Statistical Methods in Finance 2018
**December 17-20, 2018**

Overview

The fourth workshop and conference on Statistical Methods in Finance, 2018 exposed the participants to new and active areas of research and engaged researchers into active working groups.

Chennai Mathematical Institute (CMI) and Indian Statistical Institute (ISI) jointly hosted the third workshop-conference on "**Statistical Methods in Finance**" and we will continue to do so in future.

The event is sponsored by
- Indian Statistical Institute
- International Society for Business and Industrial Statistics (ISBIS)
- Indian Bank
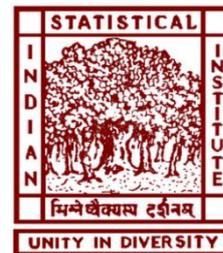
Workshop

Anindya Goswami, Indian Institute of Science Education and Research (IISER), Pune, INDIA conducted workshop on "Optimization in Finance".

Plenary Speakers
- Katherine Bennett Ensor, Rice University, USA
- Ajay Shah, National Institute of Public Finance and Policy, New Delhi, INDIA
- Nalini Ravishanker, University of Connecticut, USA

Invited Speakers

- Ananya Lahiri, IIT Tirupati
- Anirban Chakraborti, Jawaharlal Nehru University, New Delhi
- Arnab Chakrabarti, Indian Statistical Institute
- Debopam Bhattacharya, Cambridge University, UK
- N Balakrishna, Statistic, Cochin University of Science And Technology
- Rangan Gupta, University of Pretoria, South Africa
- Ravindra Khatree, Oakland University, USA
- Sonali Das, CSIR, South Africa
- Sugata Sen Roy, Calcutta University
- Susan Thomas, Indira Gandhi Institute of Development and Research, Mumbai
- T.V. Ramanathan, Savitribai Phule Pune University
- Vitthal Kulkarni, HDFC Bank, Mumbai

Contributed Speakers

- Anuj Mishra, Department of Statistics, University of Pune
- Deepak Jadhav, Tata Consultancy Services
- Harini Srinivasan, University of Madras
- Kiran Sharma, Jawaharlal Nehru University, New Delhi
- Kunal Saha, Institute for Financial Management & Research (IFMR)
- Ruchika Sehgal, IIT Delhi
- Saif Jawaid, Indian Statistical Institute
- Saranjeet Kaur Bhogal, Savitribai Phule Pune University, Pune
- Soham Banerjee, ISI Kolkata
- Subhojit Biswas, Indian Statistical Institute
- Sudarshan Kumar, IIM Ahmedabad
- Suparna Biswas, Indian Statistical Institute

Panel Discussions

Panel Discussion on Energy Markets.

- Katherine Bennett Ensor , Rice University, USA
- Vinay Kumar P., MD and CEO India Renewables
- Vivek Subramanian, Executive Director at Fourth Partner Energy

Panel Discussion on How to Write Good Research Paper?.

- Katherine Bennett Ensor , Rice University, USA
- Nalini Ravishankar, University of Connecticut, USA
- Rajeeva L Karandikar, Director, CMI, India

Student Paper Competition

The winners are:

- Mr Sudarshan Kumar, Indian Institute of Management Ahmedabad
- Mr Kunal Saha, Institute for Financial Management & Research

The following received Honorable Mention:

- Mr Soham Banerjee, Indian Statistical Institute
- Mr Anuj Mishra, Savitribai Phule Pune University

Accommodation

- For the Ph.D. students, shared accommodation at CMI student's hostel was provided from workshop/conferences.
- Local faculty and speakers were accommodated at CMI's guest house and CMI-affiliated Hotel Sabari
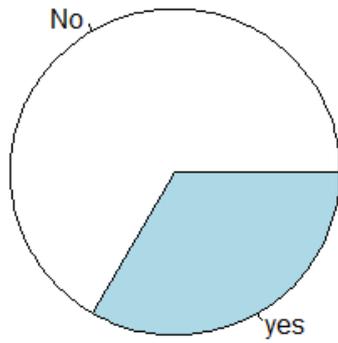
Participants Status
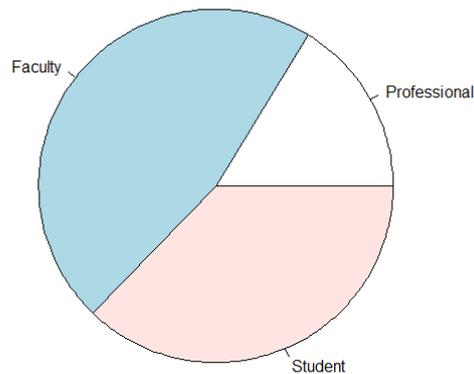
Participants by Country

Country	Participant
UK	1
South Africa	2
USA	3
India	35

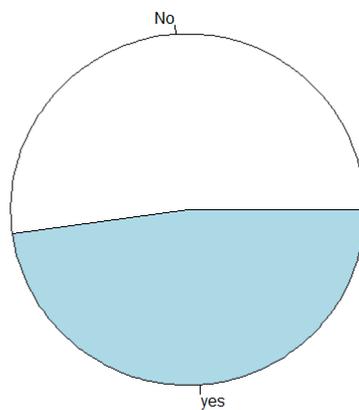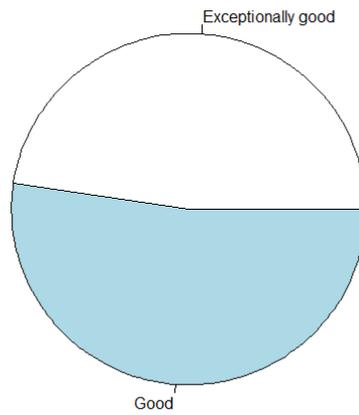**Have you attended any previous statfin conference?**

No

yes

Have you got any new research ideas after attending the statfin conference?
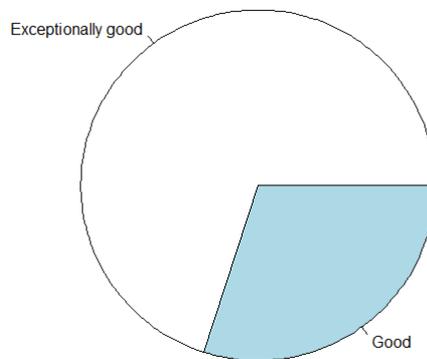
No

yes
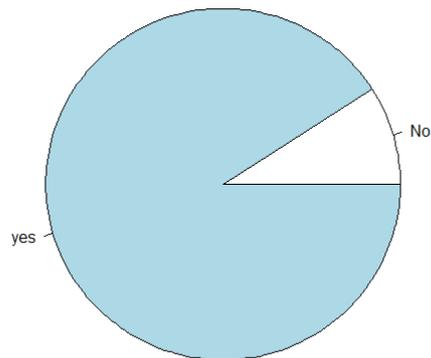
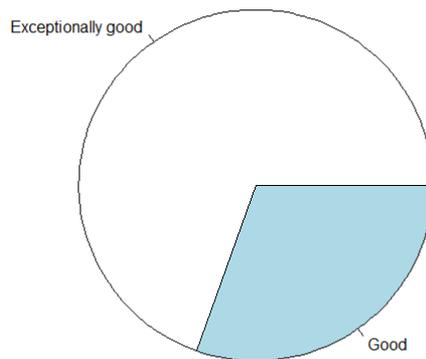**Did you start any collaboration from the statfin conference?**

No

yes

Quality of panel on "Energy Markets"

Quality of panel on "How to write a good research paper?"

Quality of Plenary talks

Quality of Invited talks
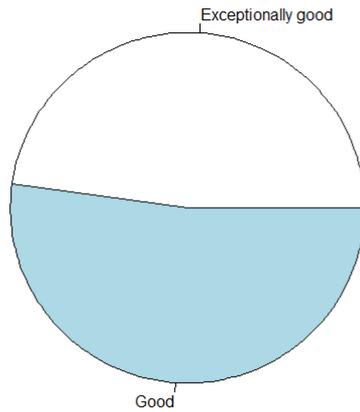
Quality of Contributed talks
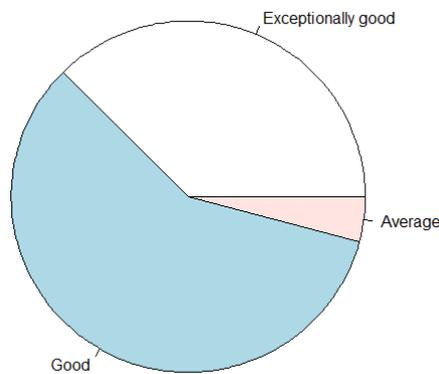
Specific Suggestions/Comments:

Conference is really wonderful. No suggestions.
Add workshop on advanced topic.
Perhaps shorten day schedule and maybe 4 days? More participation from countries other than India and US. Really appreciated attending it.
People from non-finance background and more people should be invited. More presentations from industry.
Advertise this more broadly to industry. Encourage presenters to start their preesentation with how their work matters and to whom.
More presentation of work from industry
Conference was having a good mix of theoretical and empirical studies. Future conferences should maintain the same.
More people from industry can participate. More participation from people from non-finance pedigree.

It would be beneficial if you could include few more experts from econometrics background.
Nothing in particular. It was very well organized. Looking forward for the next meet. Keep up the good work!
Probably more industry related talks or other aspects of financial risk like credit risk, operational risk.
Overall the conference was awesome which gave a platform to get to know more about research happening across the countries. However few topics are unavoidable like copulas which I can understand but I felt they were repetitive. Probably before the conference if you could filter them it might sound great.
Should be spread with longer time for discussions.
Excellent effort all the way around. Keep it going.
It is going on well for the last four years. Keep it up.
Faculty enrichment program may be taken up.
Suggestion to conduct workshop on risk management in portfolio in future.

Full List of Participants:

Forty one registered participants attended the workshop/conference from various universities, institutes and companies:

Suparna Biswas	Indian Statistical Institute, Chennai
Ananya Lahiri	IIT Tirupati
Debopam Bhattacharya	Cambridge University, UK
Sonali Das	CSIR, South Africa
Susan Thomas	Indira Gandhi Institute of Development and Research, Mumbai
Prabuddha Chakraborty	Indian Statistical Institute, Chennai
Rituparna Sen	Indian Statistical Institute, Chennai
Sourish Das	Chennai Mathematical Institute
Anuj Mishra	Pune University
Deepak Jadhav	Tata Consultancy Services
Dipankar Mondal	IIT Guwahati
Kunal Saha	Institute for Financial Management & Research (IFMR)
Saif Jawaid	Indian Statistical Institute, Kolkata
Soham Banerjee	Indian Statistical Institute, Kolkata
Subhojit Biswas	Indian Statistical Institute, Kolkata
Sudarshan Kumar	IIM Ahmedabad

Arnab Chakrabarti	Indian Statistical Institute, Chennai
Kiran Sharma	Jawaharlal Nehru University
Munmi Saikia	IIT Guwahati
Ruchika Sahgal	IIT Delhi
Saranjeet Kaur Bhogal	Savitribai Phule Pune University, Pune
Harini Srinivasan	University of Madras
Shubhangi Sikaria	IIT Madras
Anirban Chakraborti	Jawaharlal Nehru University, New Delhi
N Balakrishna	CUSAT, Cochin
Rangan Gupta	University of Pretoria, South Africa
Ravindra Khattree	Oakland University, USA
Sugata Sen Roy	Calcutta University
TV Ramanathan	Savitribai Phule Pune University
Katherine Bennett Ensor	Rice University, USA
Nalini Ravishanker	University of Connecticut, USA
Rajeeva Karandikar	Chennai Mathematical Institute
Vitthal Kulkarni	HDFC Bank, Mumbai
Ajay Shah	National Institute of Public Finance and Policy, New Delhi
Anindya Goswami	IISER Pune
A Vanav Kumar	NIT, Arunachal Pradesh
Arnab Bhattacharya	Flipkart
Diganta Mukherjee	Indian Statistical Institute, Kolkata
Mahalakshmi S	Central University of Tamilnadu
Pulkit Singhal	Tata Consultancy Services
Sivakumar Chandrasekaran	Pondicherry University
P Vinay Kumar	India Renewables
Vivek Subramanian	Fourth Partner Energy

Scientific Program

Decmber 17 -20, 2018

Workshop on **Optimization in Finance**

Anindya Goswami
Indian Institute of Science Education and Research (IISER), Pune, INDIA

Prof T. Krishnan Memorial Talk

Filtering and Estimation for a Class of Stochastic Volatility Models with Intractable Likelihoods

by **Katherine Bennett Ensor**, Rice University, USA

Abstract: We introduce a new approach to latent state filtering and parameter estimation for a class of stochastic volatility models (SVMs) for which the likelihood function is unknown. The α-stable stochastic volatility model provides a flexible framework for capturing asymmetry and heavy tails, which is useful when modeling financial returns. However, the α-stable distribution lacks a closed form for the probability density function, which prevents the direct application of standard Bayesian filtering and estimation techniques such as sequential Monte Carlo and Markov chain Monte Carlo. To obtain filtered volatility estimates, we develop a novel approximate Bayesian computation (ABC) based auxiliary particle filter, which provides improved performance through better proposal distributions. Further, we propose a new particle based MCMC (PMCMC) method for joint estimation of the parameters and latent volatility states. With respect to other extensions of PMCMC, we introduce an efficient single filter particle Metropolis-within-Gibbs algorithm which can be applied for obtaining inference on the parameters of an asymmetric α-stable stochastic volatility model. We show the increased efficiency in the estimation process through a simulation study. Finally, we highlight the necessity for modeling asymmetric α-stable SVMs through an application to propane weekly spot prices.

Plenary Talk

The statistics of exchange rate regimes: Recent developments and possibilities for new research

by **Ajay Shah,** National Institute of Public Finance and Policy, New Delhi, INDIA

Abstract: One of the most important questions in exchange rates is the nature of the exchange rate regime, i.e. the policy strategy followed by the authorities in managing (or not managing) the exchange rate. Knowing this regime, and getting early warnings about changes, are of great importance in the practitioner and policy communities. This field began with a clever regression, in 1969. We will present the questions of this field, in a historical narrative, show how innovative statistical methods have been brought to bear on the questions, give a sense of what is known and what is not known. We will offer conjectures for opportunities for interesting new research which should be done, at the interfaces of statistics and finance.

High-Frequency Financial Time Series Analysis

by **Nalini Ravishanker** University of Connecticut, USA

Abstract: This talk will discuss a broad range of statistical data analysis for high-frequency financial time series obtained from the Trade and Quotes (TAQ) database. Clustering and biclustering of the time series across a large number of stocks enables grouping based on their stochastic properties. A hierarchical dynamic Bayesian framework enables predictive modeling of vector transaction counts in regularly spaced short time intervals. These approaches may be combined by financial analysts in order to provide detailed analysis of these large financial databases.

Panel Discussion

Panel Discussion on Energy Markets.

- **Katherine Bennett Ensor** , Rice University, USA
- **Vinay Kumar P.**, MD and CEO India Renewables
- **Vivek Subramanian**, Executive Director at Fourth Partner Energy

Panel Discussion on How to Write Good Research Paper?.

- **Katherine Bennett Ensor** , Rice University, USA
- **Nalini Ravishankar**, University of Connecticut, USA
- **Rajeeva L Karandikar**, Director, CMI, India

Invited Talk

Applications of Birnbaum-Saunders Distribution in Modelling Stochastic Volatility
by **N Balakrishna** Cochin University of Science And Technology
Abstract: In this paper we propose a method of constructing a Markov sequence with one-dimensional Birnbaum-Saunders (BS) stationary distribution using a first order Gaussian autoregressive sequence. A parameter-driven stochastic volatility model is constructed using this BS Markov sequence to describe the evolution of financial returns. The parameters of the resulting model are estimated using a method of efficient important sampling. A simulation study is conducted to illustrate the method of estimation and data sets are analysed to highlight the applications of the model.

Asymptotic properties of the volatility estimator from high frequency data modeled by mixed fractional Brownian motion
by **Ananya Lahiri** IIT Tirupati
Abstract: Properties of mixed fractional Brownian motion has been discussed by Cheridito (2001) and Zili (2006). We have proposed an estimator of volatility parameter for a model driven by MFBM, useful for modeling high frequency financial data. In this talk we have shown that the estimator has some desirable asymptotic properties. We will see some application too.

Financial Inclusion Measurement : Searching for an Alternative Index
by **Sugata Sen Roy** Calcutta University

Abstract: Financial inclusion refers to a state where individuals have effective access to credit, savings, payments and insurance from formal service providers. However, there are very few comprehensive measures to assess the financial inclusion in a region or country. In this paper, we suggest better indices for measuring financial inclusion. The indices are applied to data on India and other Asian countries. The results allow us a better insight into the inclusiveness of the financial sectors of these countries.

Mesoscopic Financial Network: Sectoral Co-movements and Core-periphery Structure

by **Anirban Chakraborti** Jawaharlal Nehru University, New Delhi
Abstract: Network analysis has become a primary tool in fields as diverse as systems biology, ecology, epidemiology, sociology, economics and finance. We present the work that demonstrates the existence of an empirical linkage between nominal financial networks and the underlying economic fundamentals, across countries [1]. To study the topology of the return correlation network at mesoscopic level, we constructed correlation matrices from sectoral indices for 27 countries, and applied two commonly used clustering algorithms, viz., minimum spanning tree (MST) and multi-dimensional scaling (MDS), to group sectors based on their co-movements. The influence of the sectors in the mesoscopic network was found using the eigenvector centrality (EVC). We proposed a method to find a binary characterization of the 'core-periphery' structure by using a modification of the EVC. We showed that those sectors identified as core by the centrality measure, also constitute the backbone of the MST and cluster very closely in the MDS maps, thereby confirming the robustness of our method. We also studied the sectoral dynamics, and found that the core-periphery structure had at least two sectors in the core for all countries. But the core-periphery structure does change over time; so we compared the structures for the periods of market turbulence (2008-09) as well as periods of relative calmness (2012-13 and 2015-16). For most of the countries, Industries (ID) and Finance (FN) remained as core sectors. To establish the connection between the financial network and the underlying production process, we regressed the EVC on macro-variables: market capitalization, revenue and employment, all aggregated at the sectoral level. The results were reasonably robust with varying degrees of prosperity. We also present some related work and extensions of these analyses at the micro level (stock wise) [2] and macro level (index wise)[3].
References:
[1] K. Sharma, B. Gopalakrishnan, A. S. Chakrabarti and A. Chakraborti, Scientific Reports, 7 (2017) 8055.
[2] K. Sharma, S. Shah, A.S. Chakrabarti and A. Chakraborti, Proc. of Economic Foundations for Social Complexity Science, (2017) 211-238.
[3] K. Sharma, A.S. Chakrabarti and A Chakraborti, "Multi-layered network structure: Relationship between financial and macroeconomic dynamics", to be published in Eds. F. Abergel et al., New Perspectives and Challenges in Econophysics and Sociophysics (Springer, Milan); available at arXiv:1805.06829 (2018). "

A New Approach to the Estimation of Beta Risk and An Analysis of Stock Market Through Copula Transformation and Winsorization with S&P500 Index as Proxy

by **Ravindra Khattree** Oakland University, USA
Abstract: We consider the problem of reliable estimation of market betas. Estimation using least squares can be very sensitive to underlying assumptions of normality and presence of outliers, while various robust estimation procedures have a certain degree of arbitrariness in their implementation. This is especially of concern since returns for various equities may have very different statistical distributions and this consideration is routinely ignored when ranking stocks or other assets with respect to their beta values. At the same time, different assumptions

made on the distributions of different stocks will result in their betas becoming largely incomparable. Our approach is to bring all estimation problems to a common platform through bivariate Gaussian copula transformation where in view of linearity of regression, correlation is a meaningful measure of dependence. We then carry out the estimation of betas by combining it with winsorized relative volatility of the asset. Extensive analysis of US market with S&P500 as proxy indicates that when the data show departure from assumptions, our approach provides more stable estimates of betas than least squares and estimates are essentially same when assumptions are met. Improvement is realized in upto 53% of the instances.

Investigating effect of global crisis index on historical comovement of stock returns in the G7 countries: An FDA approach

by **Sonali Das** CSIR, South Africa

Abstract: In this paper we consider the comovements (or correlations) of the stock markets of the US with the other six G7 countries. We use historical data, which in some cases spans from the 1800's. Our objective is to ascertain the effect of global crises on these comovements in a Functional Regression framework, by regressing comovement (monthly frequency) with the Global Crises Index (annual frequency). A major advantage of the Functional Data Analysis (FDA) framework is that it allows us to perform this mixed frequency regression, as aggregating comovements data would make us loose information. The regression coefficient functions are analysed, and considerable knowledge on the effects of crises on comovement of data is gained. Some preliminary analysis indicates that stock comovement between the US and UK has been significant since the early 1900's; while for the other countries (France, Japan, Germany and Italy), the comovements became significant after the mid 1950's. Most of the regression coefficient functions were significant, indicating the validity of most of these results. Another noteworthy point, is that the comovement between the US and Canada has always been significant, indicating perhaps that these two neighbouring economies have always been highly integrated.

A new class of asymmetric volatility models

by **TV Ramanathan** Savitribai Phule Pune University

Abstract: In this talk, we consider a new class of asymmetric volatility models. The proposed class is formed by treating the parameters as a stationary and ergodic sequence of coefficients. This proposed family can nest several non-linear asymmetric generalized autoregressive conditional heteroskedastic (GARCH) models with stochastic parameters into its ambit. It also generalizes the Markov switching GARCH and Glosten, Jagannathan and Runkle (GJR) models. The geometric ergodicity of the proposed process is established. Sufficient conditions for stationarity and existence of moments have also been investigated. Geometric ergodicity of various volatility models with stochastic parameters has been discussed as special cases. An attempt has been made to address the related inference problems.

Cricket and Stock Markets

by **Rangan Gupta** University of Pretoria, South Africa

Abstract: The objective of this paper is to analyze whether One Day International (ODI) cricket match performances can predict returns and volatility of the Indian stock market, over the period of 1992-2017. For our purpose, we use a k-th order Nonparametric Causality-in-Quantiles approach, recently developed by Balcilar et al., (2018). This approach has three advantages: Firstly, it is robust to misspecification errors as it detects the underlying dependence structure between the examined time series based on a nonparametric framework. Secondly, we are able to test for not only causality-in-mean (1st moment), but also causality

that may exist in the tails of the distribution of the variables. Finally, we are also able to investigate causality-in-variance and, thus, study higher-order dependency. Based on this test, we find strong evidence of predictability over the entire conditional distribution of returns, with losses being a stronger predictor at lower quantiles, while wins performs better at upper quantiles. For volatility predictability is restricted to lower quantiles only, with losses being the stronger predictor. In a robustness analysis, we find more or less similar results for Pakistan as well.

The Empirical Content of Discrete Choice Models
by **Debopam Bhattacharya** Cambridge University, UK

Abstract: Empirical demand models used for counterfactual predictions and welfare-analysis must be rationalizable, i.e. consistent with utility-maximization by heterogeneous consumers. This paper establishes global, closed-form conditions for rationalizability in nonparametric discrete-choice models under general unobserved heterogeneity. These conditions differ from Slutsky-restrictions for continuous goods. For binary choice, they amount to simple shape-restrictions on choice-probabilities. For multinomial choice with smooth demand, the critical condition is "Slutsky-Invariance" -- a discrete-choice analog of Slutsky-symmetry. The multinomial results are based on the theory of partial differential equations and the Picard-Lindel??f theorem. Unlike McFadden-Richter's Stochastic Revealed Preference, our conditions are closed-form, hence easy to test, impose, and use for predicting demand/welfare on counterfactual budget-sets.

Copula estimation for bivariate nonsynchronous financial data
by **Arnab Chakrabarti** Indian Statistical Institute, Chennai

Abstract: Copula is a powerful tool to model multivariate data. Due to its several merits Copula modelling has become one of the most widely used methods to model financial data. To fit a copula, we have to have synchronous multivariate data. We discuss the problem of modelling intraday financial data through Copula. The problem originates due to the nonsynchronous nature of intraday financial data whereas to estimate the Copula, we need synchronous observations. We show that this problem may lead to serious underestimation of the Copula parameter. We also propose a modification to make the estimator unbiased.

Challenges in derivatives valuations, risk and current developments in Emerging markets
by **Vitthal Kulkarni** HDFC Bank, Mumbai

Abstract: Derivatives contract valuations have come a long way from risk neutral valuation coming out of traditional pricing models to the fair valuations used in the books of account. After global financial crisis during 2007 - 2009, risk neutral valuations are adjusted for credit, funding, liquidity and other risks faced in the market place. This presentation will highlight fair value adjustments conducted by the market participants and the its importance to manage model risk.

Volatility forecasting for Distance-to-Default estimation
by **Susan Thomas** Indira Gandhi Institute of Development and Research, Mumbai

Abstract: A key input to estimating the distance to default measure for a firm is the forecast of the volatility of its stock returns. In this paper, we present the distance to default estimated for a sample of well-traded stocks using forecasts for volatility, selected from three different volatility estimators -- range, historical volatility, and implied volatility calculated from the options prices on the stock. We first test the performance of the forecasts from these three

estimators to predict the realised volatility of the stock returns. Next, we use these estimators to calculate the distance to default measure for the firm, and analyse how the different forecasts affect the distance to default measure.

Contributed Talk

Bayesian Non-parametric modelling of durations in high-frequency finance
by **Anuj Mishra**
In this paper, we propose an infinite regime Autoregressive Conditional Duration (ACD) model. The stationarity, moments and tail behaviour of the proposed model are studied. The conditional density of duration is modelled in a Bayesian approach by putting prior on the space of transition densities using Dirichlet process mixtures(DPM). We establish the asymptotic property of the Bayesian procedure by proving the consistency of the sequence of posterior distributions.

Modified Expected Shortfall : A Coherent Risk Measure for Elliptical Family of Distributions
by **Deepak Jadhav**
The Modified Expected Shortfall risk measure proposed in Jadhav et al. (2013) intended to eliminate the effect of exceptionally high returns. It provides a balanced risk measure, valued higher than the Value-at-Risk, but, lesser than the Expected Shortfall, based on shrinkage parameter a. However, it is not a coherent risk measure. In this article, we prove that the Modified Expected Shortfall is a coherent risk measure under univariate and multivariate elliptical family of distributions. The Modified Expected Shortfall performs better than the Expected Shortfall and found to be lower in magnitude. Backtesting results support the Modified Expected Shortfall.

Application of Transformed Distribution: Volume and Market Cap of Bitcoin
by **Harini Srinivasan**
Bitcoin is digital currency which is emerging and becoming popular in the financial market. Studies have shown that lognormal, generalized hyperbolic parametric distributions has been best fit for studying the bitcoin datasets. In this study, we considered transformed distributions for fitting the volume and market cap of bitcoin dataset. Further, a comparison is also attempted by considering Gamma-Pareto, Weibull-Pareto, Beta-Pareto, Beta-Cauchy and Gamma-Exponential-Cauchy transformed distributions. The study shows that Weibull-Pareto is more appropriate for fitting the volume and market cap of bitcoin dataset.

Predicting the unpredictable: A case study of financial market crashes
by **Kiran Sharma**
Catastrophic events, though rare, do occur and when they occur, they have devastating effects. The study of the critical dynamics in complex systems is always interesting yet challenging. First, we present a brief overview of the random matrix theory and correlated Wishart ensemble. Then, we choose financial market as an example of a complex system, and do the analysis of the S &P 500 (USA) stock market based on the evolution of cross-correlation structure patterns. We identify ``market states" as clusters of similar correlation structures, which occur more frequently than by pure chance (randomness). Power mapping method from the random matrix theory is used to suppress the noise on correlation patterns, and an adaptation of the intra-cluster distance method is used to obtain the optimum number of market states, and also identify the ``precursors" to the crashes. The dynamics of the transitions

between the states are interesting. Further, the resulting ``emerging spectrum'' of eigenvalues near zero, have intriguing properties: (i) the shape of the emerging spectrum reflects the market instability, (ii) the smallest eigenvalue is able to statistically distinguish the nature of a market crash or crisis. We finally investigate whether the smallest eigenvalue is able to predict a high market correlation, which is a signature of a crash.

An investigation into the dependence structure of major cryptocurrencies
by **Kunal Saha**
This paper attempts to examine the dependence structure of four major cryptocurrencies chosen by current market capitalisation (Bitcoin, Ethereum, Ripple and Litecoin). It is a well known fact that there is huge volatility in the prices of these cryptocurrencies. The Vine Copula model is used to get some insights about the dependence structure in these asset prices. This is done using daily closing prices from August 2015 to July 2018. This information can be used to calculate risk based metrics such as Conditional Value-at-Risk of a portfolio of these currencies. This analysis becomes more important as complex financial instruments (e.g. indices) based on these currencies are being introduced.

Enhanced Indexing using Weighted Conditional Value at Risk
by **Ruchika Sehgal**
We propose an enhanced indexing portfolio optimization model that not only seeks to maximize the excess returns over and above the benchmark index but simultaneously control the risk by introducing a constraint on the weighted conditional value at risk (WCVaR) of the portfolio. The constraint in the proposed model can be seen as hedging the risk described by WCVaR of the portfolio. To carry out a comparative analysis of the proposed model, we also suggest an enhanced indexing CVaR model.We analyze the performance of the proposed model at various risk levels on eight publicly available financial data sets from Beasley OR library, and S&P 500, S&P BSE 500, NASDAQ composite, FTSE 100 index, and their constituents, for average returns, Sharpe ratio, and upside potential ratio. Empirical analysis exhibits superior performance of the portfolios from the proposed WCVaR model over the respective benchmark indices and additionally the optimal portfolios obtained from various other enhanced indexing models that exist in the literature. Furthermore, we present evidence of better performance of WCVaR model over the CVaR model for long-term investment horizons.

Application of Feature Selection and Extraction techniques on Indian Stock Market
by **Saif Jawaid**
The analysis of the financial market always draws a lot of attention from investors and researchers. The trend of stock market is very complex and is influenced by various factors. Therefore, to find out the most significant factors to the stock market is very important. Feature Selection is such an algorithm that can remove the redundant and irrelevant factors and figure out the most significant subset of factors to build the analysis model. In this paper, 8 stocks of 8 different industries were analysed. Based on the results given by the 5 different feature selection algorithms a score system was developed and features with scores of more than 2.5 were chosen for further analysis. A comparison of the absolute error was made between features chosen based on company specific score vs features chosen based on composite score. Further, new features were extracted from the features selected based on the composite. An absolute error comparison was made between features selected based on composite score, both, with and without the newly extracted features.

High frequency risk measures: An empirical study of the Indian stock market

by **Saranjeet Kaur Bhogal**

The purpose of this paper is to compute intraday high-frequency risk (HFR) measures for market risk of some of the selected stocks listed on the National Stock Exchange of India (NSE). We compute value-at-risk (VaR) accompanied with a time-at-risk (TaR) measure. An autoregressive conditional duration (ACD) model is applied to model the duration dynamics whereas, the volatility is captured using generalized autoregressive conditional heterocedastic (GARCH) models. The validity of the VaR and TaR forecasts is assessed using a backtesting procedure. The stocks are selected from three different sectors: IT-software sector, cement and construction materials sector and pharmaceuticals and drugs sector. Selected stocks from the pharmaceuticals and drugs sector show frequent small gains and few extreme losses. Whereas selected stocks from IT-software sector (except one) and cement and construction materials sector (except one) show frequent small losses and few extreme gains. Comparable results are obtained when median (instead of arithmetic mean) is used for aggregation of transactions having the same time stamp for one of the stock.

Short Term Stock Price Prediction in Indian Market: A Neural Network Perspective
by **Soham Banerjee**

In the realm of finance, behavior of equity markets have a deep-seated impact on individual investors as well the economy at large. Thus a prescient knowledge of the underlying market dynamics, that orchestrate stock price movements plays a critical role in engineering successful strategies for the investor. A lot of effort has been already devoted on stock price forecasting using traditional time series models (like MA, ARMA, ARIMA, ARCH, GARCH) which model the data using a predefined mathematical framework, restricting their ability to learn latent patterns in the data. In recent times, Artificial Neural Networks(ANN) have garnered a lot of positive attention from researchers in this domain. ANNs are able to consistently outperform traditional models because of their model independent approach which enable them to learn complex hidden patterns in the data using a highly non-linear architecture. In this report we have focused on the application of advanced Neural Network paradigms like stacked Multi Layer Perceptrons(MLP), Long Short Term Memory (LSTM), Gated Recurrent Unit(GRU) and Bidirectional Long Short Term Memory (BLSTM), Gated Bidirectional Recurrent Unit(BGRU) on NSE listed companies to predict short term stock price and compared their performance with a shallow neural network benchmark.

Statistical arbitrage of multiple asset under drawdown constraint and stochastic Sharpe's ratio
by **Subhojit Biswas**

We consider an investor who seeks to maximize his expected utility of the portfolio consisting of two risky assets and one risk free asset derived from the terminal wealth relative to the maximum wealth achieved over a fixed time horizon, and under a portfolio draw down constraint, in a market with local stochastic volatility. The two assets have been found out with the help of pairs trading. In the absence of closed form solution of the value function and the optimal strategy we obtain the approximates of these quantities using coefficient series expansion techniques and finite difference schemes. We utilize the risk tolerance factor function to ease our approximations of this value functions and the strategies. All the parameters were estimated from the triplets and all these parameters are put in the equation to illustrate and compare the stochastic volatility with the constant volatility situation, and how an investor can deploy different portfolio plans.

Liquidity and term structure estimation: Non-linear state-space framework

by **Sudarshan Kumar**

Term structure estimation in the emerging markets has additional complexity of the infrequent trading in many securities and concentration of the liquidity in the few maturity segments. Infrequent trading in many securities reduces the number of bonds with the complete panel data. Additionally, because of the lack of liquidity in many maturity segments, term structure estimation using small number of liquid securities is not practical. Term structure studies in these markets usually ignore these market specific complexities, and borrow the framework directly from developed market. This study extends an existing popular dynamic term structure framework (Dynamic Nelson Siegel) to non-linear state-space setting to incorporate the impact of liquidity on the bond prices. To incorporate heterogeneous Liquidity of the securities in and across maturity segments, study explores two alternative specifications of the liquidity. In the first, liquidity is defined as a function of the observable proxy variables - trading volume, age of the security and duration. In the second framework, study assumes market liquidity as a latent factor and augment it with the three existing latent actors of the Dynamic Nelson Siegel model. Study explores the impact of the liquidity on the bond prices (Liquidity premium) and its measurement error both, and finds strong empirical evidence supporting that. Study empirically evaluates the proposed framework on the Indian government bond market data for the period 2009-2017.

Kernel based estimation of Spectral Risk Measure
by **Suparna Biswas**

Spectral risk measures (SRMs) proposed by Acerbi (2002, 2004) belong to the family of coherent risk measures and hence inherit the properties of such measures. SRM is a weighted average of the quantiles of a loss distribution, the weights of which depend on the user's risk aversion. A natural estimator for the class of SRMs has the form of L-statistics. In the literature, properties of the estimator of SRM are obtained using the empirical distribution function. We try to investigate the large sample properties of general L-statistics based on i.i.d cases and apply them to our kernel based estimator of SRM. We prove that the estimator is strongly consistent.