India's financial markets: research on functions and structure

Discussion meeting at the
Dynamics of Complex Systems 2019,
ICTS, Bangalore

Susan Thomas
IGIDR

11 July, 2019

Structure of the talk

- Why does finance matter?
- Early work
- Phase 1: measurement
- Phase 2: causal analysis
- Looking forward

Setting the context

Setting the context

- Finance aims to smooth consumption requirements of economic agents.

  This is done by shifting endowments across time by creating contracts between individuals.
- These are financial instruments.

  Examples: Savings accounts, fixed deposits, bonds (debt) and shares (equity).
- A useful distinction: Financial contracts vs. securities.

  Financial contracts are restricted to be bought from / sold back to the same producer.

  Financial securities where the contracts can be bought from / sold to either the issuer or third parties.
- The latter is attractive: prices are not set by a monopoly.

Trading among strangers

- Holding securities raises other questions:
  - Where do we go to sell these securities (and get cash back)?
  - Who sets the price, if not the producer?
  - How do we know the price is “fair”?
- Answers: • Financial markets, • Financial markets, • Aggregation of information by crowds often get to better decisions than made by any single member.

  James Surowiecki (2004): *The wisdom of crowds: Why the many are smarter than the few, and how collective wisdom shapes business, economies, societies and nations*

  Where the “wise” crowd has to have (a) diversity of opinion, (b) independence, (c) decentralisation – local knowledge, and (d) an unbiased aggregation.
- Icing on the cake: we know that a “fair” price looks like a random walk.

  Paul Samuelson (1965), “Proof that properly anticipated prices fluctuate randomly”.

Choice of work

- Financial markets makes the price.
- Intermediaries use the price to guide savings (household) into investment (firms) decisions.
- Financial markets guide resource allocation!
- India is increasingly becoming a market economy.

$\rightarrow$ I need to study financial markets.

A spoonful of sugar ...: Data availability

- A lot of economics suffers from weak observation sets, poor measurement.
- Finance is unusual, in comparison:
  1. Operations and actions of firms are measured fairly well.
  2. Transactions on securities markets are measured very well, particularly today with modern exchanges.

$\rightarrow$ The right place to do quantitative economics.

Data for finance in India

- NSE/BSE daily returns data - CMIE Prowess (From 1/1/1990 onwards)
- Information about the balance sheet of firms - CMIE Prowess. (late 1980s onwards)
- High frequency finance - exchanges (BSE, NSE, MCX, NCDEX) makes available all trades and all orders.

Early years: characterising the working of Indian securities markets

Finance research, 1995

- **Eugene** Fama, 1965: "The behaviour of stock market prices".

  Statistically test whether prices are *weak form*, *semi-strong form* and *strong form* efficient relative to available information.

- **Thesis**: "Empirical characterisation of the Bombay Stock Exchange"

  Data: time series of stocks and index.

  1. Tests of market efficiency (examples – runs test, variance ratios tests, event studies of stock events like bonus and rights issues)
  2. Models of heteroskedasticity (simple GARCH, regime shifts in GARCH, Multivariate GARCH, MVGARCH-in-mean)

- Finding: statistical inefficiencies.

- Missing: any estimation of economic inefficiency.

  Missing: use of market institutions, market microstructure.

Reforms in the Indian equity markets, 1995

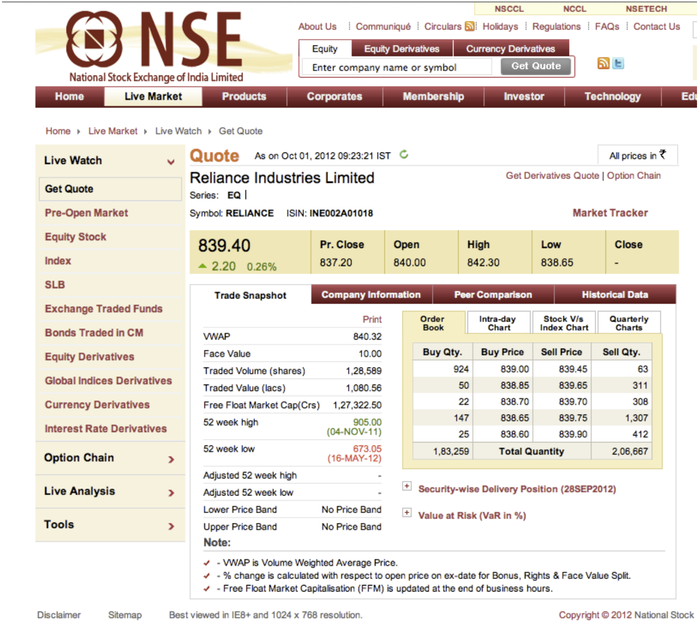
- Pre-1995: fragmented securities markets, low price transparency, low transaction certainty.
- Post-1995: Structural changes in microstructure –

  • single, national, electronic exchange with satellites collecting information and computers matching demand and supply, • transparency of prices in real-time, • guaranteed settlement, • a securities market regulator.
- Post-1999: derivatives trading simultaneously with stock (securities to trade risk).

Susan Thomas (2005), "How the financial sector in India was reformed." in Documenting Reforms: Case studies from India;

Ajay Shah and Susan Thomas (2000), "David and Goliath: Displacing a primary market". Journal of Global Financial Markets

Information from markets, post 1995



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Option Chain

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Tools

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839.40 ▲ 2.20 0.26%	Pr. Close	Open	High	Low	Close
	837.20	840.00	842.30	838.65	-

Trade Snapshot | Company Information | Peer Comparison | Historical Data

Print

VWAP	840.32
Face Value	10.00
Traded Volume (shares)	1,28,589
Traded Value (lacs)	1,080.56
Free Float Market Cap(Crs)	1,27,322.50
52 week high	905.00 (04-NOV-11)
52 week low	673.05 (16-MAY-12)
Adjusted 52 week high	-
Adjusted 52 week low	-
Lower Price Band	No Price Band
Upper Price Band	No Price Band

Order Book | Intra-day Chart | Stock V/s Index Chart | Quarterly Charts

Buy Qty.	Buy Price	Sell Price	Sell Qty.
924	839.00	839.45	63
50	838.85	839.65	311
22	838.70	839.70	308
147	838.65	839.75	1,307
25	838.60	839.90	412
1,83,259	Total Quantity		2,06,667

+ Security-wise Delivery Position (28SEP2012)

+ Value at Risk (VaR in %)

Note:

- VWAP is Volume Weighted Average Price.
- % change is calculated with respect to open price on ex-date for Bonus, Rights & Face Value Split.
- Free Float Market Capitalisation (FFM) is updated at the end of business hours.

Disclaimer Sitemap Best viewed in IE8+ and 1024 x 768 resolution.

Research and developments in market microstructure

Building the NSE-50 index ("Nifty")

- The NSE wanted a benchmark index for their exchange.
- Traditional approach to create an index:

  • pick the biggest stocks, • pick the most "liquid" stocks, • create an index of their prices weighted by their market cap.
- Our idea: use information in the limit order book to measure liquidity.

$$\text{Impact Cost, } IC(q) = \frac{P(q) - P_{opt}(q)}{P_{opt}(q)}, \quad P_{opt}(q) = \frac{1}{2} P_a + P_b$$

- Create an index with the lowest cost by selecting those stocks that have the lowest cost to trade.
- This index will be the cheapest to trade.
- Rare instance of a new index taking over an existing index.

Ajay Shah and Susan Thomas (1998), "Market microstructure considerations in index construction", CBOT Research Symposium Proceedings.

Calculating market implied volatility

- Expected risk is important to know in finance.
- Typically measured as variance of observed stock returns. Called "historical volatility".
- When markets have options, their price can be used to directly estimate a forecast of variance. Called "implied volalitity".
- Problem: There are multiple options on the same stock.
  Each gives different values of volatility! volatility smile.
- Our idea: Option pricing models assume frictionless markets.
  Create a single implied volatility value using a liquidity (impact-cost) weighted average of the observed values.

Rohini Grover and Susan Thomas (2012), "Liquidity considerations in estimating volatility indexes", Journal of Futures Markets.

Research on risk measurement

Context setting: building anonymous LOB exchange

- Any financial transaction is between a buyer (L) and Seller (S):

$$L \rightarrow S$$

- Fear in all financial transactions: Between the time that we have agreed to trade on a particular price, will our counter-party default on the agreement if the price moves against us?
- Possible mechanism for contagion – a domino effect of defaults when anyone agent fails.
- How do we incentivise strangers to trade with each other?
- Answer in Indian equity: *Novation* at the clearing corporation (CC). Legally, L buys from the CC, S sells to the CC.

$$L \rightarrow CC \rightarrow S$$

- The CC protects itself using a system of margins:

$$\text{Initial margin} + \text{mark-to-market margin}$$

Context setting: Price risk and optimal margins

- CC collects losses (and pays out profits) on a daily basis – "mark-to-market" margin.
- At the start of the trade, every trader needs to post "initial margin", which will be returned when the trade is completed.

  Ideally, the initial margin should cover the one–day price risk at every point in time. What should this value be?
- Set intial margin to be the "Value at Risk" (*VaR*) of the position on a one–day horizon.
- If the one–day rupee profit on a position is $x \sim f(x)$, then the VaR v at a 95% level is:

$$\int_{-\infty}^{v} f(x)dx = 0.05$$

- Critical input: what is $f(x)$ and what are it's parameter values?

  If $f(x)$ is the normal distribution, then (μ, σ) become critical inputs to managing default risk and systemic risk at the exchange.

The Parallel RIsk Management System, PRISM 1998

- Regulatory requirement to starting derivatives trading:

  (a) Calculate counterparty risk at the level of the end customer;

  (b) Calculate this in real-time.

- Our insight: This is an eminently parallelisable problem

  Solution: Parallel computation using commodity hardware of the VaR for every customer. Aggregate back to the central aggregator "mother" computer.

- Remains in place since 1999.

Which volatility forecasting model fits best?

- An embarassment of riches in volatility forecasting models.
  Problem: Varying cost-benefit of use – how to choose? (EWMA vs. GARCH(1,1)?)
- Empirical back-tests: run the candidates on existing data, generate forecast, and test which has the least forecast error.
- Standard testing frameworks then:
  1. **Peter** Christoffersen (1998): "Evaluating interval forecasts" – test for independence of the forecast errors.
  2. **Jose** Lopez (1999): "Methods for evaluating value-at-risk estimates" – test errors using the utility function of the forecast user.
  3. **Hansen**, Lunde, Nason (2004): "Model Confidence Sets for forecasting models" – test errors agnostic to the competiting models.
- We combined Christoffersen and Lopez (with a regulator's utility function) for the Indian derivatives market.
- **Mandira** Sarma, Ajay Shah and Susan Thomas (2003): "Selection of Value-at-Risk" models, Journal of Forecasting.

Phase 2: impact of changes

Richness of data and the attempt for causal inference

- The transparency of the markets, and constraints imposed by regulations, make for clean measurement.
- Indian equities markets have been a veritable fund of "exogenous" changes – most permanent.
- The combination allows for many research efforts to establish causal inference.
- Caveat: most often the change is universal.

  So there are still challenges in setting up the experimental design carefully.

Impact of derivatives on price discovery

- Acceptance about markets for securities. Scepticism about derivatives markets.
- Market microstructure features suggest derivatives have a role in price discovery. Early empirical evidence suggests not.
- But there are measurement problems in these to confound the analysis.
- Our question: Futures on Indian stocks are free from these – what do they tell us about price discovery of derivatives?
- Approach: Estimating information share from cointegration coefficients.
  1. The Component Share (CS) – **Jesus** Gonzalo and Clive Granger (1995), “Estimating long memory components from cointegrated systems”, Journal of Business and Economic Statistics.
  2. The Information Share (IS) – **James** Hasbrouck (1995), “One security, many markets: determining the contributions to price discovery”, Journal of Finance.

Role of derivatives in price discovery, contd.

- Our novel ideas:
  1. Use sequence of estimating the IS of futures relative to the stock, and validated it using its CS.
  2. Estimate this for individual stocks.
  3. Build a model of trader choice of futures vs. stock as a function of leverage and liquidity.
  4. Incorporate time variation for these choices depending upon information arrival and volatility.
- Our findings: (a) futures prices lead the stock price when adjusting for heterogeneity across stocks; (b) futures prices are even more informative during episodes of volatility.

Nidhi Aggarwal and Susan Thomas (2019), "When stock futures dominate price discovery", Journal of Futures Markets.

Public domain source code: **pdshare @** `http://ifrogs.org/systems.html`.

Causal impact of algorithmic trading

- An inevitable transformation of the markets: from humans trading to humans writing code that does the hard work.

  Great scepticism that technology will cause great harm with lower probability than humans will.
- Empirical research almost unilaterally finds evidence in support of technology.
- Measurement problems are exacerbated because algorithmic traders are notoriously opaque.

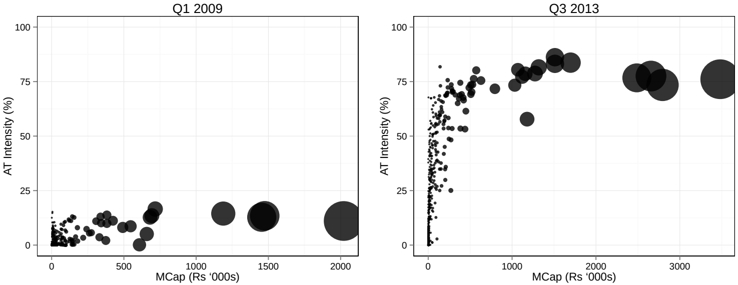
  Source of origin of orders to trade is considered very sensitive.
- Indian equity markets tag all orders as coming from an algorithmic or a non-algorithmic traders.

  This is unique and allows us to measure the impact of algorithmic trading cleanly.

Causal impact of algorithmic trading

- Event: SEBI allows “co-location” of servers at the exchanges in 2010.

  Algorithmic trading grows (in a traditional S-shaped curve of adoption) from 10% on average in 2010 to around 60% in 2013.
- However, there is interesting variation across stocks!



- Exploit this variation for a causal analysis of AT impact.

Causal impact of algorithmic trading

- Our novel idea: create a treatment and control group for a Difference-in-Difference analysis where:
  1. Treated stocks are those that saw a significant change in AT adoption.
  2. Control stocks are “matched” stocks that did not.
  3. Where the match is done using a propensity score matching approach using stock specific characteristics that hold before the event.
- What we find: those stocks where AT adoption grew saw improved market quality – price efficiency (variance ratios), liquidity (depth, impact cost), volatility (liquidity risk).

Nidhi Aggarwal and Susan Thomas (2014), “The causal impact of algorithmic trading on market quality”, `http://ifrogs.org/releases/ThomasAggarwal2014_algorithmicTradingImpact.html`

Ongoing and new research

Exploiting the natural experiments associated with SEBI's "ASM/GSM"

- SEBI sometimes decides that a certain stock is suffering from market manipulation
- In an ideal world SEBI would find and punish the wrong-doers
- Instead, SEBI chooses to (largely) shut off the trading in these firms.
- This is an interesting natural experiment in the role of speculative markets
- When a stock is put into ASM/GSM, there may be a decline in liquidity and pricing efficiency
- When it comes out of this, these changes may be undone
- The trouble is, SEBI's decisions are non-random.
- Some kind of matching scheme is required, to find controls for each treated stock.

Bans on commodity futures trading

- In socialist India, every now and then, the authorities ban commodity futures trading on a certain commodity
- Problems of supply, demand, and storage are blamed on "speculators" and "hoarders"
- Can these experiences be studied to discover the impact of speculation and hoarding?
- This is similar to the ASM/GSM problem - how do you find the control, a commodity who was not treated?
- How to design the right matching scheme?

Using the new measure of liquidity

- We have a great step forward in liquidity measurement: Impact cost.

  The instantaneous cost of doing any transaction size; no more tyranny of the bid-offer spread.

  - How does IC compare across time and across firms?
  - At what size should we do this comparison?
    1 share makes no sense. Rs.10,000 is not comparable across time, nor across across firms.
    Idea: Can we define a standard transaction size as 10^{-6} of the market cap of the firm. E.g. for a company with a market capitalisation of Rs.0.6×10^{12} such as Brittania.
    This is attractive insofar as we have shifted to a scale that is comparable across firms and across time.

- If there is a Liquidity Supply Schedule which has size on the x axis, and IC on the y-axis, what does it look like for the generic firm? For an individual firm? How does this move through time?

- How do we use this to understanding expected risk and return?

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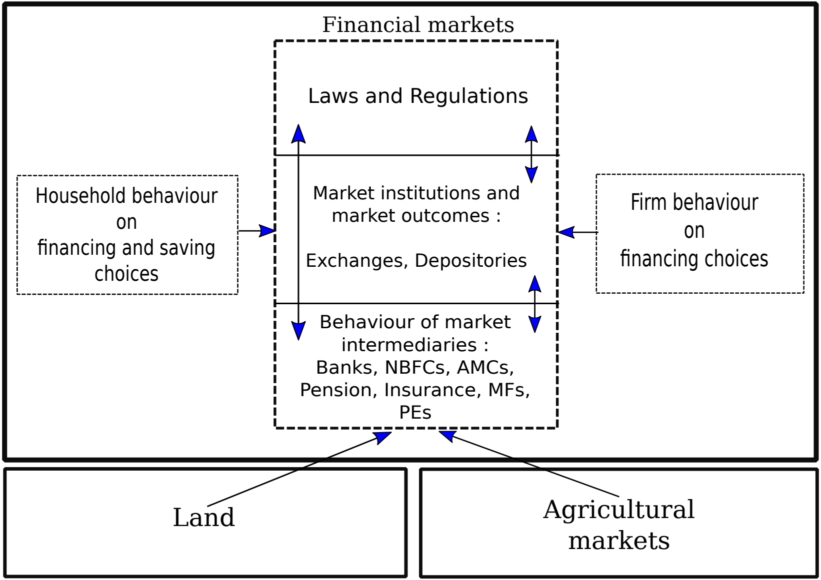

• Empirical; • Interdisciplinary; • Policy-oriented.

Thank you

Comments / Questions?

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