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Statistical analysis of the inflation in the case of Albania

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Abstract. This study is a first attempt to investigate whether the inflation rates for Albania follow a normal distribution and the inflation process is a fair game. The general results of the study include: i.The Kolmogorov's Central Limit Theorem is not valid for Albania's monthly inflation rates over the period January 1994 – December 2010 at the 99.9 % confidence level. ii. The inflation process for Albania, relates to the monthly inflation rates, over January 1994 – December 2010 is an unfair game. iii. The Kolmogorov's Central Limit Theorem is not valid for Albania's quarterly inflation rates over the period January 1996 – December 2010 at the 99.5 % confidence level. iv. The inflation process for Albania, related to the quarterly inflation rates over January 1996 – December 2010 is an unfair game. The observed extreme departures of inflation rates from normal distribution and the unfair game inflation process for Albania over the specified periods seems to have as a surprise to some international scientists and politicians.

Keywords: inflation process, inflation rate, Central Limit Theorem, fair game, Shapiro – Wilk test.

1 Introduction

Inflation is a major focus of economic policy worldwide. Inflation is the process of a raise in the general level of prices of goods and services in an economy over a specified period of time. When the general price level rises, each unit of currency buys fewer goods and services. Consequently, inflation also reflects an erosion in the purchasing power of money. Since there are many possible measures of price level, there are many possible measures of price inflation.

Most frequently, the term inflation refers to a rise in the Consumer Price Index (CPI), which measures prices of a representative fixed basket of goods and services purchased by a typical consumer, see Romer (2001). The formula for calculating the inflation rate is:

$$\text{Inflation rate} = \frac{P_0 - P_{-1}}{P_{-1}} * 100\%, \quad (1)$$

where P_0 denotes the current average price level,
P_{-1} denotes the average price level a year (or quarterly or month) ago.

Inflation effects on an economy are various. Negative effects of inflation include a decrease in the real value of money and other monetary terms over time. Uncertainty over future inflation may discourage investment and savings. Economist generally agree that high rates of inflation are caused by an excessive growth of the money supply. Today, most economists favor a low and steady (stable) rate of

inflation, because low inflation may reduce the severity of economic recession (crisis) and the risk of destabilizing the economy, see Honohan and Lane (2004), Cogley and Sargent (2005), Giannellis (2011).

Inflation is one of the most largely and deeply investigated economic variables both theoretically and empirically. Its causes, impacts on other economic variables, and cost to the overall economy are well known and understood. Economists and mathematician agree on inflation's negative impact on output and economic growth rate via three different channels, see Lucas (2000), (2002), Krugman and Obstfeld (2006).

Inflation is primary a monetary phenomenon that is produced by a more rapid increase in the quantity of money in circulation than in output. The behavior of quantity of money is the senior partner, the behavior of output is the junior partner. There is no example in history of a substantial inflation lasting for a more than six month that was no accompanied by a corresponding rapid increase in the quantity of money, and vice-versa.

Albania's inflation has varied greatly during the period January 1994 – December 2010, in response to economic policy, excess demands for all sectors of the economy: goods and services, money, financial assets, government deficit, imported inflation, exchange rate regime shifts, oil crises, speculative activities, level of corruption, as well as legislative and technological changes. Inflation rate and volatility have significantly declined over the last nine years, see Table 1. To find out why, we follow a system analysis approach. We treat Albania's inflation as responding to excess demands for all sectors of the economy, including variables representative for labour costs, foreign prices, interest rates, exchange rates, as well as excess demands for money, debt, goods, services, and labour.

Concerning the probability distribution law for monthly inflation rates (quarterly inflation rates or annual inflation rates, respectively), the normal distribution is the most frequently used. The assumption of normality is commonly motivated in Macroeconomics and Econometrics on the basis of the Kolmogorov's Central Limit Theorem and the fact that much of the inflation data is aggregated across time, space, and across consummators (agents). The normal distribution hypothesis for monthly (quarterly or annual) inflation rates is very popular, see Bidarkota (1996), Mankiw (2007), Barro (2007), Taylor (2008).

The relationship between the inflation rates and the Central Limit Theorem (CTL) has been a topic of considerable interest, and the economic literature have produced conflicting results. Some scientists suggest that the inflation rates follow a normal distribution, see Bidarkota (1996), Mankiw and Romer (1999), Hendry (2001), Clements (2004), Sarno (2005), Giannellis (2011), etc. In contrast, other scientists show that the inflation rates diverge from normal curves, see Blacke and Fomby (1994), Liziak (2002), Ireland (2007), Mestre (2007), Dias, Duarte and Ruo (2008), Nelson (2009), etc.

The remainder of this paper is organized as follows:

In Section 2, we briefly review the mathematical apparatus; Section 3 presents the investigation of the monthly inflation rates; Section 4 provides the investigation of quarterly inflation rates; Section 5 presents the conclusion.

2 Mathematical apparatus

The Central Limit Theorem (CLT) explains why many probability distributions tend to be very close

to the normal distribution. The key ingredient is that the random variable being observed should be the sum or the mean of many independent identically distributed random variables. The CLT is responsible for this remarkable result: The probability distribution law of the random sample mean tends to be normal (Gaussian), even when the probability distribution of the parent random variable (from which the random sample is obtained) is decidedly non-normal. The CLT is also known as the second fundamental theorem of Probability Theory. The Law of Large Numbers is the first fundamental theorem, and the Law of the Iterated Logarithm is the third fundamental theorem of Probability Theory. The Law of the Iterated Logarithm tell us what is happening "in between" The Law of Large Numbers and The CLT. Specifically, it says that the normalizing function $\sqrt{nl_n(l_n n)}$, intermediate in size between n of The Law of Large Numbers and $\sqrt{n}$ of The CLT, provides a nontrivial limiting behavior, see Shiryaev (2006). A contemporary version of the CLT for axiomatic probabilities is given by A.N.Kolmogorov.

Theorem 1 (CLT)

If all random samples $(x_1, x_2, \dots, x_n)$ of a reasonably large size n > 30 are selected from any random variable (population) X with finite expectation μ and variance σ^2 then the probability distribution of the sample mean $\bar{x}$ is approximately normal with expectation μ and variance $\frac{\sigma 2}{n}$. This approximation improves with larger samples, as n → ∞, see Kolmogorov (2002).

Theorem 2 (Berry – Esséen)

If the third central moment $E(X- \mu)^3$ exists and is finite, then the above convergence is uniform for all x ∈ (-∞, +∞) and the speed of convergence is at least on the order $\frac{1}{\sqrt{n}}$, see Kallenberg (1997),

Shiryaev (2006).

Theorem 3 (Arstein – Ball – Barthe – Naor)

The convergence to normal distribution is monotonic in the sense that the entropy of the random variable

$$Z_n = \frac{n(\bar{x}-\mu)}{\sigma\sqrt{n}} \qquad (2)$$

increases monotonically to that of the standard normal distribution, see Arstein, Ball, Barthe, and Naor (2004).

The amazing and counterintuitive thing about CLT is that no matter what the probability distribution of the parent (original) population X, the probability distribution of the sample mean $\bar{x}$ approaches a normal curve.

Consider a random sample $(x_1, x_2, \dots, x_n)$ selected from an arbitrary population X. The formula for the skewness of sample data is :

$$\text{Skewness} = \frac{n}{(n-1)(n-2)} * \sum_{k=1}^{n} \left(\frac{x_k-\bar{x}}{s}\right)^3, \qquad (3)$$

Where s denotes the sample standard deviation, and the formula for the kurtosis of sample data is :

$$\text{Kurtosis} = \frac{n*\sum_{k=1}^{n}(x_k-\bar{x})^4}{\left[\sum_{k=1}^{n}(x_k-\bar{x})^2\right]^2} - 3. \qquad (4)$$

If the population X has normal distribution, then skewness (X) = kurtosis (X) = 0.

Skewness represents the asymmetry and kurtosis represents the excess of the probability density function.

The Shapiro – Wilk test for normality (or W test) compares a set of sample data $(x_1, x_2, \dots, x_n)$ against the normal distribution. The W test for normality is a very powerful test. This test is of regression type and assesses how well the observed cumulative frequency distribution curve fits the expected normal cumulative curve. The W test for normality is sensitive to both skewness and kurtosis. The W test and Anderson – Darling test for normality are comparable in power, with W test having a slight advantage in many real situations. In general, W test is more accurate that Kolmogorov – Smirnov – Lilliefors test, Cramer – Von Mises test, Durbin test, Chi-squared test, and b_1 test. The W statistics exhibits sensitivity to non-normality over a wide range of alternative distributions. The W test provides a generally superior omnibus measure of non-normality. In most case, W test has power as good as or better than the other statistical tests for normality, see Shapiro and Wilk (1965), Shapiro, Wilk and Chen (1969), Wackenly, Mendenhall, and Schaeffer (2007), Hogg (2009), Field (2009). The Shapiro – Wilk test seems great : in one easy procedure it tells ua whether the random sample is selected from a normal random variable.

3 Investigating the monthly inflation rates.

The data set is monthly inflation rates for Albania over January 1994 – December 2010, and was derived from two sources: INSTAT and the Bank of Albania, see Table 1. Statistical parameters:

Sample size	n = 204 > 30
Sample mean	$\bar{x} = .58$
Sample median	.40
Sample variance	$S^2 = 3.23$
Sample standard deviation	S = 1.80
Sample coefficient of variation	cv = 3.10 = 310 %
Sample standard error	.126
Minimum	- 3.38
Maximum	14.05
Range	17.43
Skewness	2.80
Kurtosis	17.21

The 95 % confidence interval for the population mean is : P (.33 < μ < .82) = 95 %

In this study, using Shapiro – Wilk test for normality, we test the hypothesis:

Test the hypothesis:

H_0 : The monthly inflation rates for Albania over January 1994 – December 2010 follow a normal distribution.

H_1 : The monthly inflation rates for Albania over this period follow a non – normal distribution.

Using SPSS we compute, for the given data set, the W statistics for normality. Then, a corresponding p-value is generated to evaluate the significance level of W, see Field (2009). We found the following results:

The computed value of W statistics is W = .81, degrees of freedom = 204, and p-value = .000

Decision Rule: We reject the null hypothesis H_0 at the confidence level .999. In other words, The CLT is not valid for Albania's monthly inflation rates over January 1994 – December 2010 at the confidence level 99.9 %.

Remark 1. To merit empirical modeling, the data must measure the variables of interest with reasonable accuracy. However, given the long time period investigated here, associated with turbulent years 1995 – 1997, there must be substantial errors of the monthly inflation rate measurements, both conceptual and numerical. Mismeasurement of inflation rates in such nonstationary historical processes induces nonconsistency in derived economic results.

Definition (according to J.L.Stein, 1974). The inflation process is said to be a fair game if the successive differences of the monthly (quarterly or annual) inflation rates follow a normal distribution.

This definition is important and has found many applications in economic sciences see Stein (1974), Lucas (2000), Sargent et al. (2006), Stock and Watson (2007).

The successive differences of the monthly inflation rates for Albania over January 1994 – December 2010 are given in Table 2. We present statistical parameters related to this data set.

Sample size	n = 204
Sample mean	$\bar{x} = .009$
Sample median	- . 0015
Sample variance	$S^2 = 4.59$
Sample standard deviation	S = 2.14
Sample coefficient of variation	cv = 237.8
Sample standard error	. 15
Minimum	- 15.59
Maximum	8.73
Range	24.32
Skewness	-1.63
Kurtosis	16.03

95% confidence interval for the population mean is: P (-2.87 < $\mu < .30) = 95\ \%$

Test the hypothesis:

H_0: The successive differences of monthly inflation rates for Albania over January 1994 – December 2010 follow a normal distribution.

H_1: The successive differences of monthly inflation rates for Albania over this period follow a non - normal distribution.

We apply The Shapiro – Wilk test for normality.

The computed value of the test statistics is W = .812 and the corresponding significance level of W is .000

Decision Rule: Reject the null hypothesis H_0 at the confidence level .999. That is, the inflation process for Albania over January 1994 – December 2010 (in relation to the monthly inflation rates) is an unfair game.

*Remark 2.*Since inflation remains a central policy concern, there is a multiplicity of theoretical explanations, and all sources of possible evidence need to be carefully explored. In this sense, Remark 2 complements Remark 1. The most interesting finding of our study is the evidence of "unfair game

inflation process for Albania" over January 1994 – December 2010. Those responsible for this unfair game must be identified by the appropriate institutions, and they must be hold accountable and suffer legal penalties as well. Those who lose the most from the unfair game inflation process are of course the poorest Albanian households, retirees, and thousands of families who still leave below the subsistence level. That is why it becomes very urgent the implementation of relevant policies from the Albanian Government, in order to stop (and destroy) these fraudulent (and corruptive) activities (practices)

4 Investigating the quarterly inflation rates

The data set is quarterly inflation rates for Albania over January 1996 – December 2010. The sources of the data are INSTAT and the Bank of Albania, see Table 3. We present statistical parameters related to this data set.

Sample size	n = 60 > 30
Sample mean	$\bar{x} = 14.70$
Sample median	14.35
Sample variance	S2 = 2.96
Sample standard deviation	S = 1.72
Sample coefficient of variation	cv = . 12 = 12 %
Sample standard error	. 22
Minimum	12.10
Maximum	18.40
Range	6.30
Skewness	. 60
Kurtosis	-. 64

95% confidence interval for the population mean is: P (14.26 < $\mu < 14.64) = 95$ %

Test the hypothesis:

H_0: The quarterly inflation rates for Albania over the period January 1996 – December 2010 follow a normal distribution.

H_1: The quarterly inflation rates for Albania over this period follow a non – normal distribution.

We use The Shapiro – Wilk test for normality

The computed value of the test statistics is W = .936 and the significance of W is . 004.

Decision Rule: Reject the null hypothesis H_0 at the confidence level 99.5 %. In other words, The CLT is not valid for Albania's quarterly inflation rates over the period January 1996 – December 2010 at the confidence level 99.5 %.

The successive differences of the quarterly inflation rates for Albania over January 1996 – December 2010 are given in Table 4. We present statistical parameters related to this data set.

Sample size	n = 60 > 30
Sample mean	$\bar{x} = -.0067$
Sample median	-. 05

Sample variance	S^2 = . 199
Sample standard deviation	S = . 446
Sample coefficient of variation	cv = - 66.567
Sample standard error	. 0576
Minimum	-. 90
Maximum	1.60
Range	2.50
Skewness	1.286
Kurtosis	3.22

95% confidence interval for the population mean is: P (- . 122 < $\mu <$ .1087) = 95 %

Test the hypothesis:

H_0: The successive differences of quarterly inflation rates for Albania over the period January 1996 – December 2010 follow a normal distribution.

H_1: The successive differences of quarterly inflation rates for Albania over this period follow a non – normal distribution.

We use The Shapiro – Wilk test for normality

The computed value of the test statistics is W = .874 and the significance of W is .000.

Decision Rule: Reject the null hypothesis H_0 at the confidence level . 999. That is the inflation process for Albania over the period January 1996 – December 2010 (related to the quarterly inflation rates) is an unfair game.

Remark 3. We can not investigate the validity of CLT for annual inflation rates in the case of Albania over January 1994 – December 2010 since the sample size n=17 < 30.

5 Conclusion

The present study was motivated by some indications of divergence for Albania's inflation rates from normal distribution. The purpose of this study is to contribute to the debate on whether monthly or quarterly inflation rates for Albania over the specified periods (January 1994 – December 2010 and January 1996 – December 2010, respectively) follow a normal distribution and whether the inflation process was a fair game. These issues are of particular relevance from a policy point of view; for example, to Albanian Government and Bank of Albania. We found a strong evidence for the departure of the inflation rates from normal curve. Furthermore, an interesting finding of this study is the evidence of "unfair game inflation process" for Albania over the specified periods. This inconsistency cannot be corrected by partial adjustments.

The main factors that affect the departure for Albania's inflation rates from normality are : excess demands for all sectors of the economy (goods, services, money, financial assets, etc), monetary policy, inflation – wage spiral, government debt, imported inflation (economic recession, financial crisis, oil crisis), unemployment rate dynamics and labour costs, speculative activities and level of corruption, exchange rate regime shifts, interest rate regime, the circulation of dirty money, legislative and technological changes, the competitiveness between the interest groups, how conflicting interest are solved, the rational behavior of the consumers, etc.

One important question is: The Albania's inflation rates divergence from normal distribution and

"unfair game inflation process" are transitory or persistent? The answer to this question is crucial for Albania. The presence of persistent inflation rate divergence from normal distribution implies internal and external asymmetries, such as different growth opportunities and different competitiveness power across Albania, Greece, Italy, Macedonia, Kosovo, Serbia, Montenegro, Slovenia, Croatia, Bulgaria, etc.

The contradiction between the monthly or quarterly inflation rates data set for Albania and the CLT is serious, as the CLT is a fundamental theorem of Modern Probability Theory. The contradiction with the mathematical science is always serious!

In order to successfully fight the inflation process as an unfair game, some concrete actions are suggested to the Albanian Government and the Bank of Albania. First, the government must apply optimal strategies in order to minimize the loss function. According to Lucas (2000, 2002), the loss function is expressed as the sum of two terms, where the first term is proportional to the inflation rate, while the second term is proportional to the unemployment rate. Using this approach, we estimate the numerical values of the loss function per month, and then the losses accumulated over years. During the period January 1994 – December 2010, the total loss is in the range of billions of euros. Second, the Albanian Government and the Bank of Albania should minimize the circulation of dirty money, as well as speculative or corruptive activities into the Albanian markets.

We believe that the integration of Albania into NATO and EU structures, anticipates an uncompromised fight of the Albanian Government and the Bank of Albania against inflation process as an unfair game.

6 Appendix

Table 1 The monthly inflation rates for Albania.

month / year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	1.93	1.68	.64	8.99	1.73	1.62	-3.31	-2.05	.13	1.00	.87	1.90
1995	1.77	2.24	.38	1.67	-.48	-1.73	-3.38	.82	1.06	.66	2.33	.68
1996	2.05	1.73	1.55	1.45	1.05	-.75	2.53	2.36	2.50	1.59	-.46	.66
1997	1.63	5.32	14.05	-1.54	1.04	5.42	-1.21	.61	1.61	5.04	2.28	2.28
1998	3.46	1.82	1.16	1.61	-.18	-1.74	-2.01	.41	1.44	.26	.22	2.05
1999	.91	-.61	-.29	.01	-.64	-2.28	-1.30	-.28	.10	.39	.78	2.24
2000	.64	-.61	-1.11	.72	.67	-2.10	-2.67	.40	1.70	1.26	.85	4.58
2001	-1.29	-1.34	.29	.84	.21	-.66	-1.20	-.99	1.10	-.45	1.88	5.30
2002	1.51	-.27	.17	-.08	-1.62	-1.50	-.70	.17	.92	.05	-.11	3.21
2003	-.22	.89	.44	.86	-1.15	-1.70	-.37	.19	.71	.20	.37	3.10
2004	-.23	1.93	.11	.05	-1.72	-1.43	-.15	-.23	.06	.23	.54	3.11

month / year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	.83	.43	.00	-.28	-1.11	-.56	-1.23	.19	.85	.47	.19	2.15
2006	.18	.46	.09	.54	-.36	-1.18	-.37	-.18	.65	.09	.82	1.18
2007	.53	.44	-.09	-.27	-.80	-.62	-.27	1.80	.88	-.09	.82	1.18
2008	1.08	1.00	.89	-.39	-.98	-.79	-.60	.60	1.10	.00	.00	.89
2009	.39	.78	.58	-.10	-.77	-.58	-.68	.59	.78	.39	.48	1.63
2010	1.13	1.12	.00	-.37	-1.21	-.75	-.47	.76	.75	.19	.19	2.15

Table 2 The successive differences of the monthly inflation rates for Albania

month / year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994		-.25	-1.04	8.35	-7.26	-.11	-4.94	1.26	2.18	.87	-.14	1.04
1995	-.14	.47	-1.86	1.30	-2.15	-1.25	-1.65	4.20	.24	-.39	1.67	-1.65
1996	1.37	-.33	-.18	-.10	-.40	-1.80	3.28	-.17	.10	-.87	-2.06	1.27
1997	.97	3.69	8.73	-15.59	2.58	4.37	-6.63	1.82	.99	3.43	-2.76	.00
1998	1.18	-1.64	-.66	.46	-1.79	-1.56	-.27	2.42	1.03	-1.18	-.04	1.83
1999	-1.14	-1.52	.33	.30	-.65	-1.64	.98	1.02	.38	.29	.39	1.46
2000	-1.60	-1.25	-.50	1.83	-.05	-2.77	-.57	3.07	1.30	-.44	-.41	3.73
2001	-5.87	-.05	1.63	.55	-.63	-.87	-.54	.21	2.10	-1.55	2.33	3.42
2002	-3.79	-1.78	.43	-.25	-1.54	.124	.79	.88	.75	-.87	-.16	3.32
2003	-3.42	1.10	-.45	.42	-2.00	-.55	1.33	.56	.52	-.51	.18	2.73
2004	-3.33	2.16	-1.82	-.07	-1.77	.29	1.28	-.09	.29	.17	.31	2.57
2005	-2.28	-.40	-.43	-.28	-.83	.55	-.57	1.32	.66	-.38	-.28	1.96
2006	-1.96	.27	-.37	.45	-.91	-.82	.81	.18	.83	-.55	.73	.99
2007	-1.28	-.09	-.53	-.18	-.53	.17	.36	2.07	-.92	-.97	1.40	1.79
2008	-2.00	.00	-.10	-1.10	-.60	.20	.20	1.20	.50	-1.10	.00	.00
2009	-.50	.40	-.20	-.68	-.67	.20	-.10	1.27	.20	-.40	-.10	1.15
2010	-.50	.00	-1,12	-.37	-.84	.46	.28	1.23	.00	-.56	.00	1.96

Table 3 The quarterly inflation rates for Albania

year \ quarter	Q1	Q2	Q3	Q4
1996	13.10	12.40	12.40	12.10
1997	12.90	13.60	14.90	15.90
1998	16.50	16.90	17.60	17.90
1999	17.90	18.00	18.20	18.40
2000	17.60	17.30	16.90	16.00
2001	15.20	14.90	14.60	16.20
2002	16.10	16.00	15.80	15.50
2003	15.20	15.00	15.20	14.90
2004	14.80	14.60	14.40	14.40
2005	14.30	14.20	14.20	14.00
2006	13.90	13.80	13.90	13.60
2007	13.50	13.18	13.20	13.04
2008	12.66	12.62	12.68	12.68
2009	12.70	12.76	13.75	13.83
2010	13.78	13.52	13.49	13.43

Table 4 The successive differences of the quarterly inflation rates for Albania

year \ quarter	Q1	Q2	Q3	Q4
1996	.00	-.70	.00	-.30
1997	.80	.70	1.30	1.00
1998	.60	.40	.70	.30
1999	.00	.10	.20	.20
2000	-.80	-.30	-.40	-.90
2001	-.80	-.30	-.30	1.60
2002	-.10	-.10	-.20	-.30
2003	-.30	-.20	.20	-.30
2004	-.10	-.10	.00	-.20
2005	-.10	-.10	.00	-.20
2006	-.10	-.10	.10	-.30
2007	-.10	-.32	.02	-.16

year \ quarter	Q1	Q2	Q3	Q4
2008	-.38	-.04	.06	.00
2009	.02	.06	-.01	.08
2010	-.05	-.26	-.03	-.06

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