DOCTORAL PROGRAMME

TIME SERIES CLUSTERING, TESTING OF MEMORY IN TIME SERIES AND QUANTIFYING DEPENDENCE IN VOLATILITY OF FINANCIAL TIME SERIES USING COMPLEX NETWORK THEORY

By

GIRIRAJ

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INDIAN INSTITUTE OF MANAGEMENT
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A Dissertation submitted in Partial Fulfillment of the Requirements for the Doctoral Programme of the

INDIAN INSTITUTE OF MANAGEMENT BANGALORE

2022

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Time Series Clustering, Testing of Memory in Time Series and Quantifying Dependence in Volatility of Financial Time Series Using Complex Network Theory

Dedicated to my parents and my teachers

Acknowledgements

When I joined the doctoral programme in Decision Sciences, I did not have the foundations but only a deep fascination. I could reach this far in the doctoral programme journey only because my teachers showed me the way. I thank my professors, my family and my friends for their whole-hearted support throughout the journey.

I extend my sincerest gratitude to Prof. Malay Bhattacharyya for guiding me through this programme with infinite understanding and patience. I thank Prof. Bhattacharyya for believing in me even during times when I had lost confidence in myself. Through his amazing mental agility and insight in distilling any topic or problem to its core fundamentals, often in a matter of minutes, Prof. Bhattacharyya has helped me to diagnose and solve the problems I faced while working on my thesis. His philosophy of simplicity and deep empathy, his courage for standing up for what is right, are qualities I hope to be guiding lights in my life.

I am deeply grateful to Prof. Rajluxmi V. Murthy for generously supporting me and for providing invaluable inputs to improve my work. I thank Prof. Murthy for ensuring that I was focused on my work during critical stages in the programme.

I was fortunate to attend Prof. Abhinav Anand's course on Financial Mathematics and Computation. The foundations of mathematical finance and the techniques of reproducible research Prof. Anand covered in the course have immensely helped me with my work. I extend my sincere thanks to Prof. Anand for his support and insightful suggestions.

I thank Prof. V. Ravi Anshuman and Prof. Anand Venkateswaran for introducing me to the area of Finance.

I thank Prof. Haritha Saranga and Prof. Rejie George Pallathitta for their unstinted support as Doctoral Programme Chairpersons. I am grateful to Madam Anjali G. S., Madam Ashoka S. Nag and Madam P. Shilpa for greatly helping me in navigating the official aspects of the programme.

I thank my seniors Prof. Saparya Suresh, Prof. Ravi Prakash Ranjan, Prof. Vinu C. T., Prof. Tapan Kar and Prof. Pranjal Chandrakar for helping me at each step throughout the program.

I thank my friends Jose Manu M. A., Agnitra Das Sarma, Sowmya Kini, Ravikanth Vazrapu, Aishvarya, Anoop Chakkingal for all their support and for making sure I am smiling. Special thanks to Srirang Ranjalkar and Raghavendra Ramesh for their support and insights, and for deep discussions on a variety of topics.

I thank my sister Prof. Anjali Rajan and my brother-in-law Prof. Keerti Pendyal for keeping me motivated.

I thank my mother N. Geethakumari and my father B. Rajappan Achari for holding my hand and walking with me. My life will always be in their debt for their unconditional love and sacrifice.

Abstract

The four essays in this dissertation are grounded in the central and interconnected concepts of multifractality and long-range dependence observed in financial time series. We focus our attention particularly to the dependence behaviour of a suitable measure of volatility in financial asset returns. Therefore, the implications of our work are mostly in the area of financial risk management.

In the first three essays, we attempt to study the observed dependencies in financial time series from the lens of complex network theory. Specifically, we explore a relatively recent approach called visibility graphs, which involves mapping a time series to a complex network based on a particular geometric criterion.

In the first essay, we utilize the concept of visibility graphs, proposed by Lacasa *et al.* (2008), for developing a method to cluster multiple financial asset return series based on their underlying dependence characteristics. Using simulations, we show that the proposed method exhibits better clustering performance as compared to certain feature-based and model-based time series clustering techniques.

In the second essay, we build upon the concept of binary visibility graph, proposed by Ahadpour & Sadra (2012), to develop a reasonably powerful nonparametric test for the presence of memory in time series. The test is predicated on a statistic based on the principle of symbolic entropy.

In the third essay, we utilize a scaled version of the symbolic entropy based statistic (developed in the second essay) for estimating the memory in volatility of financial asset returns. We find that the estimator performs well at measuring varying magnitudes of long-range dependence in volatility.

In the fourth essay, we augment the Copula-Markov Switching Multifractal (MSM) model (Calvet & Fisher, 2004) by allowing the innovations in the margins to follow leptokurtic and skewed distributions, expecting to obtain better portfolio Value-at-Risk (VaR) forecasts during times of high market volatility. We find that the augmented Copula-MSM models exhibit better forecasting performance as compared to several traditional and popular VaR forecasting methods.