Research Article
Volume 11:07, 2022

Journal of Business & Financial Affairs

ISSN: 2167-0234 **Open Access**

Effect of Global Crisis and Demonetization in India on Financial Sectors of Indian Stock Market Using MFDCCA Method

Pooja Devi[1*], Pawan Kumar[1], Ravendra Singh[1] and Sunil Kumar[2]

[1]*School of Basic and Applied Sciences, K.R.Mangalam University, Gurugram, Haryana-122103, India*

[2]*Department of Physics, Ramjas College, University of Delhi, Delhi-110007, India*

Abstract

To study the statistical properties of financial markets there are various methods. We applied multi-fractal detrended cross correlation analysis method to study multi-fractality, efficiency and cross correlation of banking sector of Indian financial market for the period of global financial crisis and demonetization in India. We calculated Hurst exponents and strength of singularity spectrum. We find that variation in strength of multi-fractality is maximum during crisis. We conclude that if there is any crisis or booms in the market then multi-fractality will increase and value of that exponent which measure correlation will also increase for persistent time series.

Keywords: Multi-fractality • Cross-correlation exponents • Singularity spectrum • Efficiency

Introduction

The variation of prices w.r.t. time in financial market is very complex. The reason behind this complexity is non-linear interactions among heterogeneous agents and external events. Recently many researchers prove that financial market behaves like a fluid turbulence. It has been proved that fluctuations reveal both multiscaling properties and multifractal behavior. Multifractality is one of the most observed phenomenon's found in many complex fields such as earthquakes, biology, media and financial market. Recently many researchers from various fields have contributed a lot in the new field well known by Econophysics [1,2]. The multifractality of financial market has been studied by various researchers using two powerful methods, the multifractal detrended fluctuation analysis (MFDFA) method [3-22] and the Wavelet Transform Modulus Maxima method [WTMM]. In this paper we use Multifractal Detrended Cross- Correlation Analysis [MFDCCA] which is used by many researchers [23-26].

In this paper we are taking financial sector of Indian stock market and we study the effect of global crisis and demonetization on the multifractality and Efficiency. We also study cross- correlation between stocks. Now before discussing about the organization of paper we want to describe briefly The Global Financial Crisis and Demonetization. By financial crisis we mean that financial assets loose a large part of their nominal value. The financial crisis of 2007-2008, also known as global financial crisis had a huge impact on each and every market of the world. Now demonetization may be defined as when new currency replaces the old currency unit/s then old currency will be useless. Public cannot use that currency for any trading. On November 8, 2016, currency notes of denominations of Rs.500 and Rs.1000 were demonetized. Demonetization is like a crisis for the financial sector. This paper is organized as follow: Section 2 include brief description of data under study. Section 3 introduces in detail MFDCCA method. In section 4 we analyze data. We show how to calculate cross-correlation exponents and strength of multifractality. In section 5 we give the conclusion and results.

***Address for Correspondence:** Pooja Devi, School of Basic and Applied Sciences, K.R.Mangalam University, Gurugram, Haryana-122103, India; E-mail: poojavats23@gmail.com*

Received: 22 Feb, 2020, Manuscript No. jbfa-22-003-Pre-Qc-22; **Editor assigned:** 25 Feb, 2020, Pre QC No. jbfa-22-003-Pre-Qc-22; **Reviewed:** 16 Mar, 2020, QC No. jbfa-22-003-Pre-Qc-22; **Revised:** 02 May, 2022, Manuscript No. jbfa-22-003-Pre-Qc-22; **Published:** 04 Aug, 2022, DOI: 10.37421/ 2167-0234.2022.11.413

Data

For any study data is very important part. We utilize daily closing price of three stocks namely State Bank of India, Industrial Credit and Investment Corporation of India Bank and Industrial Development Bank of India (SBIN,ICICIB and IDBI) of financial sector of Indian stock market. We collect data from national stock exchange. In order to have a systematic study we divide our data in two periods. First period is of global financial crisis of 2008 consisting three sub periods i) Before crisis (7-06-2006 to 30-11-2007) ii) During crisis (3-12-2007 to 30-06-2009) iii) After crisis (01-01-2010 to 3006-2011) and the second period is of Demonetization in India consisting of three sub periods (i) Before demonetization (09-11-2015 to 07-11-2016) (ii) During demonetization (8-11-2016 to 12-06-2017) (iii) After demonetization (13-06-2017 to 20-06-2018).

Methodology

Podobnik and Stanley introduced DCCA method to investigate power law cross- correlation between different time series. Based on DCCA and MF-DFA , Zhou [27] propose a method called multifractal detrended cross correlation analysis to investigate the multifractal behaviors in two time series or higher-dimensional quantities recorded simultaneously . Since then, these two methods [DCCA, MFDCCA] become more popular to study multifractal behavior and cross-correlation of two time series. Following are the steps to perform MFDCCA method.

Step 1: Calculate the cumulative sum of deviations for the two time series.

1) $(t)=\sum t \quad xk-\bar{x},\ t=1,2,3,\ldots\ldots.N.$

(2) $(t)=\sum t \quad yk-\bar{y}\ ,\ t=1,2,3,\ldots\ldots.N.$

Where $\bar{x}$ and $\bar{y}$ stands for mean of the two time series x(t) and y(t), respectively.

Step 2: Divide the series X(t) and Y(t) into Ns=int(N/s) segments of equal length s which are non-overlapping . As the length Ns need not be a multiple of the considered time scale s, some part at the end of series may be left. Because of this, the same procedure is repeated from the downward direction. Hence we obtained 2Ns segments in all.

Step3: By least-square fit of the series calculate the local trend for each segment ν and then calculate the detrended covariance for each segment as follows.

Where Xν (i) and Yν (i) are the polynomial functions of order m in segmentν for X(t) and Y(t) , respectively. These polynomial functions are also called fitting polynomials.

Step 4: Take average of all segments to obtain the qth order fluctuation function.

Step 5: The scaling behavior of the fluctuation can be detected by analyzing the log-log plots of Fq(s) versus s for each q .The power-law relationship can be expressed as follow,

(7) Fq(s) a $s(q)$

if the two series are long-range cross-correlated.

The exponent Hxy(q) , named as the generalized cross-correlation exponent, can be find out by calculating the slope of the log-log plots of Fq(s) versus s for each q by ordinary least square. If Hxy(q) decreases with increasing values of q , then the cross-correlation between two series are multifractal, otherwise it is monofractal. For the negative values of q , Hxy(q) describes the scaling behavior of the segments with small fluctuations while for positive values of q , Hxy(q) describes the scaling behavior of the segments with large fluctuations. If Hxy(q)=0.5 , the two time series are independent of each other, i.e. change in one series does not affect the other. When Hxy(q) >0.5, the time series are positively correlated, which means that increase in one time series is statistically followed by increase of the other series. When Hxy(q)<0.5 , then the time series are negatively correlated which means increase in one is followed by decrease in the other and vice- versa . When x(t) and y(t) stand for the same time series, MF-DCCA reduces to MF-DFA and the scaling exponents Hxy(q) represents the generalized Hurst exponent.

In order to measure strength of multifractality we use the following formula.

(8) Δh=Max(Hxy) – Min(Hxy)

More the value of Δh more will be the degree of multifractality. We can measure the extent of multifractality as the width of the multifractal spectrum, which is defined as,

(9) Δα=Max(αxy) – Min(αxy)

Stronger degree of multifractality is the result of wider multifractal spectrum.

Results and Discussion

Multifractality and efficiency of three time series for the first period

In this paper we are taking three stocks of financial sector. We investigate multiscaling behavior of the fluctuation function Fq(s) versus the time scale s for the pair ICICIB-SBIN and IDBI-SBIN respectively. The Figures 1 and 2 show respectively log-log plot of Fq(s) versus the time scale s for different values of q. From Figures 1 and 2 we can observe that the plotted points for each of 11 values of q are well fitted by least-square lines.

From Figures 3 and 4 we observe that the cross-correlation exponent Hxy(q) presents a non-linear decreasing trend for increasing values of q which shows multi-fractal feature of financial sector.

Another way to describe multi-fractality is the strength of singularity spectrum. From the Figures 5 and 6 we can notice that the shape of the curve is inverted parabola. Also we know that if the curve reduces to a single point then the series will be mono-fractal.

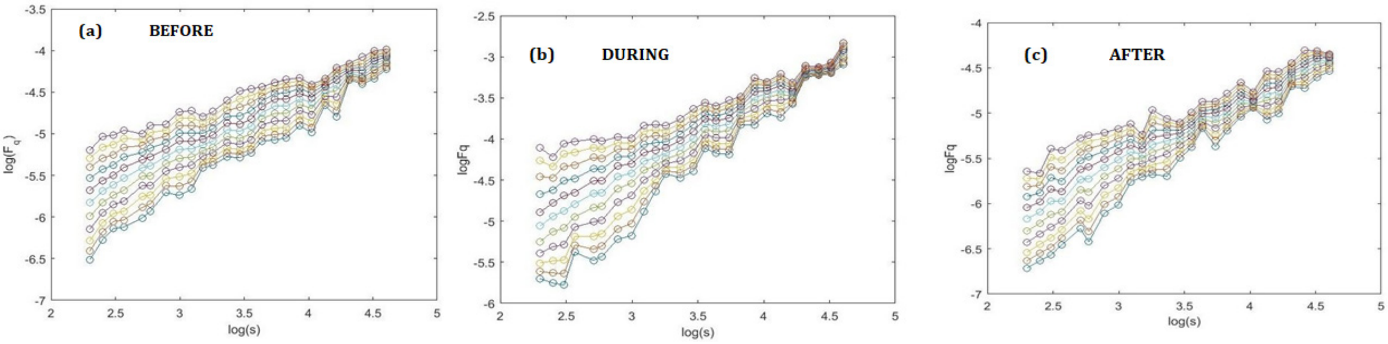

Figure 1. logFq *vs.* logs plot for pair ICICIB-SBIN.

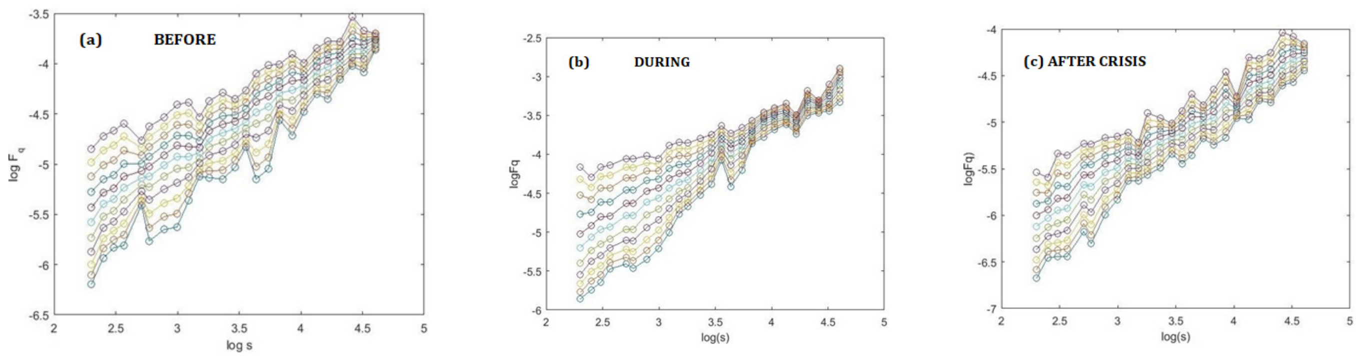

Figure 2. logFq vs logs plot for pair IDBI-SBIN.

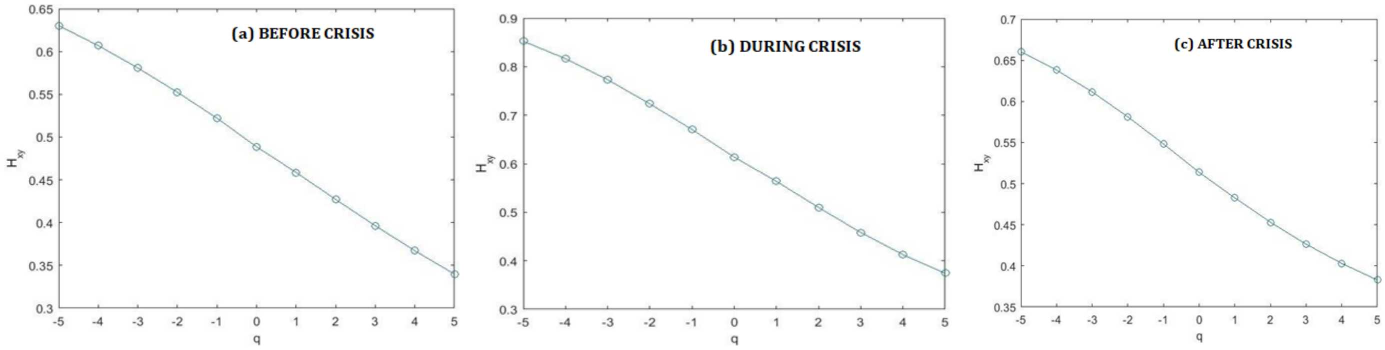

Figure 3. Hxy *vs.* q plot for pair ICICIB-SBIN.

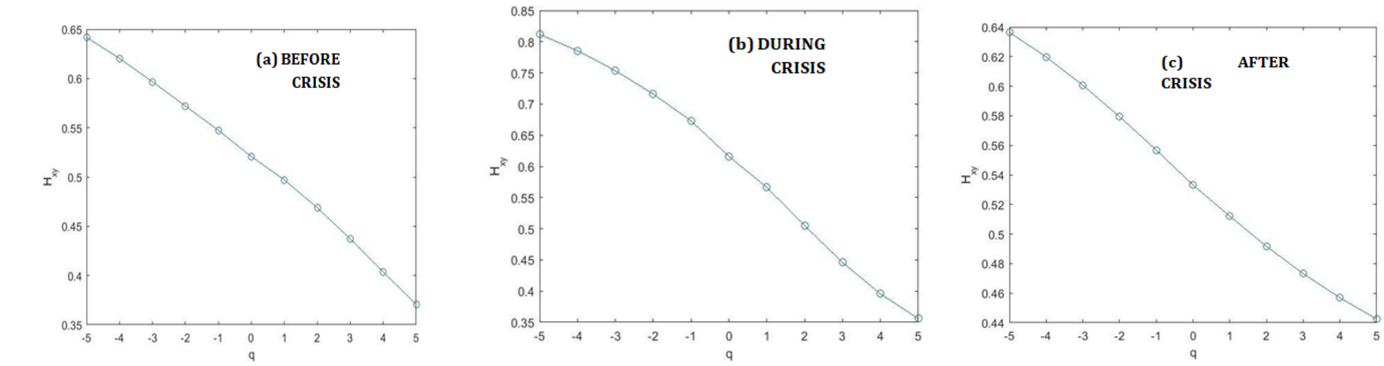

Figure 4. Hxy *vs.* q plot for pair pair IDBI-SBIN.

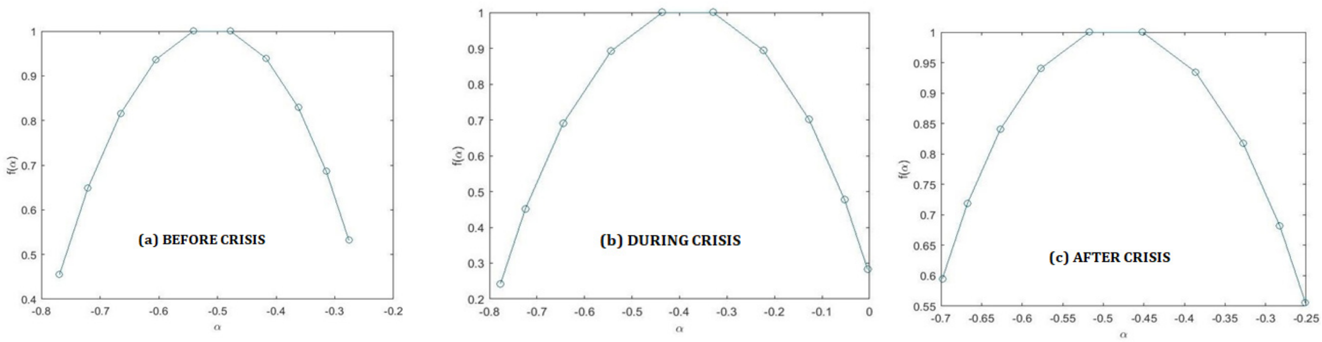

Figure 5. f(α) *vs.* α plot for pair ICICIB-SBIN.

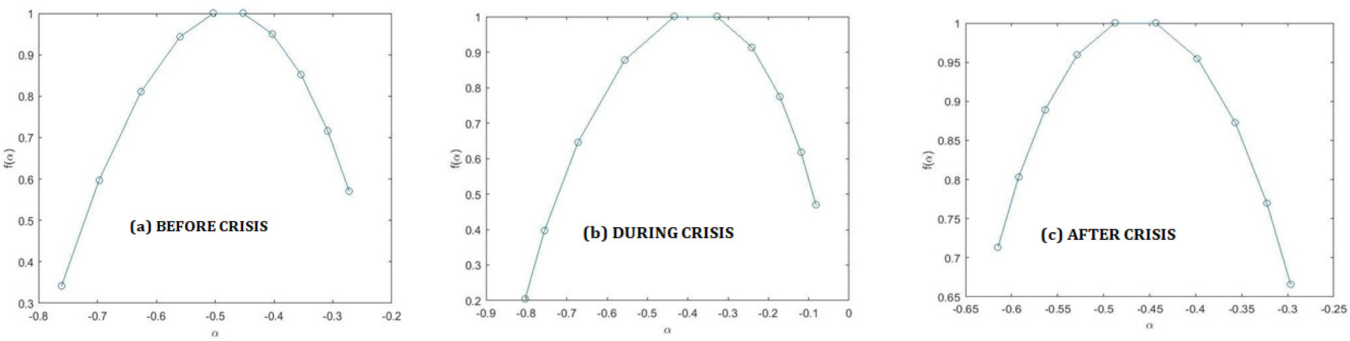

Figure 6. f(α) *vs.* α plot for pair IDBI-SBIN.

Now we are able to calculate degree of multi-fractality with the help of following formula $\Delta\alpha=\alpha max - \alpha min$. Following are the results: From the Table 1 it is clear that during crisis strength of multi-fractality will increase and hence efficiency will decrease.

Table 1. Delta Alpha values for first period.

Pair	Before crisis	During crisis	After crisis
ICICIB-SBIN	0.493	0.7727	0.4474
IDBI-SBIN	0.488	0.7207	0.3181

Multi-fractality and efficiency of three time series for the second period

Here second period is the period of Demonetization, this may be consider as a crisis/boom for banking sector. So we also study multifractal behavior for this period. We investigate multiscaling behavior of the fluctuation function Fq(s) versus the time scale s for the pair ICICIB-SBIN and IDBI-SBIN respectively. The Figures 7 and 8 show respectively log-log plot of Fq(s) versus the time scale s for 11 values of q. From Figures 7 and 8 we can see that the plotted points for each of 11 values of q are well fitted by least-square lines.

From Figures 9 and 10 we observe that the cross-correlation exponent Hxy(q) presents a non-linear decreasing trend for increasing values of q which reveals the multifractal feature of financial sector.

Another way to describe multifractality is the strength of singularity spectrum. From the Figures 11 and 12 we can notice that the shape of the curve is inverted parabola. Also we know that if the curve reduces to a single point then the series will be monofractal. Now we are able to calculate degree of multifractality with the help of following formula $\Delta\alpha=\alpha max-\alpha min$. The results are as follow

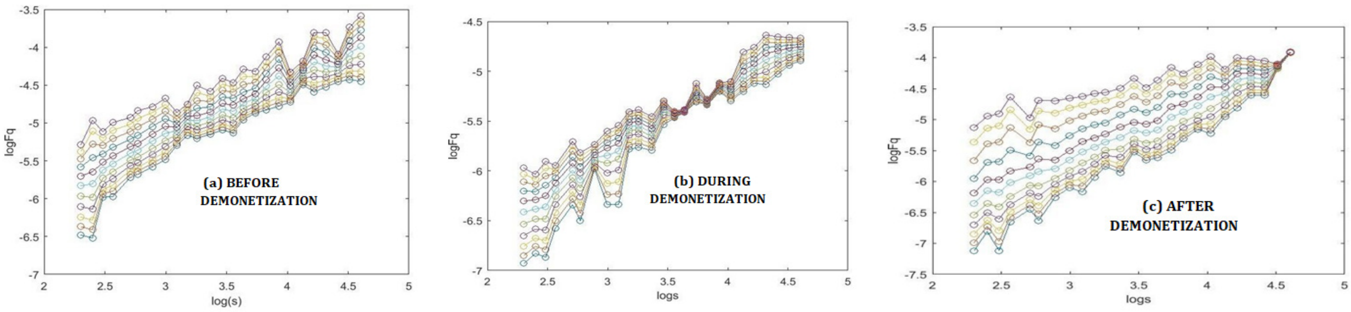

Figure 7. logFq vs. logs plot for pair ICICIB-SBIN.

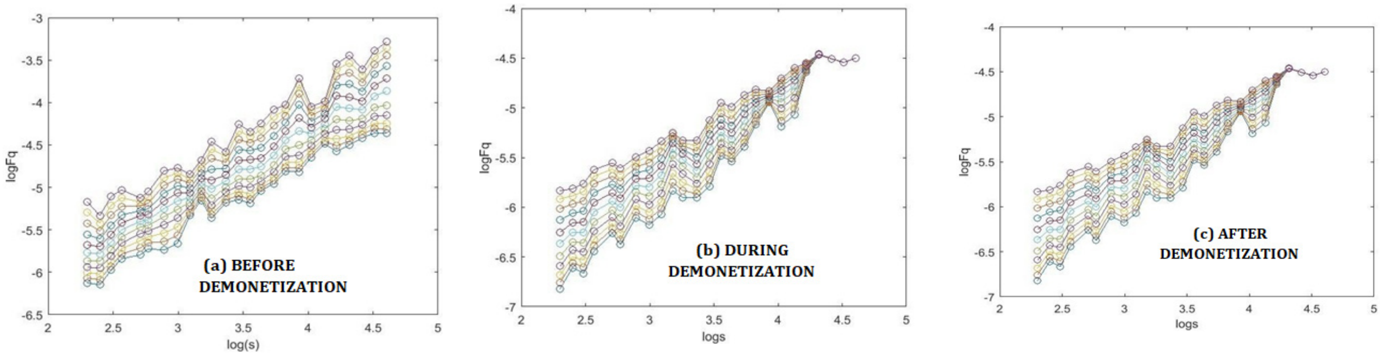

Figure 8. logFq *vs.* logs plot for pair IDBI-SBIN.

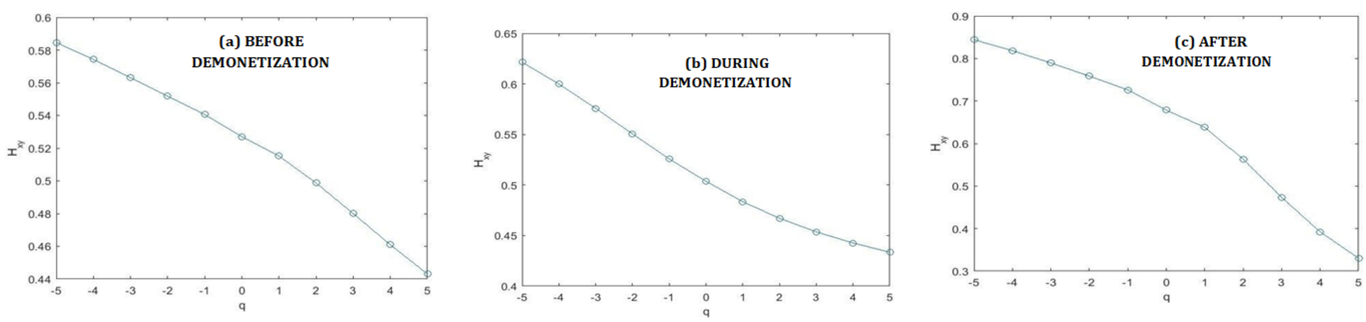

Figure 9. Hxy *vs.* q plot for pair ICICIB-SBIN.

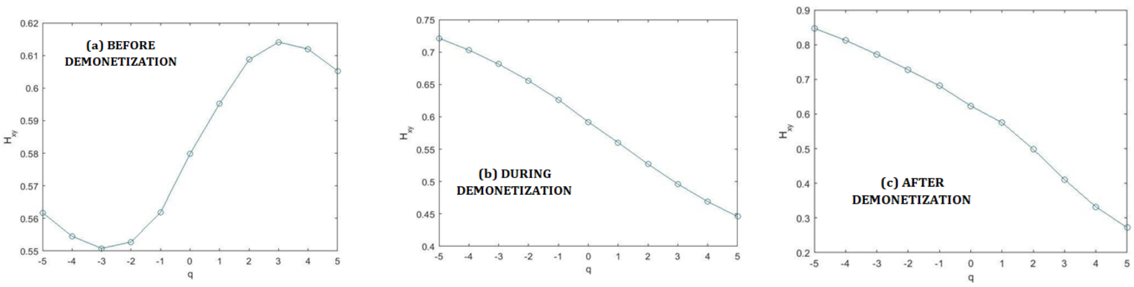

Figure 10. Hxy *vs.* q plot for pair IDBI-SBIN.

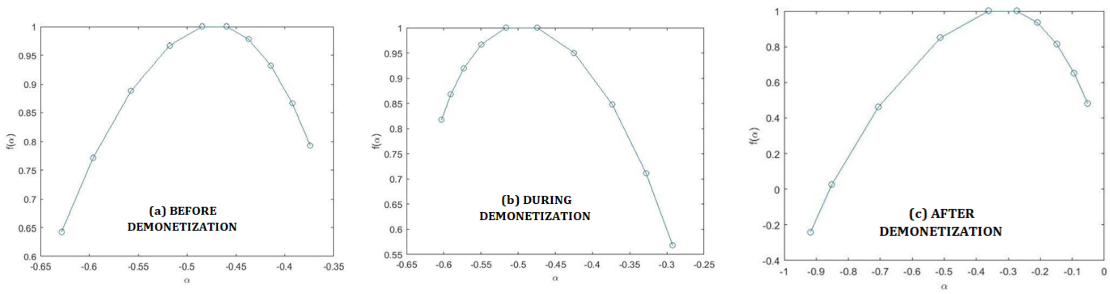

Figure 11. f(α) *vs.* α plot for pair ICICIB-SBIN.

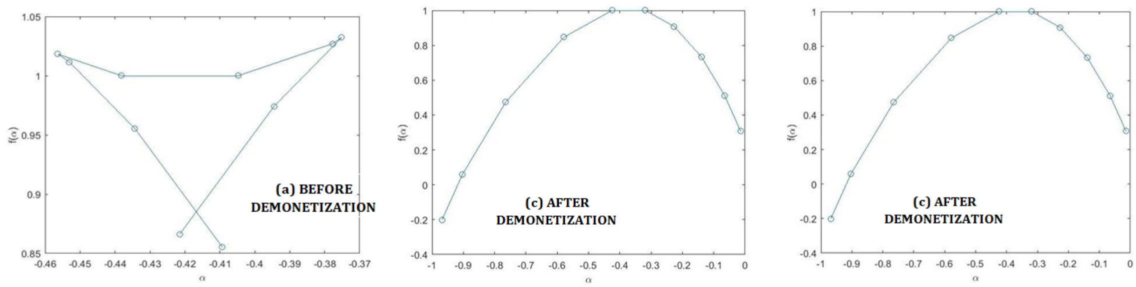

Figure 12. f(α) *vs.* α plot for pair IDBI-SBIN.

Hence from this quantitative study we can analyze the qualitative aspect i.e. From the Table 2 we can see that for banking sector strength of multifractality will increase during as well as after demonitization i.e. the banking sectors were in more pressure after demonitization and hence efficiency will decrease.

Table 2. Delta Alpha values for second period.

Pair	Before demonetization	During demonetization	After demonetization
ICICI-SBIN	0.2545	0.3109	0.864
IDBI-SBIN	0.0812	0.4416	0.9537

Cross-correlation and descriptive statistics

From MFDCCA method we know that if H > 0.5 then the series are persistent. Also we verify it by calculating Karl Pearson coefficient of correlation. The results are shown in Tables 3 and 4 for the first period and in Tables 5 and 6 for the second period.

Table 3. Cross-correlation Exponent for first period.

Pair	Before crisis	During crisis	After crisis
ICICIB-SBIN	0.6302	0.8524	0.6602
IDBI-SBIN	0.6418	0.8118	0.789

Table 4. Karl Pearson Cofficient of correlation for first period.

Pair	Before crisis	During crisis	After crisis
ICICIB-SBIN	0.666	0.6933	0.6001
IDBI-SBIN	0.5768	0.7265	0.5915

Table 5. Cross-correlation Exponent for second period.

Pair	Before Demonetization	During Demonetization	After Demonetization
ICICIB-SBIN	0.5846	0.6215	0.8443
IDBI-SBIN	0.5618	0.7214	0.8471

Table 6. Karl Pearson Cofficient of correlation for second period.

Pair	Before Demonetization	During Demonetization	After Demonetization
ICICIB-SBIN	0.6978	0.571	0.6664
IDBI-SBIN	0.6131	0.5752	0.5285

Strength of multifractality versus time for moving window

From the Figure 13 for First period and Figure 14 for second period we can conclude that strength of multifractality is maximum during global crisis.

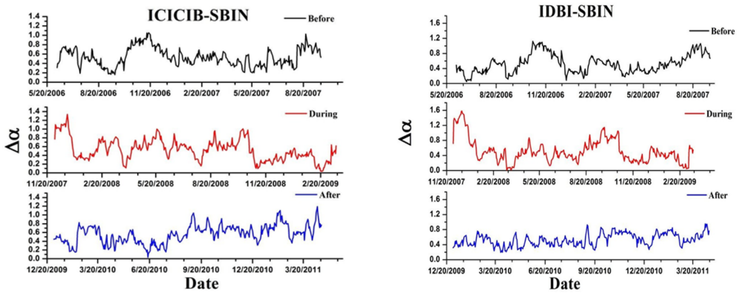

Figure 13. Delta Alpha - Time Plot for First Period.

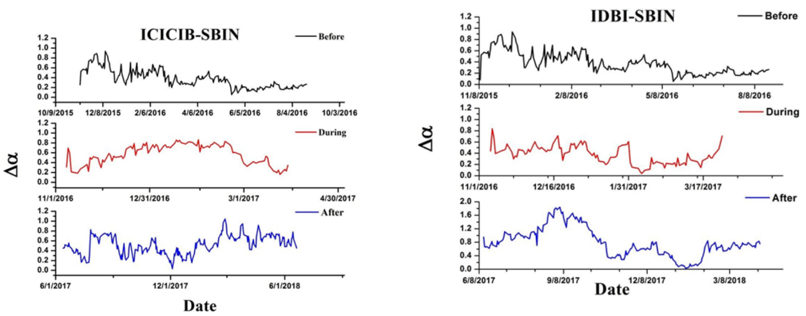

Figure 14. Delta Alpha - Time Plot for Second Period.

Conclusion

In this paper we investigate the multifractal properties, efficiency and cross-correlation between the time series of financial sector. We first calculate the fluctuation function using MFDCCA method, from which we estimate the cross-correlation exponents. Then we calculate the strength of multifractality. Our results suggest that during any crisis strength of multifractality will increase and efficiency will decrease.

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How to cite this article: Devi, Pooja, Pawan Kumar, Ravendra Singh and Sunil Kumar " Effect of Global Crisis and Demonetization in India on Financial Sectors of Indian Stock Market Using MFDCCA Method." *J Bus Fin Aff* 11 (2022): 413