rate US dollar / Albanian lekë during the period 1 January 1994 – 31 December 2012 in Albania's exchange market.

Test the hypothesis

H_0 : **r(t)** follow a normal distribution.

H_1 : **r(t)** follow a non-normal distribution.

Using the Kolmogorov – Smirnov – Lilliefors test as well as Shapiro – Wilk test for normality, we obtain the following results: The observed value of KSL test is 0.114; the observed value of SW test is 0.890; at the 99.99% confidence level reject the null hypothesis H_0. In other words, the Albanian foreign exchange market was inefficient regarding to the monthly US dollar / Albanian lekë during the period 1 January 1994 – 31 December 2012, at the 99.99 confidence level.

Now, we consider the relative monthly changes, quoted in terms of Albanian lekë, for US dollar during the period 1 January 2008 – 31 December

2012 in Albania's exchange market. Table 5 lists summary statistics for this random variable, denoted by **r(t)**.

Table 5. Statistical parameters for the relative monthly changes of the exchange rate US dollar / Albanian lekë during the period 1 January 2008 – 31 December 2012

Sample size	n = 60
Sample mean	0.004550
95% confidence interval for mean	-0.002847; 0.011947
Median	0.0035
Variance	0.001
Standard deviation	0.0286353
Coefficient of variation	6.2923
Maximum	0.0810
Minimum	-0.0610
Range	0.1420
Interquartile range	0.0328
Skewness	0.316
Kurtosis	0.296

Test of normality. The observed value of KSL test is 0.114 and the significance is 0.050. Therefore, at confidence level 95%, the Albanian foreign exchange market was inefficient regarding to the relative changes in the monthly exchange rate US dollar / Albanian lekë during the period 1 January 2008 - 31 December 2012. Equivalently, the exchange rate process **r(t)** was un unfair game over the specified period in Albania's exchange market.

Conclusion

The main objective of the study is to test the fair game hypothesis (or the efficient foreign exchange market hypothesis in the sense of Levich) for the exchange rate process US dollar / Albanian lekë during the period 1 January 1994 – 31 December 2012 in Albania's exchange market. Although it is hard to distinguish the nominal exchange rate process from a martingale, we showed that the martingale model for the nominal exchange rate US dollar / Albanian lekë is inconsistent with the data set over the specified periods.

An important problem is the severity of rejection of the efficient currency market hypothesis, because the Albania's foreign exchange market is inefficient at the 99.99% level of confidence.

We strongly reject the fair game hypothesis regarding to daily nominal exchange rate as well as monthly exchange rate US dollar / Albanian lekë during the specified periods in Albania's market.

We believe (make the conjecture) that there might be two reasons why the Albania's currency market is inefficient. **First,** the existence of speculative activities and the emergence of a parallel black exchange market. **Second**, the US dollar / Albanian lekë nominal exchange rate is not set at the Bayes – Nash – Harsanyi equilibrium level for the game with incomplete information. Therefore, there is a difference between the equilibrium level for US dollar / Albanian lekë exchange rate and corresponding spot exchange rate reported by the Bank of Albania. These findings are **noteworthy** because it has long been thought of that the movements in the US dollar / Albanian lekë nominal exchange rate must be represented by a **fair game**.

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