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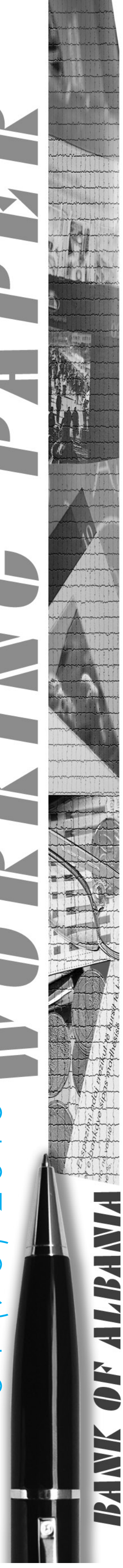

BANK OF ALBANIA

Altin Tanku
Research Department, Bank of Albania, email: atanku@bankofalbania.org

Kliti Ceca
Research Department, Bank of Albania, email: kceca@bankofalbania.org

# C O N T E N T

# ABSTRACT

The post crisis period in Albanian economy has been distinguished by low inflation and slow economic growth. In response to negative inflation and output gaps, Bank of Albania has persistently reduced its policy rate to support economic activity and bring inflation to its objective. Hence, the growth in credit and aggregate demand is lagging. The transmission mechanism seems to have lost some of its efficiency. This paper investigates the hypothesis that the relationship among interest rate, money and inflation has changed in the post crisis period (the case of Albania). Density estimation techniques based on Tanku and Ceca (2013), is used as an alternative method of empiric investigation within the probability framework. Two dimensional densities of inflation, money and interest rates are estimated for two different periods. The PDF and CDF of the estimated densities are reported graphically and are used to test whether pre-crisis and post-crisis datasets arise from the same distribution. The comparison of probability spaces is based on the two-dimensional Kolmogorov-Smirnov (K-S) test. We conclude that the relationship between interest rate and inflation, and interest rate and money has changed in the post-crisis period. These findings have important implications for the conduct of monetary policy in Albania.

Key Words: Monetary policy regime switch, kernel density estimation, probability density function, probability space, two dimensional KS test.

*JEL: B41, C18, C51, E52*

# 1. INTRODUCTION

The post 2008 period has marked significant changes in the economic performance in terms of growth, inflation and credit developments in Albanian economy. Following the demise of absorption growth model, the post crisis period has been distinguished by low inflation and slow economic growth, leading to persistent negative inflation and output gaps. In response to these developments, Bank of Albania has pursued an expansionary monetary policy to support economic activity and bring inflation to its target. Starting from 2010, the policy rate has been reduced persistently from 6.25 to the historically low level of 1.25.

The reduction of the policy rate has been fully transmitted to interest rates of all maturities and across the range of financial instruments. Despite this reduction in interest rates the response of credit growth has been sluggish. Credit in domestic currency is growing, but rather than contributing to overall credit growth, its growth is substituting for the decrease of credit in foreign currency. Investments and aggregate demand has responded positively, but less vigorously than expected. Prices and economic growth remain below their average pre-crisis level. On the other hand, banks' time deposits are flocking toward the extreme ends of the maturity spectrum rather than flowing to consumption or investments. The transmission mechanism seems to have shifted all together into a new regime of efficiency relative to the pre-crisis period.

This paper takes note of these developments and asks whether the post-crisis period has altered the transmission mechanism of monetary policy in Albania. The main hypothesis is that the relationship among interest rate, money and inflation has changed in the post crisis period. Empirical investigation is based on a new method of multidimensional density estimation proposed by Tanku and Ceca (2013). Essentially two dimensional densities of inflation, money and interest rates are estimated using multidimensional estimation techniques for two different periods. The PDF and CDF of the estimated densities are reported graphically and are used to test whether pre-crisis and post-crisis datasets arise from the same distribution. The comparison of probability spaces is based on the two-dimensional Kolmogorov-Smirnov (K-S) test. We find that with the exception of money-inflation relationship, the crisis has induced a change in the rest of transmission mechanism, respectively relationships between policy rate and inflation and policy rate and money.

There is significant interest in empiric investigation to transmission mechanism from academic and policy making point of view. Therefore, the study of transmission mechanism has a long and broad history and involves research for developed and developing economies. In the context of Central and South Eastern European economies, research in this area has preceded the introduction of indirect instruments of monetary management or the change of monetary regime in transition economies. The topic of monetary policy transmission mechanism and its regime change is covered by very prominent authors, using the entire range of available empiric research methodologies from pure observation, to time series analysis based on VAR-s SVAR-s, BVAR-s, Cointegration, VECM and sophisticated DSGE platforms (models). As usual, the analysis is based on estimated coefficients, IRF and similar shock analysis.

There are also a significant number of studies conducted in the context of transition economies, including the economies of South-East Europe (SEE). The most recent among them is Koukouritakis, Papadopulos and Yannoupoulos (2014) which revisits the transmission mechanism of SEE economies. This study benefits from the unit root and cointegration tests that can adjust for structural breaks, which are necessary to accommodate potential regime shifts introduced by the process of EU membership or monetary regime changes. In similar fashion, monetary transmission mechanism has been studied in Albania, first to discuss the shift of monetary policy from monetary targeting to inflation targeting regime and, second, to perfect the modeling for monetary policy forecast and analysis purposes. They are all based on the above mentioned methodologies and try to depict exactly the potential changes in the transmission mechanism.[1]

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[1] For a list of Albanian Studies please see: Kolasi, Shijaku and Shtylla (2009), Shijaku G. (2016), Dushku and Kota (2011)

Such empiric models are well established and broadly accepted; yet, past and recent practice (eg. Bank of England 1999), suggests that from the point of view of understanding economic developments and decision making, the imposition of a framework of specific channels through which monetary policy works may be too restrictive. Therefore, regardless of the technique employed and estimation, it is important to have full understanding of the implications of such limitation in the interpretation of econometric results. This critique remains very relevant and deserves due attention from academics and policymakers.

The study of monetary transmission mechanism regime changes in US represents a very good example that beautifully illustrates the limitations indicated by the critique above. The US monetary transmission mechanism has a long history of empiric research and represents one of the leading sources for the development of different empiric investigation strategies. A brief review of this research shows that it is not easy to reach a firm and clear conclusion on the identification of monetary policy regime changes. Studies conclude with contradicting results. On one hand, we have DeLong (1997), Taylor (1997), Sargent (1999), Clarida, Gali and Gertler (2000), and Lubik and Schoorfheide (2004), who conclude that policy changes are responsible for economic outcome. In other words, they observe a change in the estimated parameters of the econometric models. On the other hand, a larger group of authors reject the conclusion that monetary policy has changed drastically. Among them, Bernanke and Mihov (1998), Leeper and Zha (2003), Stock and Watson (2002) and Orphanides (2004) find little evidence against stable coefficients suggesting only modest changes in monetary policy and monetary policy rules used in the 25-30 years preceding the 2008 crisis. Likewise Sims (2001) and Sims and Tao Zha (2006) suggest that changes in observed data are caused by changes in the variance of exogenous shocks rather changes in relationships.

It is therefore not easy to dismiss the fact that: assumption of structural relationship, endogeneity status among variables, the choice of functional form, along with data availability and the employed empiric methodology, can affect the results and the conclusion of the study. This is also observed by Canova and Gambetti (2010, pp.184) who remark that "the division appears to be linked, in part, to the type of empirical analysis conducted".

We believe that the method of density estimation, proposed by Tanku and Ceca (2013), provides an advantage compared to traditional methods described above. The traditional framework takes a stochastic event, "adopts" the data to empirical method, imposes particular functional form and model identification structure, estimates the system via empiric techniques and finally compares the estimated coefficients and IRF assuming that the results carry over to the stochastic model. Alternatively we propose to estimate the probability mass in two dimensional spaces (by using density estimation techniques) and, after that, to compare those probability masses using Kolmogorv-Smirnov techniques. In this respect, density estimation does not introduce or force any structure in the model and data. Most importantly, the comparison is based on the estimation and comparison of the probability model rather than the estimated coefficients and/or IRF.

In line with the above discussion, the next section introduces briefly the economy as a random event, the rest of the paper is organized as follows: section three describes density estimation methodology and the KS test vs. traditional methodology; section four discusses research plan, data and methodology; section five presents and discusses results and section six concludes.

## 2 THE ECONOMY AS A RANDOM EVENT – METHODOLOGICAL ISSUES

This section provides a general description of theoretical background, the main concepts and definitions that are considered in the adaption of density estimations techniques.

## 2.1. THE PROBABILITY APPROACH IN ECONOMICS

Economic behavior and economic developments fit very well the characteristics of random events. As such, it must be studied or fitted by stochastic models that are able to replicate this stochastic environment. Haavelmo (1944) formalized and present the economic phenomena in the form of a probability model. In his view, the economy is represented by a multi-dimensional set of variables $x^1, x^2, \ldots, x^d$. A particular set of values ($\underline{x}^t$) that corresponds to a particular moment in time "$t$", where ($\underline{x}^t$) = $(x_t^1, x_t^2, \ldots, x_t^d)$, is represented by a point (entry) in $d$-dimensional Cartesian space. There are altogether $t$ such point entries in this $d$ dimensional space, forming a set $S$ in the same space.

Haavelmo (1944) observes that if one can identify a system of rules or operators ζ which define a subset $S'$ of all these points, than she/he can define the entire set of points by the property of belonging to $S'$ or not belonging to $S'$. This rule ζ defines the function $F(x)$:

$$F(x) = f(x_t^1, x_t^2, \cdots, x_t^d), \qquad 2.1.$$

which represents the "model" that generates the particular $S'$ in this $d$ dimensional time series. Building upon this representation of the random economic process, the assumed presence of more than one system of rules or operators leads to the generalization below:

$$F(x) = f^{i_1}(x_t^{i_k}) \otimes f^{i_2}(x_t^{i_l}) \otimes \cdots \otimes f^{i_m}(x_t^{i_m}), \qquad 2.1.1.$$

$where\ i_k \neq i_l$, for $k \neq l\ and\ m \leq d;\ k, l \in \{1,2, \ldots, m\}$ and $f^{i_k}, f^{i_l}, \ldots, f^{i_m}$ are subsets of $S$, that cover the entire set $S$.

Expression 2.1.1. represents the "model" that generates the entire space $S$ spanned by this $d$ dimensional random event. Therefore the economy can be defined and expressed in terms of function $F(x)$ which represents a joint set of rules, or operators ζ that satisfies equation 2.1.1 for the entire space $S$.

Function ***F(x)*** in 2.1.1. above is comprised of ***m (m ≤ d)*** different sets of rules or operators ζ denoted $\zeta_m$, that span the entire space ***S***.[2] The identification of all ***m*** functions $f_j^i$ in the ***d*** dimensional space as defined by 2.1.1. provides the exact model of the natural process that generates a particular set of data[3]. Haavlemo (1944) points out that the deterministic solution of model 2.1.1, "would not absolutely cover every single $x_t$ in the ***d*** dimensional Cartesian space". Therefore this probabilistic nature of the economy requires to split the information given by 2.1.1. into two parts: ***one*** containing "restrictions which form the theoretic model or general fundamental laws" and ***two*** "the disturbances or the stochastic part".

## 2.2. PORTRAYING ECONOMY AS A RANDOM MULTIDIMENSIONAL EVENT

Economists study the economic phenomenon using the observed set of economic data that is created by some unobserved data generating process (DGP). The economy as a random phenomenon, is also discussed by Hendry and Richard (1983) and Ericsson, Hendry and Mizon (1998). These authors define the data generating process (DGP) in the form of a probability space [*Ω, F, P(·)*] and express it in the form of a joint density function of the initial conditions or vector $X_0$ initial conditions for all observed economic variables, a vector of parameters ζ and all the subsequent vectors $X_t$ (realizations of economic variables at time *t*) for all $t \in (1,2,\cdots t-1)$ as follows:

$$D_X(X_T|X_0,\zeta) = \prod_{t=1}^{T} D_x(x_t|X_{t-1},\zeta_t) \qquad 2.2.$$

Here $X_{t-1}$ represents the stochastic process $(X_0, x_1, \ldots x_{t-1})$ and $\zeta_t$ representing a subset of the parameters set $\zeta = (\zeta_1, \ldots \zeta_T)$. The subset of parameters is the mechanism that relates all random variables

[2] Index m stands to denote the number of models, restrictions or functions ***f(x)*** in the d-dimensional space ***S***.

[3] Hendry and Richard (1983) call this natural process "the data generating process *(DGP)*".

together. It is not known to the researcher or the policy making authority and therefore it is the focus of the empiric research. The estimation of the parameters is necessary for forecasts and policy analysis and renders this probabilistic representation of the economy useful to authorities. The empirical model takes the form:

$$f_x(X_T^1|X_0,\theta) = \prod_{t=1}^{T} f_x(x_t|X_{t-1},\theta) \qquad 2.3.$$

This is the framework that supports the empiric analysis of time series and dynamic stochastic models, including the works of Sims (1980) and its later developments with SVAR, BVAR, VECM and the development of the DSGE models. It relies on the decomposition of the joint probability into a conditional probability and marginal probability for each $t \in T$ repeating the process until we reach $t_0$ as in eq. 2.3. above. The solution comes in the form of set of estimated parameters that depict the relationships among the present and past values of the variables of interest (part **one** of 2.1.1.) and a set of i.i.d. vectors of errors (part **two** of 2.1.1.), which accounts for the errors of estimation and "fits" the model to the stochastic real world.

Following this setup, current econometric analysis requires that the researcher formulates a hypothesis for the supposed economic model 2.3., (and its functional form) which is accepted or rejected in the basis of statistical tests. The estimation of the parameters requires several additional assumptions; several long and short term restrictions of assumed theoretic relationships and identification are required to generate a uniquely identified solution imposing additional structure in the assumed data generating process[4]. Finally, the estimation requires the correct identification of the endogeneity status among variables.

Given this complicated and imposing nature of assumptions and their potential negative implications in the estimation and representation of DGP, Tanku and Ceca (2013) propose an alternative methodology that goes back to the original Haavelmo's

[4] See Juselius and Franci for a detailed discussion on the implication of the imposed theoretic restrictions and their implications.

description of the random process. The objective is to use kernel density estimation techniques to estimate the joint probability density function of the $d$ dimensional random event $f(.)$ and its conditional density function as method of empiric observation, investigation and representation of the true DGP. The general idea is to reformulate the DGP in terms of $x^d$ as a conditional process of dimensions in the form of joint density function of our d-dimensional in the following general form:

$$D_X(X^i; |f(.), X^j) = D_x(x^i|x^j, \hat{f}(.)) \qquad 2.4$$

*where:*

$i \leq d$ *is the variable which density function is estimated (the variable or the set of variables of interest),* $j = (1,2, \dots, i-1, i+1, \dots, d)$ *represents the conditioning dimensions,* $f(.)$ *represents the true d-dimensional joint density function and* $\hat{f}(.)$ *represents the estimated d-dimensional joint density function.*

Alternatively, the DGP could be expressed as an unconditional process in terms $x^d$ by estimating the joint density function of our d-dimensional space spanned by the variables of interest in the following general form:

$$D_{X^d}\left(X^d, f(.)\right) = D_{x^d}(x^d| \hat{f}(.)) \qquad 2.4.1.$$

In principle, expression 2.4.1., estimates the probability of location of points $x^i_t$ along dimensions $i$ of the multidimensional (d-dimensional) space spanned by economic variables (as given in 2.2.1). *It provides an alternative representation of the equation 2.1.1. It also defines the economy as a sequence of expanding spaces, within any* **d** *dimensional space generated by* **d** *different random variables. Given this framework, Tanku and Ceca (2013) note that: "each* **m** *dimensional space (where* **m** ≤ **d**)*, represents a subspace of the entire random event. Adopting Hendry (2004) definition, we will call such subspaces a local data generating process (LDGP). The resulting* **m** *dimensional LDGP represents a* *projection of the DGP into a lower dimensional (remember* ***m*** *≤* ***d****) space defined by the LDGP itself. This projection preserves the original DGP in the lower dimensional space by identifying as much of eq. 2.1.2, as is included in the LDGP. Therefore no information is lost regardless of the particular choice of the variables that are included in LDGP*." This conclusion is very important because, Hendry (2004) shows that under current empiric methods "reduction" of the true DGP into a transformed LDGP (read: a subset of variables), can radically alter the causality and endogeneity status of the variables" (Hendry 2004, pp.3).

Therefore, using the representation of the DGP in 2.4.1., one can make correct inferences about stochastic behavior of economic variable ***i*** given knowledge of the joint density function of the chosen LDGP and alternative values of conditioning variable(s) ***j***. This is rendered possible by the estimation of joint density function of the chosen LDGP using the framework of kernel density estimation.[5] This alternative methodology yields two particular benefits. First, it studies the DGP without related assumptions and the imposed theoretic structure. Practically Tanku and Ceca (2013) propose to estimate the multidimensional PDF and CDF of the LDGP of the set of variables of interest and use it to obtain information about the existence and nature of relationships among variables of LDGP. Further the comparison of different events is based on comparison of the probability spaces which are approximated by the estimation of joint probability density functions. Practical estimation of joint densities and their comparison is discussed in the following section.

[5] An extended discussion of the density estimation of the single and multidimensional random events is provided in the following section.

# 3. BRIEF DESCRIPTION OF DENSITY ESTIMATION TECHNIQUES AND KOLMOGOROV - SMIRNOV TESTS

Density estimation technique and KS tests are well known and discussed tools in the Probability Theory. A formal description can be found in Silverman (1986) and other authors mentioned below. However, because they are the tools of empiric investigation therefore we devote a brief description of both in the following paragraphs.

## 3.1. KERNEL DENSITY ESTIMATION

Probability distribution of a random variable provides the fullest information regarding this random variable – so does the probability density function. The estimation of the probability distribution (or its probability density function) is therefore fundamental goal of theoretic and applied probability and the best way to gain full understanding of the true nature of the random event. The probability density function of a random variable $X$ is called a nonnegative function $f(.)$, that satisfies the condition:

$$\forall a, b \in R: \quad P(a < X < b) = \int_a^b f(x)dx. \qquad 3.1.$$

Tanku and Ceca (2013) assume that the "event" is composed of random variables with unknown probability density function $f$. Therefore, the estimation of densities focuses on the estimation *of non-parametric distributions*. In principal the estimation of $f$ is a generalization of the histogram concept and is based on different techniques called *density estimation techniques*[6].

Assuming the existence of a sample $x_1, x_2, \ldots, x_n$, from the random

[6] The density estimation theory is described in several monographs and other literature mentioned in the article.

variable *X*, with a starting point $x_0$ and the bin width parameter *h*.[7] Then in the right-closed intervals $[x_0 + mh, x_0 + (m+1)h]$[8] one can build verticals equal to the absolute or relative occurrence of $x_i$ in the same interval. The functional form of the histogram is given:

$$\hat{f}(t) = \frac{1}{nh} \cdot (nr.of\ x_i\ in\ the\ same\ interval\ with\ t) \qquad 3.2.$$

*If the random variable X has the density $f(\cdot)$, it is true that:*

$$f(t) = \lim_{h \to 0} \frac{1}{2h} P(t - h < X < t + h) \qquad 3.3.$$

*Then, as a natural estimator of the density $f(\cdot)$, becomes:*

$$\hat{f}(t) = \frac{1}{2nh} \cdot (nr\ of\ x_i \in ]t - h, t + h[\,) \qquad 3.4.$$

*In a more formal way, the above estimator can be written:*

$$\hat{f}(t) = \frac{1}{nh} \cdot \sum_{i=1}^{n} w\left(\frac{t - x_i}{h}\right), \text{ where } w(x) = \begin{cases} \frac{1}{2}, & for\ |x| < 1 \\ 0, & x\ other \end{cases} \qquad 3.5.$$

This estimator given by eq. 3.5. is known as "naive estimator" and has two main features: first, it is a direct generalization of the histogram and second (and most important) its canonical form allows the further generalization into the "kernel density estimation"[9].

Kernel estimation is a natural generalization of the expression 3.5. Assume that *K(x)* is a density probability function, hereinafter called

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[7] The bin width parameter h acts as a smoothing parameter, in the meaning that increasing the value of h suppresses the statistical noise and gradually wipes the statistical significance of the curve while, the decreasing the value of h increase the statistical noise and gradually makes unreadable the statistical significance. A discussion on the smoothing parameter h is given in the 8th chapter.

[8] The choice of $x_0$ may have no restrictions in the classical way of building the histogram.

[9] Other methods are in place and they are not in the focus of this paper.

*the kernel function* (or simply Kernel) following the terminology of "density estimation". If the function ***w(x)*** is substituted with kernel ***K(x)*** in the expression 3.5., the general form of density kernel estimation takes the form:

$$\hat{f}(t) = \frac{1}{nh} \cdot \sum_{i=1}^{n} K\left(\frac{t-x_i}{h}\right). \qquad 3.6.$$

Methods of kernel density estimation are provided in Devroye and Gyorfi (1985), Silverman (1986), Devroye (1987), Wand and Jones (1995), and Devroye and Lugosi (2000) and Silverman (1986) who describe the details of the estimation process of a density distribution.

## 3.2. THE TWO-SAMPLE KOLMOGOROV-SMIRNOV TEST

The Kolmogorov-Smirnov (KS) test is a non-parametrical that is used to test if a continued distribution, one-dimensional, fits or not with a given distribution, or to compare two one-dimensional samples if they come from the same set or not.

In this paper we use a generalized form of KS mentioned test. It is two-dimensional KS test of goodness of fit and is given by J. A. Peacock (1983). We apply it to compare two-dimensional samples if they come from the set or not. Based on the algorithm of Peacock paper, we programed a routine in Matlab. The algorithm makes the comparison of two two-dimensional CDFs, using the statistical hypothesis testing at the confidence level of 95%.

# 4. RESEARCH PLAN, DATA AND METHODOLOGY

This project intends to use density estimation techniques based on Tanku and Ceca (2013), as alternative methods of empiric investigation of the monetary policy transmission mechanism in Albania. We use multidimensional density estimation techniques to estimate and project two dimensional densities of inflation, money and interest rates for two different periods respectively pre-crisis 2001-2009 and post-crisis 2010-2016. The interest rate variable is lagged by one quarter, to account for potential lags in interest rate effects on other variables. Money and interest rate data come from Bank of Albania. Money is represented by the growth rate of M3 Monetary aggregate, while interest rate represents the level of weekly repurchase agreement rate (the policy rate). Inflation represents the percentage changes in CPI as calculated by the authors based on CPI data reported from INSTAT. This information is summarized in table 1 below.

We estimate probability density function (PDF) and cumulative density functions (CDF) and report them graphically in figures 1-6 below. PDF is portrayed in both surface and contour representation. Dark blue color represents events with 0 probability of occurrence, while dark red colors represent events with the highest chance of occurrence. Lines of similar color indicate isobars with the same ***F(X)***. In addition we have also reported the mode of the estimated two dimensional densities as a proxy of the implied "relationship" (co-movement) of the variables in the exercise. It is supposed to show how the dependent variable in the vertical axe responds to changing values (in fact for all values) of the independent variable in the horizontal one.

Given the policy framework of the Bank of Albania (which is inflation targeting) one would expect to observe a negatively sloped relationship (mode) between inflation and interest rate and a positive relationship between money and inflation rate on the assumption that inflation is a monetary phenomenon. Higher interest rates are also expected to result in a slower monetary expansion in economy. If that is the case we expect to see that estimated PDF "bells" are positioned at an angle with the x and y axes in the horizontal plane of the graph. Otherwise a perfect round bell (and concentric circles in the counter representation) would indicate the lack of any form of relationship or co-movement in between the variables in the graph. The same would be true even in the case the PDF is located perpendicular to either one of the axes of the horizontal plane of the graph.

Finally the information provided by the CDF is used to test whether pre-crisis and post-crisis datasets arise from the same distribution. Basically we compare two dimensional densities of the same pare of variables before and after the crisis. The comparison of probability spaces is based on the two-dimensional Kolmogorov-Smirnov (KS) test proposed by J. A. Peacock (1983). As it is already mentioned before, the null hypothesis is that both data sets were drawn from the same continuous distribution at 95% confidence level.

Table 1. Data and data sources

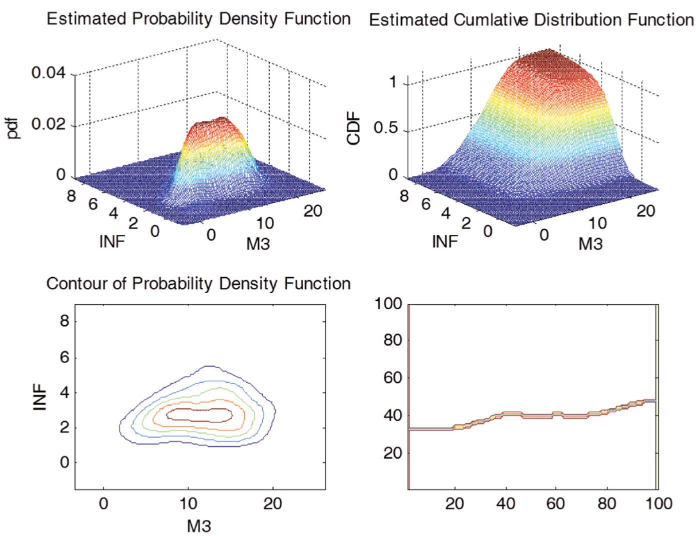
| Variable | Variable description | Source | Variable name | Time period |
|---|---|---|---|---|
| MONEY | M3 annual growth rate | BoA | M3 | [M1,2001-M12,2009] [M4,2010-M8,2016] |
| INFLATION | Annual percentage changes of Consumer Price Index | INSTAT | INF | [M1,2001-M12,2009] [M4,2010-M8,2016] |
| Interest Rate | Bank of Albania Policy rate *lagged one quarter* | BoA | Repo | [M1,2001-M12,2009] [M4,2010-M8,2016] |

## 5. RESULTS AND DISCUSSION

This section presents and discusses the results of the empirical exercise. First results are portrayed in the form of the estimated PDF (surface and contour representation) and CDF (surface representation) of the joint density function. In addition, the mode of the joint density is reported as a proxy for the visualization of the relationship, are reported in figures 1-6. Later results of KS tests are presented in Table 2 below.

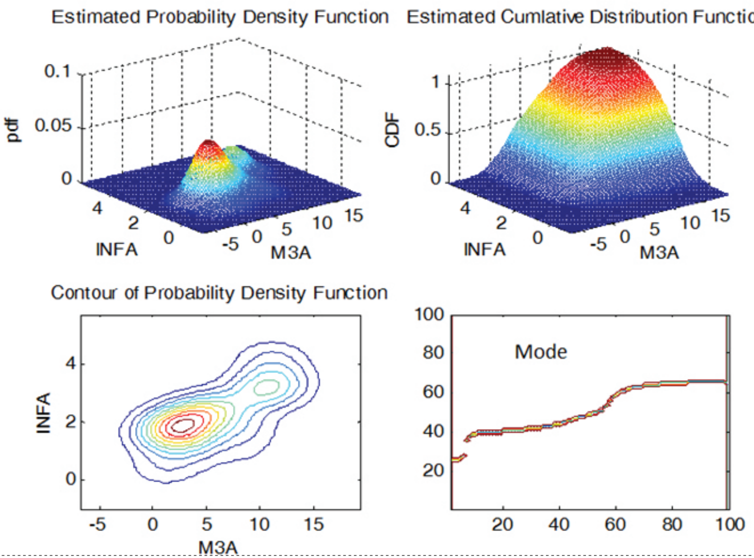
We begin this discussion with the analysis of inflation and money relationship. Focusing on the pre-crisis period reported in Figure 1 below, we observe that the estimated PDF seems to represent a unimodal distribution which is located almost horizontally on the horizontal plane of the chart. The mode portrayed in the lower right corner of the figure shows that the mode of estimated density is slightly upward sloped, indicating a positive relationship between money and inflation. The post crisis period is portrayed in Figure 2. The PDF representations for the post crisis period show that the estimated density is located almost diagonally in the horizontal plane indicating the existence of the positive relationship between money and inflation. This is also confirmed by the upward sloping mode projected in the lower right corner of the Figure 1. The results seem to confirm the Friedman conjecture that inflation is everywhere and always a monetary phenomenon during both periods. However, the relationship is much more pronounced in the post crisis period.

Figure 1. Inflation response to money before the crisis



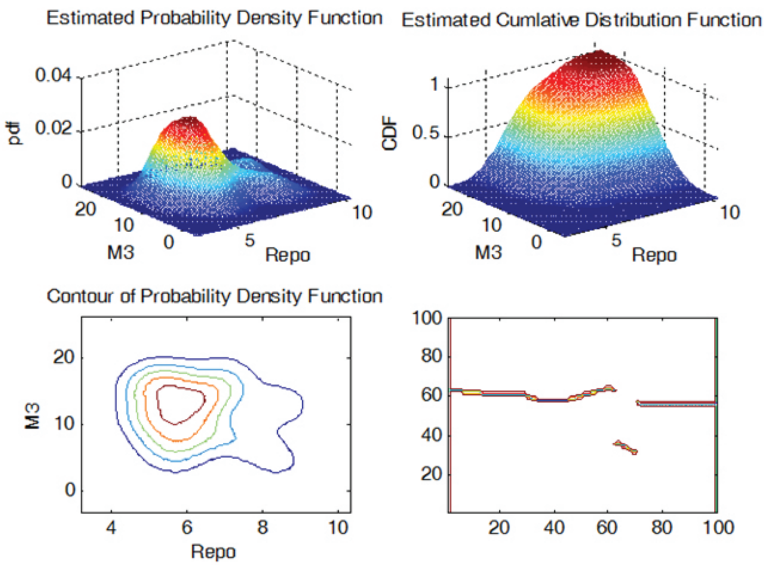
Moving to the discussion of the policy variable and its impact on monetary and price changes we observe as follows. The estimated PDF and CDF are expected to show how changes in the repo rate are followed by simultaneous changes in money and inflation. This discussion is important for hints to the efficiency of monetary policy. We begin by analyzing the relationship between money and repo rate portrayed in Figures 3 and 4.

Figure 2. Inflation response to money growth after the crisis



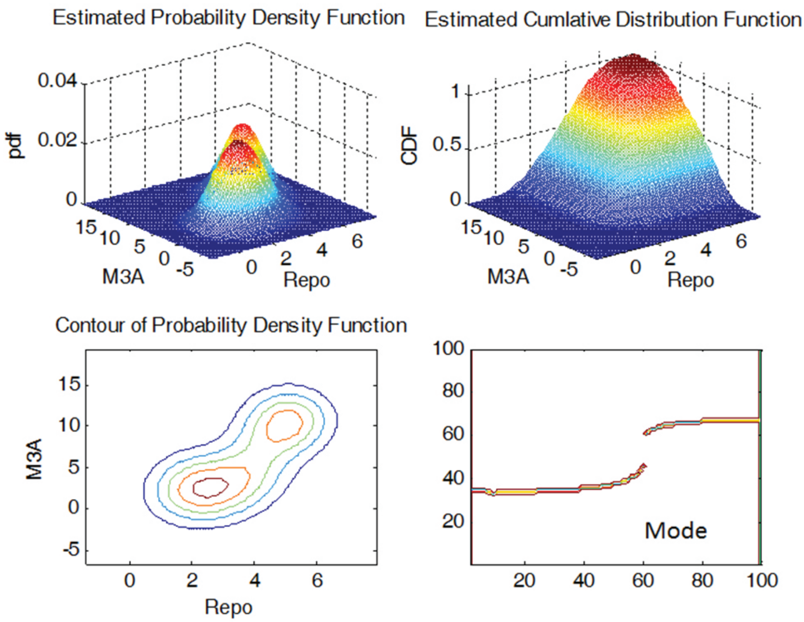

The pre-crisis period in Figure 3, shows an irregular bell shaped PDF indicating almost no co-movement in money and interest rate, with the exception of relatively high interest rates in the right tail of the PFD. This is also confirmed from the mode in the lower right corner of Figure 3, which is almost horizontal, with the exception of downward sloping section in the 7.5-8.5 interval. This interval represents the upper limit of the repo rate for the period. We interpret this as a fact that money growth rate is indifferent of changes in the policy rate with the exception of the very high or very interest rated which are accompanied by a reduction of money growth rates. We also observe a positive relationship emerging in the neighborhood of 6%. Probably, indicating that the repo rate has been following faster money growth rates.

Figure 3. Money response to repo rate before the crisis




The post crisis Figure 4 shows a different relationship between money and interest rate. The estimated PDF is now bimodal and is positioned along the upward diagonal in the horizontal plane. This indicates that changes in interest rate are accompanied by co-movements in same direction in money growth. This positive relationship is somehow unexpected. However, the mode shown in the lower right corner of the graph indicates that most of the positive relationship is associated with the change from one mode to the other rather than in the entire distribution. At the end, the estimated PDF seem to be different in both form and position, suggesting that money interest rate relationship has changed.

Figure 4. Money response to repo rate after the crisis




Finally, the last and the most important (given the inflation targeting framework of the BoA) relationship between inflation and the policy rate, is portrayed in the Figures 5 and 6 below showing the pre and post crisis periods respectively. Both figures show that the estimated PDF are represented by single modal bell shaped densities. The estimated densities seem to portray different behavior with the pre-crisis positioned almost horizontally and the post crisis holding an upward trend along the main diagonal. Yet looking at the mode line in the lower right corner of both figures, both relationships seem positive overall, with a more pronounced upward trend in the post crisis period. This overall conclusion is contrary to the general belief and previous empirical estimations of the Taylor rule in Albania.

A more careful observation of the post-crisis period (lower right corner of Figure 6) shows a slight negative response in inflation whenever repo rate is lower than 5.5 %. This interval corresponds to the period during which Bank of Albania has implemented its expansionary monetary policy and shows that this policy has been somehow effective. The magnitude of response is small and much lower than the findings of Dushku and Kota (2011) in their Taylor rule estimation. One might, however, expect an even more pronounced downward trend for longer lags of repo rate as this provides more time for the economy to adjust. In conclusion both the shape of the PDF and the mode suggest that the relationship between interest rate and inflation has changed (for better) after the crisis.

Figure 5. Inflation response to repo rate before crisis

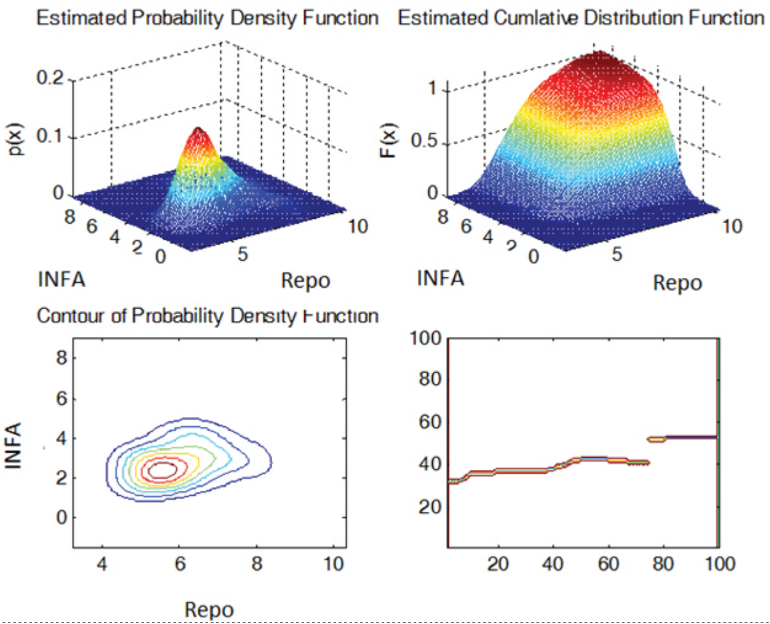
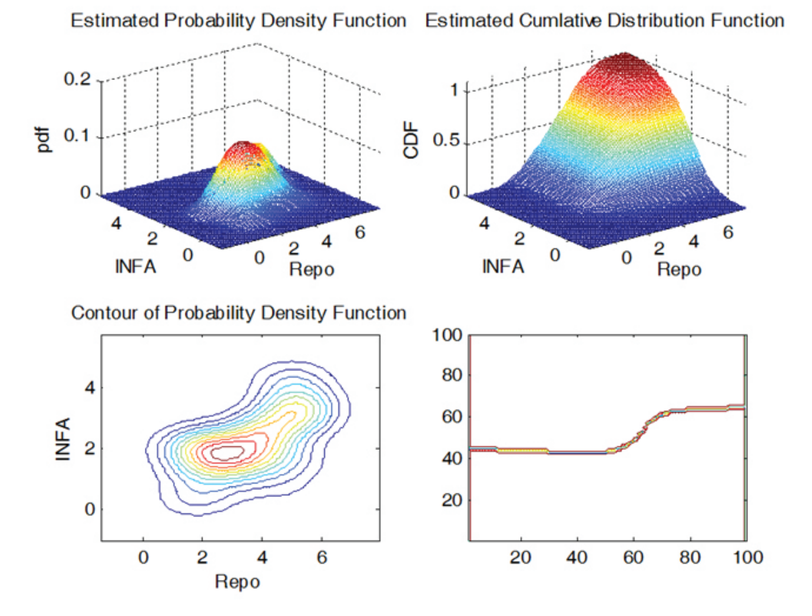


Figure 6. Inflation response to repo rate after the crisis




Despite the interesting information provided by the visual inspection of the Figures 1-6 above in terms of the nature and similarity of relationships among money, inflation and policy rate, we have only guessed the answer to the fundamental question based on the visual inspection of the estimated PDF-s, their position and their shapes and modes. Therefore, for a more formal analysis we apply two-dimensional K-S test to provide statistical evidence whether both (pre and post crises) samples are drawn from the same distributions. The tests are based on the CDF which are portrayed at the upper right corners of the Figures 1-6. The K-S test results are reported in Table 2 below as logical values of 0 or 1, where 0 indicates that both samples are drawn from the same distribution and 1 indicates otherwise (samples come from different distributions).

Results show that with 95% confidence level, among all three relationships considered in this study, only money-inflation relationship remains the same for both periods indicated by the 0 reported in the corresponding entry in the diagonal matrix of results. The other two entries are represented by 1, indicating that pre and post-crisis samples are not coming from the same distributions. This leads us to conclude that there has been a change in the transmission mechanism following the crisis period.

Table 2. K-S test results

| KS Statistics | CDF – Pre-crisis data | | | |
|---|---|---|---|---|
| CDF – Post-crisis data | | INF-Repo | INF-M3 | M3-Repo |
| | INF-Repo | 1 | | |
| | INF-M3 | | 0 | |
| | M3-Repo | | | 1 |

## CONCLUSIONS

This paper looks at the transmission mechanism (the relationship among interest rate, money and inflation) and tests the hypothesis that the crisis has not changed the transmission mechanism of monetary policy in the case of Albania. The novelty relies to the application of an alternative method of modeling economic relationships and the comparison based on the probability spaces. Eventually the comparison is based on kernel density estimation and the use of multi-dimensional K-S test rather than the traditional time series and DGSE methods. We believe that this alternative methodology poses several advantages vis-à-vis the traditional one due to the fact that it proceeds without imposing any theoretic structure or model form on the data. Most importantly the comparison of random events is based on their probability space rather than the estimated coefficients. The study focuses at the relationship of inflation with money and interest rate as two potential instruments under different regimes of monetary policy. We also investigate the relationship between money and interest rate as well.

Based in this alternative methodology we conclude that among all three relationships considered above, only the Inflation-M3 relationship seems to be drawn from the same distribution for both periods. The results of KS test for the comparison between estimated densities of money and inflation indicate that the crisis has not induced change in the relationship between money and inflation. On the other hand, the same comparison of densities between the policy rate and inflation and policy rate and money indicates that these bilateral relationships have changed after the crisis period. In addition, we find that the response of money and inflation to policy rate is in the opposite direction of the expected relationship. Surprisingly money response to policy rate takes the expected sign only in the interval, while inflation response to policy rate seems to takes the expected sign only in the interval. These findings have important implications for the conduct of monetary policy in Albania and must be useful, not only day to day policy making, but also in the understanding of the model in which policy operates under different conditions. In the future, it is important to enrich the analysis by introducing different lags and lag structures to account for the fact that monetary policy operates with longer lags between 12-16 months. Also, it would be interesting to assess whether the above results are robust for different levels of confidence levels e.g. 90% and 99%.

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