

***Has the crisis changed the monetary transmission mechanism in Albania?
An application of kernel density estimation technique.***

***6th Research Conference
Central Banking under Prolonged Global Uncertainty:
The Latest Lessons while Searching for the “New Normal”
5-6 April 2017, Skopje***

Motivation

- The post crisis period has been distinguished by low inflation and slow economic growth.
 - *Persistent negative inflation and output gaps are closing*
- Bank of Albania has embarked in expansionary monetary policy.
 - *Policy rate changes are fully transmitted to interest rates of all maturities and across the range of financial instruments.*
 - *Credit in domestic currency is growing, but merely substituting the decrease of credit in foreign currency.*
 - *Time deposits are flocking toward the extreme ends of the maturity spectrum rather than to consumption or investments.*
- ***Our hypothesis: the relationship among interest rate, money and inflation has changed in the post crisis period.***

Research Plan

Practical implementation of the probability model in the empiric methodology relies upon the framework of difference equations

- *Rendered possible only by:*
 - *A set of rigid and often unrealistic restrictions*
 - *Data transformation process.*

Instead use density estimation techniques and K-S test as alternative methods of empiric investigation.

- *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 proposed by J. A. Peacock (1983).*
 - ***The test: The null hypothesis is that both data sets were drawn from the same continuous distribution (95 percent confidence level)***

Probability Approach in Econ.

- Ericsson, Hendry and Mizon (1998):
 - DGP is unknown to researchers
 - DGP is defined in the form of a probability space $[\Omega, F, \mathcal{P}(\cdot)]$

$$\underline{X}_0 = (x_0^1, x_0^2, \dots, x_0^d)$$

$$\underline{X}_1 = (x_1^1, x_1^2, \dots, x_1^d)$$

$$\underline{X}_2 = (x_2^1, x_2^2, \dots, x_2^d)$$

... ..

$$\underline{X}_t = (x_t^1, x_t^2, \dots, x_t^d)$$

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

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

Alternative Empiric Methodology

- *Based on Tanku Ceca 2013:*

$$X^1 = (x_0^1, x_1^1, x_2^1, \dots, x_t^1)'$$

$$X^2 = (x_0^2, x_1^2, x_2^2, \dots, x_t^2)'$$

$$X^3 = (x_0^3, x_1^3, x_2^3, \dots, x_t^3)'$$

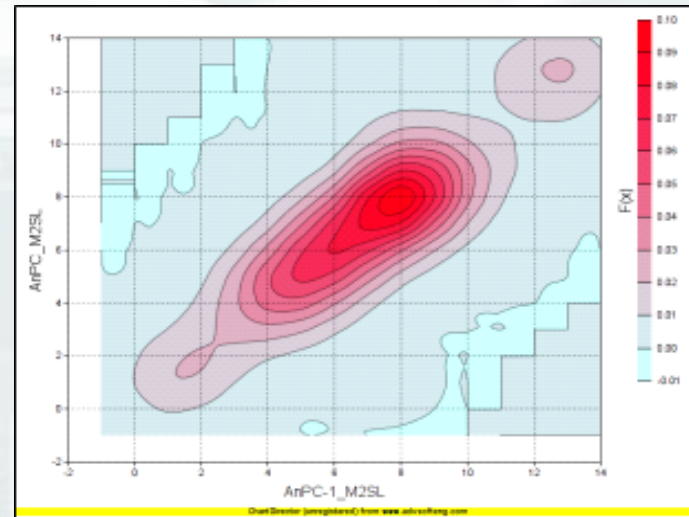
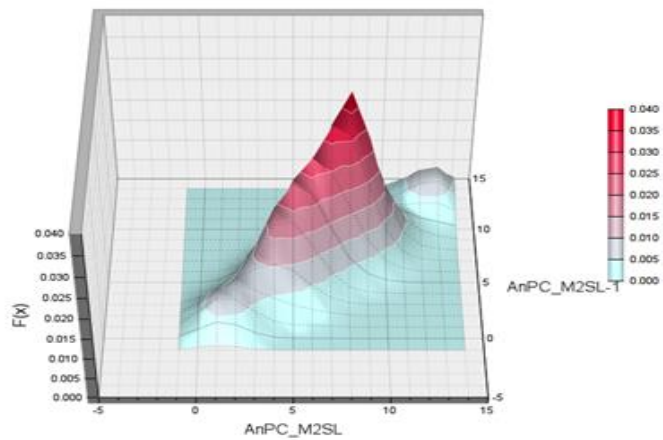
$$\dots$$
$$X^d = (x_0^d, x_1^d, x_2^d, \dots, x_t^d)'$$

$$D_{X^i}(X^i | f(\cdot)) = D_{x^i}(x^i | \hat{f}(\cdot))$$

$$D_{X^i}(X^i | X^j, f(\cdot)) = D(x^i | x^j, \hat{f}(\cdot))$$

$$\hat{f}(\underline{l}) = \frac{1}{th^d(2\pi)^{d/2}} \cdot \sum_{i=1}^t \exp \left\{ -\frac{1}{2h^2} \left[(l_1 - x_i^1)^2 + (l_2 - x_i^2)^2 + \dots + (l_d - x_i^d)^2 \right] \right\}$$

Alternative Methodology Results



Alternative Empiric Test

The two-sample Kolmogorov-Smirnov test

- Statistical test: determines whether two sets of data arise from the same or different distributions.
- The null hypothesis is that both data sets were drawn from the same continuous distribution.

$[H, pValue, KS-Statistic] = kstest_2s_2d(x1, x2 <, alpha>)$

x1 and x2 are respectively [Nx2] and [Mx2] matrixes.

alpha represents the desired significance level for rejecting the null hypothesis.

H is a logical value: true indicates that the null hypothesis should be rejected.

pValue the estimate for the P value of the test statistic.

KS-Statistic is the raw value for the test statistic

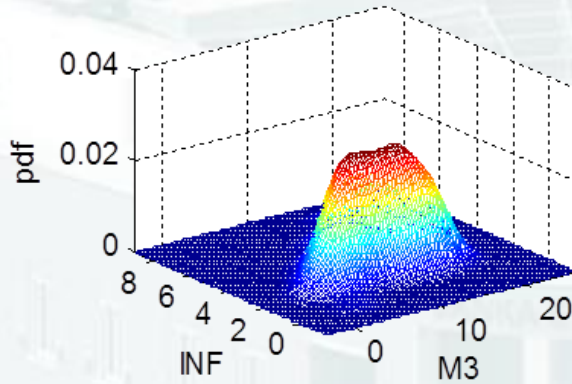
J. A. Peacock, "Two-dimensional goodness-of-fit testing in astronomy", Monthly Notices Royal Astronomy Society 202 (1983) 615-627.

Data & Sources

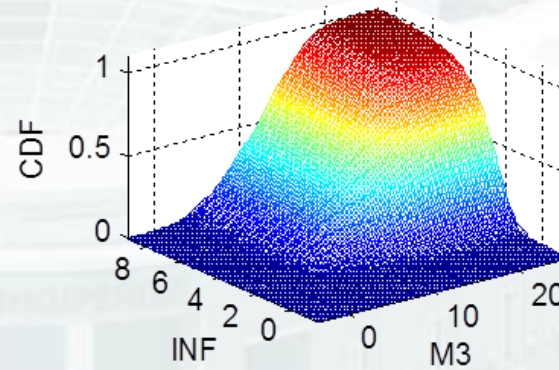
Variable	Variable description	Source	Variable name	Time period
MONEY	M3 annual growth rate	BoA	M3	[M1,2001-M12,2009] [M4,2010-M8,2016]
INFLATION	Annual percentage changes of Consumer Price Index	INSTAT	INF	[M1,2001-M12,2009] [M4,2010-M8,2016]
Interest Rate	Bank of Albania Policy rate <i>lagged one quarter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

Money Effect on Inflation Before Crisis

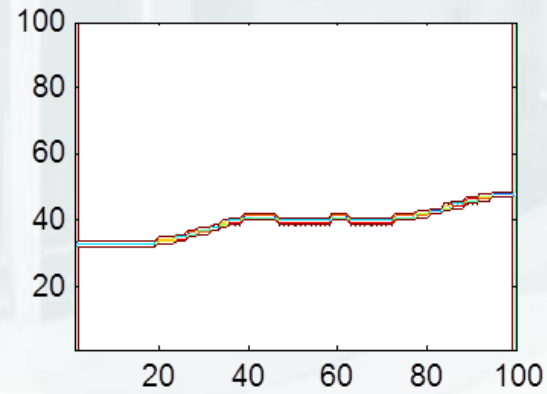
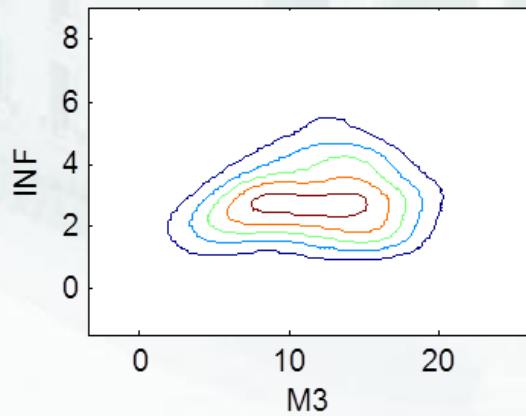
Estimated Probability Density Function



Estimated Cumulative Distribution Function

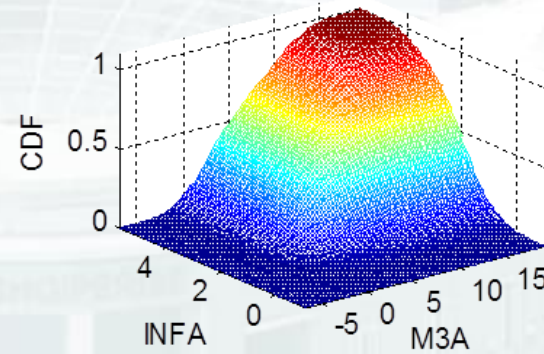
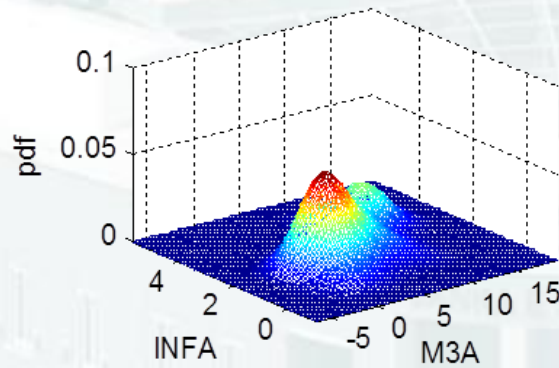


Contour of Probability Density Function

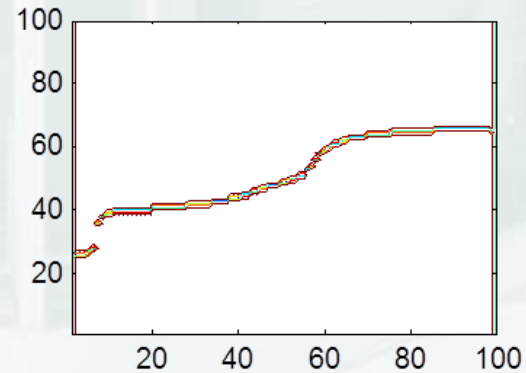
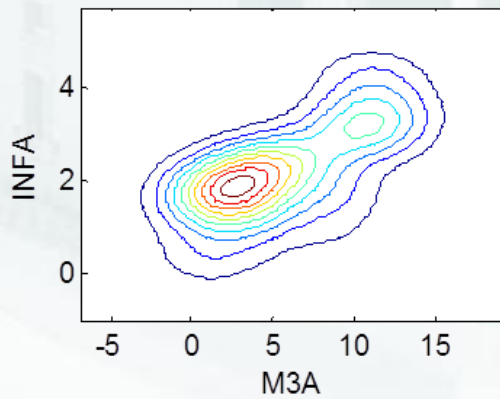


Money Effect on Inflation After Crisis

Estimated Probability Density Function Estimated Cumulative Distribution Function

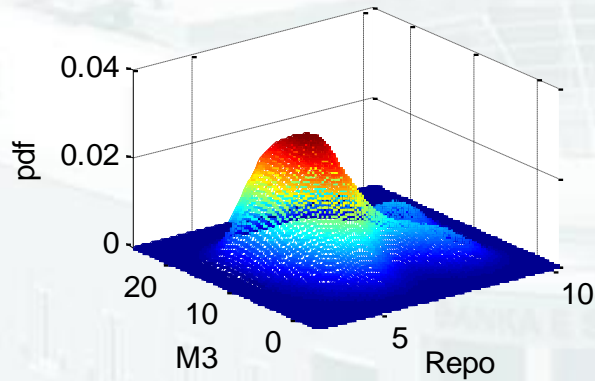


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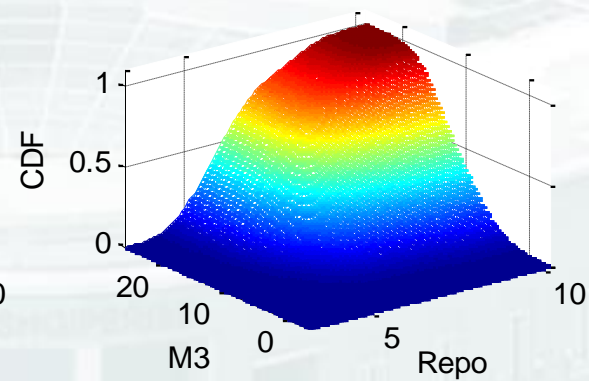


Repo Effects on Money Before Crisis

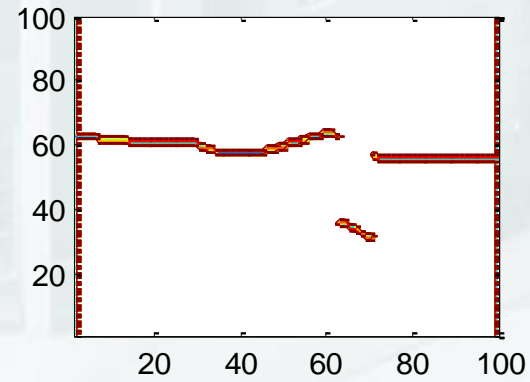
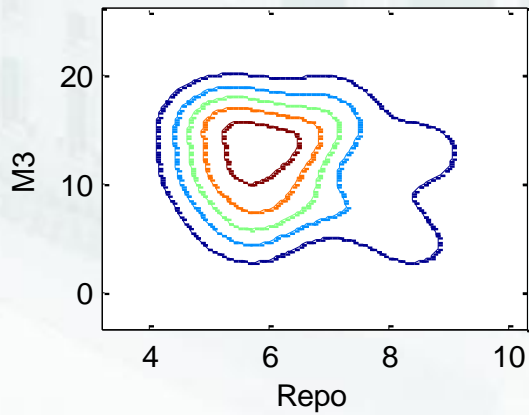
Estimated Probability Density Function



Estimated Cumulative Distribution Function

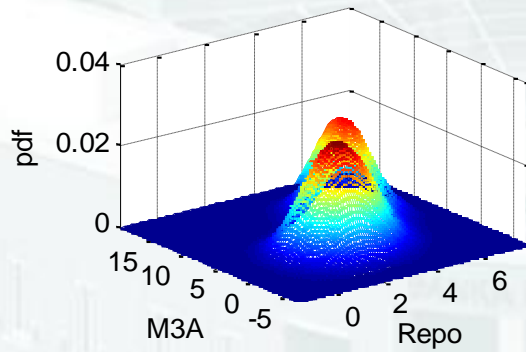


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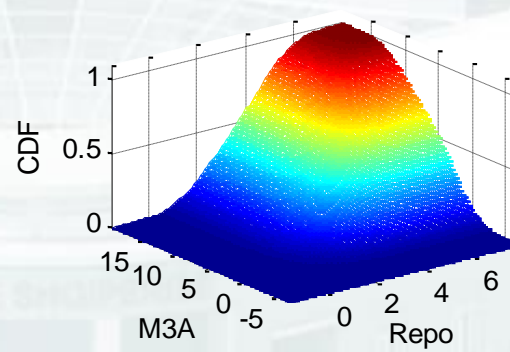


Repo Effects on Money After Crisis

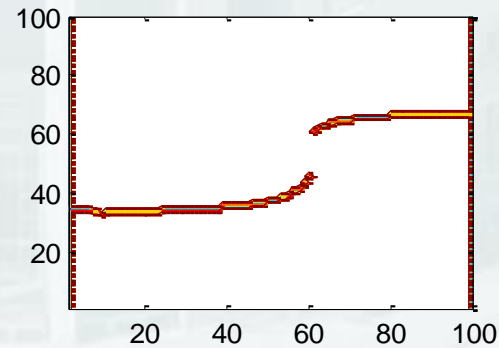
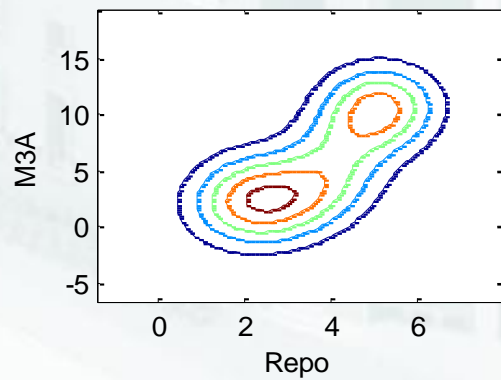
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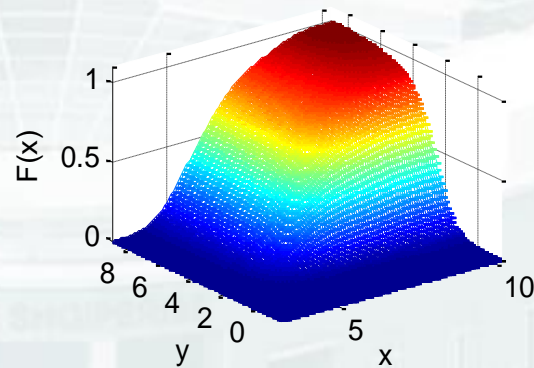
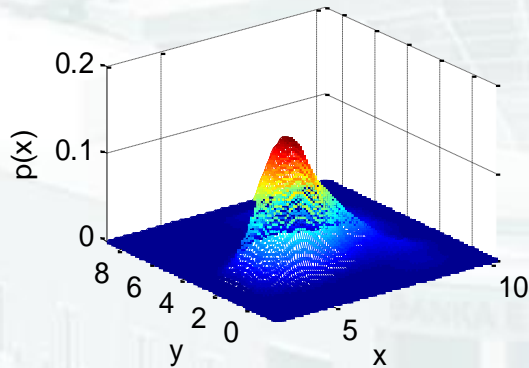


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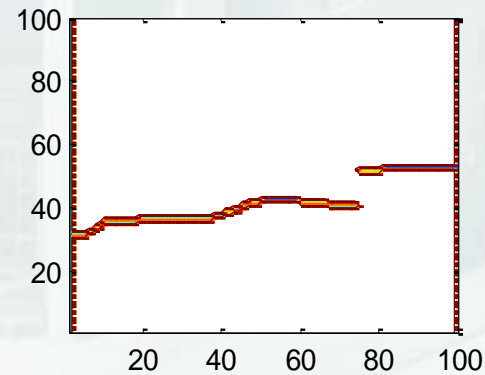
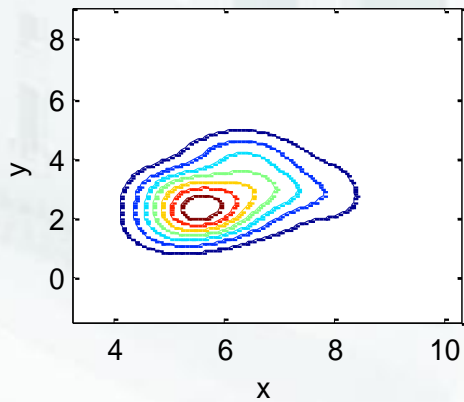


Repo Effects on Inflation Before Crisis

Estimated Probability Density Function Estimated Cumulative Distribution Function

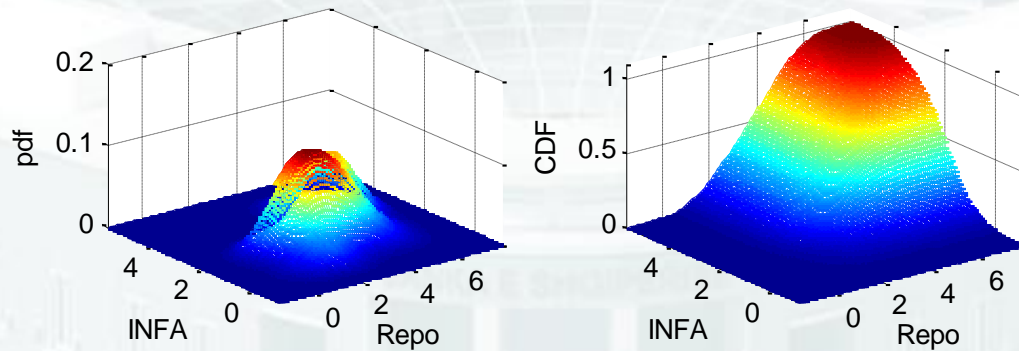


Contour of Probability Density Function

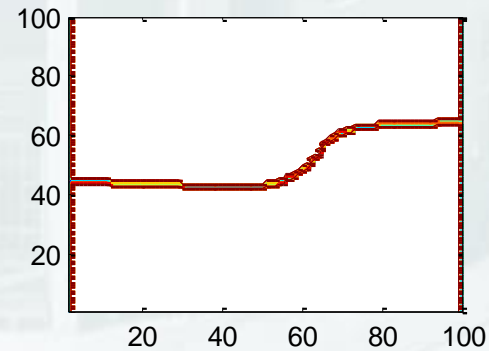
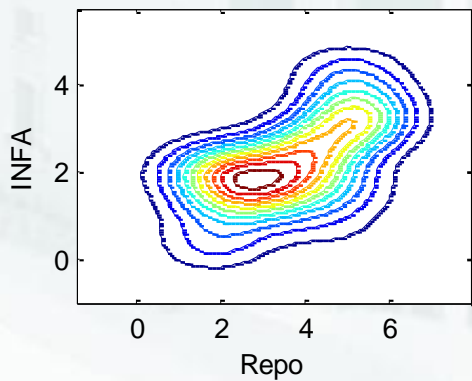


Repo Effects on Inflation After Crisis

Estimated Probability Density Function Estimated Cumulative Distribution Function



Contour of Probability Density Function



KS Test Results

KS-Statistic	CDF Para Krizes			
CDF Pas Krizes	<i>alpha=0.05</i>	<i>INF-Repo</i>	<i>INF-M3</i>	<i>M3-Repo</i>
	<i>INF-Repo</i>	1		
	<i>INF-M3</i>		0	
	<i>M3-Repo</i>			1

Discussion & Conclusions

- Among all three cases above only *Inflation-M3* relationship seems to be drawn from the same distribution for both periods

Interpretation:

- *The estimated densities of money and inflation indicate that the crisis has not induced change in the relationship between money and inflation*
- *The relationship between the policy rate and inflation and policy rate and money has changed after the crisis period*

Discussion & Conclusions

- Additional findings
 - Only money inflation relationship has the expected sign
 - *Overall the reported inflation and money response to policy rate is the opposite of the expected relationship.*
 - *Money response to policy rate takes the expected sign only in the $7 \leq repo \leq 8,5$ interval.*
 - *Inflation response to policy rate seems to takes the expected sign only in the $0 \leq repo \leq 2,5$ interval.*
- **Based on the kernel density estimation of PDF and CDF and two dimensional K-S test, we conclude that crisis seem to have altered the transmission mechanism in Albania**
- This methodology provides an alternative and useful tool in the study of economic phenomena

Limitations & Future Research

- Recently applied methodology in Economics
 - *The is not much critique on the methodology*
- We have been focusing only in 1 lag
 - *Allowing for more lags might provide additional information*
- We are working on two directions
 - *Three dimensional K-S test*
 - *Parameterization and the derivation of the functional form*