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A NEWSLETTER OF THE FINANCE LAB

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INDIAN INSTITUTE OF MANAGEMENT CALCUTTA

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Editorial

Our Hon'ble Finance Minister has indirectly criticised the note of Prof. Raghuram Rajan, former-governor, RBI on non-performing assets in Indian banking system. While one may differ with the tone and prescriptions of Rajan's note, one cannot deny the fact that the quality of Indian banks' balance sheets is of major concern to the policy makers and the central bank. Rajan's suggestion of a strong and independent board for a public sector bank is appropriate. However, one has also seen in the recent past malfunctioning of boards of a few private sector banks. Therefore, the malice is more deep and only an 'independent' board may not be the solution. It is imperative that banks now use robust analytics to take any credit decision and the government should ensure that large credit decisions are taken purely on merit basis.

The first article tries to demonstrate a new way of testing the Theory of Mind concept using market data. In the second piece, the author discusses the Indian Mutual Fund industry and how a majority of market share remains concentrated with a few big fund houses. The third article deals with the Mudra loan scheme and the author concludes that with the potential high levels of defaults and a growing loan portfolio of the Mudra loans may add to the current pile of non-performing loans (NPA). The fourth article discusses the International Mathematical Union award to MIT's Constantinos Daskalakis and concludes that Daskalakis' beautiful result promise to be an exciting time for researchers in finance, economics and computational theory, as they grapple with the many implications of his work.

The *Market Watch* section in this issue deals with Options trading and Indian Taxation.

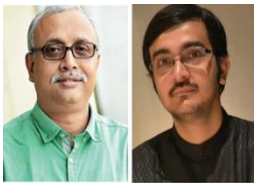
You may send your comments and feedback on this issue to ashok@iimcal.ac.in

Happy reading!

Ashok Banerjee

Theory of Mind and Algorithmic Trading

Ashok Banerjee and Samarpan Nawn



Ashok Banerjee, Ph.D., is Professor, Finance and Control, Indian Institute of Management Calcutta (IIM-C). He is also the faculty in-charge of the Financial Research and Trading Lab at IIM-C. His primary research interests are in areas of Financial Time Series, News Analytics and Mergers & Acquisitions.

Samarpan Nawn is currently assistant professor in the Finance and Accounting group of IIM Udaipur. He has completed his fellowship from IIM Calcutta in the area of Finance and Control. His primary research interests lie in the area of Market Microstructure.

A recent article in the Journal of Finance1 argues that the heterogeneity in 'individuals' cognitive capacities suggests that we may observe significant differences in their financial decisions'. Thus, behavioural finance literature claim that the failure of efficient market hypothesis (EMH) is mainly due to the variability in the abilities of the financial agents to process sensitive information in a complex financial environment.

The foundation of the EMH is based on a notion that if one financial trader makes a poor decision under the heat of emotion, another trader acting more rationally should see this as an opportunity and make an easy profit from the other trader's mistake2. Thus, very quickly any individual's irrationality (spurred by emotional outburst) will be squeezed out of the market by speculators exploiting even the smallest mispricing of assets. Therefore, due to presence of such rational economic agents (homo economicus), the price of any asset will race back to its fundamental value. But is it possible, in real life, to read other's mind? Philosophers talk about different layers of mind. For example, Sri Aurobindo highlighted higher levels of consciousness- the higher mind, illumined mind, intuitive mind, overmind, and supermind. These different layers help a human being better understand the 'self'. The psychologists, on the other hand, propose that the power of mind depends on the ability of a person to anticipate another's motive. So, anyone who simply follows what others are doing is devoid of a 'mind'. The ability to read others' mind is a great virtue in any social context. It may also be visible in certain sports, for example, chess. Garry Kasparov could look three to five moves ahead during a typical chess game3. This ability may be limited when people interact with complex financial institutions, like financial markets. In order to reach

[1] Corgnet Brice, Desantis Mark, and Porter David. *What Makes a Good Trader? On the Role of Intuition and Reflection on Trader Performance*. The Journal of Finance. Vol LXXIII, No. 3. June 2018, 1113-1137.
[2] Lo, Andrew W. Adaptive Markets, Princeton University Press. 2017.
[3] The computer that ultimately beat Kasparov, Deep Blue, would look up to sixteen moves ahead (Kasparov and Greengard, 2007)

the equilibrium price, under the EMH, the traders would require an infinite chain of reasoning capacity- 'the seller knows that the buyer knows that the seller knows that the buyer knows'4.

The ability to understand other person's mental state or intentions is known in psychology as a theory of mind (ToM). If the ToM holds true in financial markets, limit order providers in a high frequency trading environment would infer private signals from market orders. The trader would also need to know how much information other traders hold.

Theory of Mind and Human Brain

Reading others' minds is a crucial aspect of social life. Understanding how people think about minds has long been a fundamental interest in the cognitive sciences. Recent research demonstrates that people intuitively think about other minds in terms of two distinct dimensions: experience (the capacity to sense and feel) and agency (the capacity to plan and act)5. Philosophers began work on theory of mind, or folk psychology, well before empirical researchers were seriously involved, and their ideas influenced empirical research. Theory of mind (ToM) is the ability to recognize and attribute mental states — thoughts, perceptions, desires, intentions, feelings –to oneself and to others and to understand how these mental states might affect behaviour. ToM attributes mental states to others in order to understand and predict their behaviour6. It is also an understanding that others have beliefs, thoughts and emotions completely separate from our own. Theory of mind is called a "theory" because the mind is not directly observable. We never know for sure what is going on in the minds of other people — we can only make assumptions based on experiences with our own beliefs, emotions and perceptions. Empathy, a concept similar to theory of mind, refers to the ability to infer another's emotional state, or to "feel" what another must be feeling. Theory of mind, on the other hand, is the ability to understand and attribute a particular mental state to a certain behaviour without necessarily feeling it or aligning oneself to that mental state.

Neuroscientists have explored the neural basis of the ToM. The typical human brain weighs just under three pounds, but it consists of approximately 86 billion highly interconnected nerve cells (neurons)7. Three basic functions of the brain, particularly relevant for financial decision making, are fear, pain and pleasure. The central cortex is the outermost layer that surrounds the brain. It is responsible for emotion, thinking, and information. The cortex is divided into four different lobes- the frontal, parietal, temporal, and occipital. Over time, the human cortex undergoes a process of wrinkling (Corticalization). This is due to the vast knowledge that the human brain accumulates over time. Therefore, the more wrinkly our brain, the more intelligent we are! The frontal cortex carries out higher mental processes such as thinking, decision making and planning. The prefrontal cortex covers

[4] Lo, Andrew W. Adaptive Markets, Princeton University Press. 2017.
[5] Waytz, Adam, Gray Kurt, Epley, Nicholas, and Wegner, M. Daniel, *Causes and Consequence of Mind Perception*. Trends in Cognitive Sciences 14 (2010) 383–388
[6] Premack D, Woodruff G. *Chimpanzee problem-solving: a test for comprehension*. Science 1978; 202: 532-5.
[7] Lo, Andrew W. Adaptive Markets, Princeton University Press. 2017.

the front part of the frontal lobe (just behind our forehead). The basic activity of this brain region is considered to be controlling of thoughts and actions in accordance with internal goals, called executive function. Executive function relates to abilities to differentiate among conflicting thoughts, determine good and bad, prediction of outcomes etc. The dorsomedial prefrontal cortex (dmPFC), a region in the prefrontal cortex, is well known to represent the mental state of other individuals- the theory of mind.

Testing the Theory

While existing literature has used experimental finance settings and neuroimaging methods to examine the applicability of the theory, we use trade and order book data from the high frequency cash segment of the stock market (NSE). Neuroimaging methods (functional magnetic resonance imaging (fMRI)) have become very popular because these are non-invasive and hence do not cause any physical pain to the subjects. Experiments are useful techniques because they allow researchers to isolate and change one variable at a time to identify causal effects. However controlled experiments have their own limitations- experimental research can create artificial situations devoid of reality. We have, therefore, decided to use market information and the behaviour of market participants to test the effect of the ToM.

We use the historical tick by tick order level data from National Stock Exchange (NSE) of India. The data is time-stamped and includes every message sent to the exchange. A unique aspect of this data is that each order message carries an exchange marked "algo flag," to understand whether the message is coming from an algorithmic terminal or not and a "client flag" to understand whether the order is coming from a proprietary or a client account. Combining the two flags, we can segregate traders into three groups, proprietary algorithmic traders (PAT), agency algorithmic traders (AAT), and non-algorithmic traders (NAT). It is believed PAT is a superset of high frequency traders (HFT).

Relying on speed, HFT use algorithms for processing the information contained in the trading environment such as the order flow, the state of the order book, etc. and trades against the deviations of security value from its efficient price quickly. Agency algorithms are ultimately used to profit from investing in securities, whereas, proprietary algorithms are used to benefit from the temporary mispricing of a share. AAT mainly corresponds to using algorithms to break up the required order into smaller pieces with the objective of achieving average price better than some benchmark (such as Volume weighted average price). Thus, it may be said that AAT trade on the basis of price sensitive information and PAT display behaviour of uninformed traders. The issue we are trying to examine, therefore, is whether the PAT has ToM.

Using trade and order book data for the first two weeks of November 2012 (randomly selected), we observe that five large-cap stocks had witnessed trade of large market orders. We consider large market orders as those whose size exceeds 20 times the average size of the market orders for the stock-day. Then for each of the large market orders, we analyze the limit order book (LOB) for 60 seconds before and 60 seconds after the order. Large market

orders are known to carry information. Hence, liquidity providers (evidenced by the state of the LOB) should be able to trade ahead of the informed trading if they have ToM. We consider two liquidity indicators-(a) bid-ask spread and (b) order depth from top five quotes. Results are reported in Table 1.

Table 1: Reaction of Traders

	Bid-Ask Spread (Overall)		Bid-Ask Spread (PAT)		Depth (overall)		Depth (PAT)	
Company	Before	After	Before	After	Before	After	Before	After
ITC	1.4	1.6	7.3	7.4	20637	20708	5429	5742
Reliance Industries	0.9	1.3	5.2	5.8	3189	3012	889	829
HDFC Bank	1.4	1.8	6.6	6.3	4458	5113	1620	1668
Infosys	0.9	1.1	4.1	4	1062	919	159	175
ICICI Bank	1.1	1	3.4	3.5	1900	1947	529	558

Note: Bid-Ask Spread is in basis points and depth indicates number of shares.

We find that overall bid-ask spread rises immediately (60-seconds) after the large market orders arrive. Interestingly, we also find that the spread computed only from PAT orders are quite large compared to overall spread as they always fear from 'adverse selection problem' (the threat of being cheated by informed traders). The cumulative depth (number of shares) in the top five quotes did not show any significant change after a large market order was placed. Even the depth in LOB before the large market order was not significantly different from the ones after the large order. Was sixty-seconds too short a time to react? Can't high frequency traders (subset of PAT) read the mind of the informed traders?

We further examine traders' reaction to a market shock. We define market shock as unanticipated change in price. We have considered only those cases in the month of November 2012 where the price of a share moved by more than 2% on a single day.

Table 2: Reaction to shock

Company	Change in price	Overall B-A spread			PAT B-A spread			Net Position of PAT		
		Day T-1	Day T	Day T+1	Day T-1	Day T	Day T+1	Day T-1	Day T	Day T+1
Tata Motors	6.0%	1.3	1.2	1.4	3.8	4.7	4.7	-212864	22140	-84073
Asian Paints	4.6%	1.7	2	2.7	5.3	6.6	7.1	-7201	-2881	1909
HDFC	2.2%	0.7	0.5	0.7	3.3	3.3	3.7	106399	-520323	26345
Bharti Airtel	4.0%	1.7	1.3	1.3	5.7	4.8	4.7	-29184	442921	-741833

Note: Change in price is one-day change. Net position denotes inventory at the end of a day.

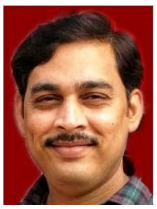
Results in Table 2 show that the bid-ask spread did not follow any pattern. If PAT were able to 'sense' price change early, they would increase the spread on the day of the trade- which we find in the above table. However, if one looks at the inventory position of the PAT, the results are confusing. If PAT are able to 'guess' the action of the market traders, they should build inventory before any positive news (large positive change in price). But we find that PAT carry negative inventory the day before any large change in price. Interestingly, the PAT had positive inventory the day before for the stock (HDFC) which witnessed smallest daily positive swing. This again raises the question- do PAT have the ability to read others' minds? If not, they would always have the fear of losing and would seek compensation from larger bid-ask spread.

Conclusions

The results shown above cannot be generalised as the sample used is very small and one may accuse us of selection bias. However, our preliminary findings show that it is a phenomenon worth studying. It also demonstrates a new way of testing the ToM concept using market data which is not as clean as any data from controlled experiments. EMH fails precisely due to traders' lack of ToM.

Asset Concentration in Indian Mutual Funds: Is it Worrisome?

Sudhakara Reddy



Dr. Sudhakara Reddy is currently assistant professor in the Finance and Control group of IIM Calcutta. He was a visiting scholar to Whitman School of Management, Syracuse University during 2011-2012. His current areas of research are Market Microstructure, Corporate finance with an emphasis on corporate governance mechanisms, Initial public Offerings and primary capital markets, etc.

On 24th August, 2018 during the 2018 AMFI summit, the SEBI chairman expressed concern that despite the tremendous growth in the Indian mutual fund industry, a majority of market share remains concentrated with a few big fund houses[8]. He has called for appropriate measures to ensure that healthy competition prevails in the MF industry. He is also worried of the fact that a few big players have excessively high profits and revenue share. He stated that, "the share of revenue of seven large AMCs is more than 60 per cent of the total industry revenue. Profit margins of large MFs have also stood at a very healthy 40-50 per cent."

The Indian Mutual fund industry has been growing at a very rapid pace, mainly due to the improved desire of the individual investors to participate in the stock markets without having to make the investment decisions by their own. For example, from March 2008 to June 2018, assets under management have grown from 5.21 lakh crore to 23.45 lakh crore.[9] Even after the global financial crisis, some fund families achieved pre-eminent status in the MF industry. For example, by the end of June, 2018 ICICI and HDFC Mutual fund individually control around 13 percent of the market share and together control one-fourth the industry market share in an industry which has 41 fund houses. At the lower end, we have Shriram AMC Limited and Sahara AMC Limited with a mere market share of 0.002 percent and 0.003 percent respectively.

From Table 1, it is interesting to see that four out of five top mutual fund houses in terms of AUMs are same in 2008 and 2018. These fund houses are ICICI Prudential, HDFC, Reliance Nippon, and Aditya Birla. These top 5 fund houses together command a market share of 52.76 % in 2008 and 57.23 % in 2018. The mutual fund industry has seen a significant increase in the AUMs over the past five years, though there has been a steady growth over the past decade. The industry has trebled in less than five years from 8.49 Lakh crore in 2013 to 23.43 Lakh crore

[8] https://www.business-standard.com/article/markets/limited-competition-in-mutual-funds-irks-sebi-ajay-tyagi-calls-for-reforms-118082400042_1.html

[9] Author's own computations. Data source: ACE Mutual Funds

in 2018 June. The main reason for this significant jump in the AUMs in the mutual fund industry is mainly due to the prevailing bull market over the last five years coupled with a below par performance of other investment classes such as debt, commodity, and real estate. The below par performance in several of the other asset classes triggered investors flocking to equity markets through investments in mutual funds. Especially, the mutual fund share in the equity market rose from 1.89 lakh crore to 6.84 lakh crore during this period.

Table 1: Market share of top 5 fund houses in 2008 and 2018

Top 5 Fund Houses in 2008	Market Share
Reliance Nippon Life Asset Management Limited	17.45%
ICICI Prudential Asset Management Company Limited	10.43%
UTI Asset Management Company Private Limited	9.40%
HDFC Asset Management Company Limited	8.59%
Aditya Birla Sun Life AMC Limited	6.89%
Top 5 Fund Houses in 2018	**Market Share**
ICICI Prudential Asset Management Company Limited	13.25%
HDFC Asset Management Company Limited	13.10%
Aditya Birla Sun Life AMC Limited	10.64%
Reliance Nippon Life Asset Management Limited	10.28%
SBI Funds Management Private Limited	9.96%

As seen from Table 2, there has been a significant rise in the mutual fund assets since 2008. The percentage of assets held by top 5 fund houses has been steady in the range of 53 – 57 %, whereas the percentage of assets held by top 10 funds is currently above 80 %. This shows the domination of top fund houses in the mutual fund industry. The large fund houses have excessively gained market share of the new business that has been attracting the industry over the recent years as seen in Table 2. Market share attained by the fund houses is the cumulative result of various decisions made by them and the response of the investors and stakeholders towards these decisions. It is the eventual reflection of selections made by investors, which is their disclosed preferences. Understanding the market share variable is very important as it reflects the revenue earned by the fund families as function of their AUMs. In this context, there is no surprise that SEBI is worried about the disproportionate market share of mutual fund assets. But, the evidence in the mutual fund industry around the world show that

there are economies of scale and scope in the industry and as a result of this fund family size has an important effect on profitability.

Another issue that the SEBI chief is worried about is the impact of Total Expense Ratio (TER) on the profitability. "You would appreciate that from an overall industry perspective, some thinking is definitely required to bring in elements that facilitate a healthy competition in the industry", said Mr. Tyagi[10]. This statement is reasonable as the revenue of the top most funds is in India is in the range of 60% of all the industry revenue. And the profit margin of the top fund houses is in the 40 – 50% bracket. The fund houses attain this disproportionate revenue with an average 0.75% to 2.5% TER, especially in the equity segment which is quite intriguing for SEBI. However, fund houses that charge a higher fee and do not pass the benefits to the investors will in the long run lose the market share. Also, not all types of fees have a negative relation with market share. We can expect a positive relation between market share fees charged for marketing and distribution expenses.

Table 2: Market Share of Top 5 and Top 10 Mutual Fund Houses

Year	AUM (Crore)	AUM of Top 5 MFs	Share of Top 5 MFs	AUM of Top 10 MFs (Crore)	Share of Top 10 MFs
June-2008	554769	294893	53%	415861	75%
June-2009	660099	381007	58%	525826	80%
June-2010	667086	389376	58%	538754	81%
June-2011	735300	410554	56%	587736	80%
June-2012	688541	377104	55%	545286	79%
June-2013	849510	451448	53%	664201	78%
June-2014	993234	541054	54%	776621	78%
June-2015	1234432	685215	56%	985018	80%
June-2016	1446453	824275	57%	1164729	81%
June-2017	1957073	1112749	57%	1586704	81%
June-2018	2344590	1341721	57%	1896794	81%

While Mr. Tyagi and SEBI are concerned about this excessive market share as well profits by the top fund houses, industry veterans say that this is not something to worry about as this an organic form of growth in a progressive

[10] Retrieved from https://www.thehindu.com/business/sebi-to-review-mf-expense-ratio-limits/article24763045.ece

industry. Firms in an industry gain the market share if they are ready to compete in a growing environment. Especially in the Indian MF industry, fund houses which took advantage of the growth opportunities with their superior management skills as well as a stable corporate governance mechanism benefited the most. I agree with Mr. Tyagi that the MF industry with more number of players and healthy competition would benefit the customers, however it is true of most of the industries that few big players account for nearly 70 – 80% of the revenue. The analysts following the Indian MF industry have observed that big fund houses have been able to successfully consolidate their positions with their timely investments penetrating into smaller cities and towns over the past few years. This is not the case only in India, but across MF industries in the world.

Several other factors have also contributed to a positive market share in MF industry. There are several features of performance that enhance the market share; the objective-adjusted returns generated by the fund families, and at least one top performer in the family. Another important factor which led to an increased market share by some of the fund houses is their superior innovative abilities compared to their competitors. However, industry commentators say that high level of innovation will have a negative impact on market share. It is to be noted that investors are highly sophisticated due to the vast amount of information available in the public domain, and due to this fund houses initiating new schemes that are similar to existing funds have a less impact on market share. Finally, this trend of market share concentration is not specific to MF industry alone. This is even higher in the Indian insurance industry, where LIC commands more than 70% industry share with respect to the insurance premiums. Private insurance companies such as HDFC, ICICI, SBI along with LIC command more than 85% of the industry share. In the similar lines, off late some of the private banks as well as automobile firms have been commanding significant market share in their respective industries.

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ALUMNI CORNER

Mudra Loans In The Eye Of The Storm

Balachandran R

Balachandran R is an alumnus of IIM Calcutta (1987-89) with extensive experience in corporate banking, investment banking and product management.

Ten years back, the collapse of Lehman brothers with its trillion dollar balance sheet nearly took down the global financial system with exotic financial products like credit default swaps and collateralized debt obligations contributing to the debacle. A decade later, Raghuram Rajan, the former governor of the Reserve Bank of India has raised the prospect of fresh trouble for the Indian banking system from a much more humble source, micro loans up to Rs 10 lakhs. Dubbed Mudra loans, these are under the aegis of the Pradhan Mantri MUDRA Yojana (PMMY) scheme.

The loans are provided to non-corporate, non-farm small/micro enterprises and are sanctioned by Commercial Banks, Regional Rural Banks, Small Finance Banks, Cooperative Banks, Micro Finance Institutions and NBFC's. Data reveals that lenders are predominantly public sector banks and micro finance institutions. Private sector banks have small size portfolios except for one well known Kolkata head quartered bank which has origins in micro finance. This bank has built up a significant Mudra loan portfolio.

The targeted beneficiaries are from the non–corporate small business segment comprising of proprietorship / partnership firms running small manufacturing units, service sector units, shopkeepers, fruits / vegetable vendors, truck operators, food-service units, repair shops, machine operators, small industries, artisans, food processors and others, in rural and urban areas.

The objectives of the scheme are laudable. The burgeoning salary earning middle class with corporate jobs and cozy retirement nest eggs, often forgets that the unorganized sector provides the livelihood for the vast majority of the population though lacking formal sources of financing. The Mudra portal has several success stories of micro businesses benefiting from this scheme.

Rajan's voice is highly respected in the Indian and global financial community. Tucked away in a small corner of his recent 17 page note to the estimates committee of Parliament on bank NPA's, is an almost passing reference to Mudra loans, exhorting the need for closely examining them for potential credit risk, and in that context also seeking urgent attention to the "growing contingent liability" emanating from The Credit Guarantee Scheme for MSME run by SIDBI. Despite taking up just a couple of lines in an otherwise lengthy report, the media has given wide publicity to this part of Rajan's report.

So why should tiny loans less than Rs 10 lakhs to the likes of shopkeepers and auto rickshaw owners attract so much attention? The numbers tell part of the story. Even since the PMMY scheme was launched in 2015, the amount disbursed has grown by leaps and bounds to Rs 6.5 lakh crores, with a CAGR of about 35%. While this may constitute circa 5% of the asset size of Indian banking, potential high levels of defaults and a growing loan portfolio of the Mudra loans, may add to the current pile of non-performing loans (NPA) of more than Rs 10 lakh crores. In all fairness, NPA figures for the Mudra loans are not available thus far in the public domain. But Rajan having been at the helm of the banking regulator, must be basing his concerns on solid grounds.

Applying the traditional risk parameters for assessing corporate loans or the credit score based risk assessment for consumer loans pioneered by Fair and Isaac of FICO score fame, does not serve the purpose for Mudra loans.

Similar to commercial loan proposals, assessing "project viability" for Mudra loans is emphasized by lenders. Recently SIDBI called for "credit counsellors" to be empaneled by it to help small businesses in preparing project reports. At the other end of the spectrum, the disastrous fate of the multibillion dollar projects appraised by the capital markets arm of India's storied public sector bank staffed by top business school graduates, is well known. Project appraisal needs to go much beyond an exercise in number crunching in a spread sheet.

The Mudra loan scheme excludes seeking collateral from borrowers. Only the assets financed by the lenders can be taken as security. What criteria do banks then adopt? The eligibility criteria for the Mudra scheme loans available in the portal of the largest commercial bank in India is pretty basic: potential borrowers should be residing in the same locality at least for the last two years, should not be a defaulter to any financial institution, and should have undergone some training.

Significantly, Mudra loans by banks are covered under the Credit Guarantee Fund for Micro Units (CGFMU) with the premium cost to be borne by the borrower. The fund comes under National Credit Guarantee Trustee Company, set up by the Government of India, thereby shifting the significant part of the credit risk to the tax payer.

Here are some salient details of the credit guarantee coverage for Mudra loans. Based on the amount in default,

a. First Loss to the extent of 5% will need to be borne by the lender

b. Out of the balance portion, the 'extent of guarantee' will be to a maximum extent of 50% of 'Amount in Default' in the portfolio, subject to maximum cap of 15% of the portfolio.

While banks are not entirely off the hook, public sector banks account for nearly half the Mudra loans, thereby shifting losses on account of future potential NPA's back to the tax payer.

Here, Rajan laments about the growing contingent liability for the Government's credit guarantee fund. The contingent liability to the tax payer would get fructified sooner or later in the event of large scale defaults. The number of Mudra loans sanctioned thus far is nearly 14 lakh crores. While this may not translate into the exact number of beneficiaries, the numbers are still mind boggling. It would be a political disaster as well as a nightmarish process for public sector banks to collect the defaulted loans back from the vast numbers of these tiny borrowers. Are they then essentially a handout from the Government masquerading as loans?

Herein lies the nub of the issue. The vast majority of the current NPA's of about Rs 10 lakh crores is on account of lending to corporates. Gold plating of projects in the form of over invoicing of costs, alluded to by Rajan as well, means that there is very little, and often negative equity from well-connected promoters in bank financed projects, which have turned NPA's. These few elite promoters continue to lead tax payer funded lives of luxury either in India or in safe havens abroad, away from the reach of the Enforcement Directorate, the CBI and Indian courts. Would it not be ironic if tax payers also need to pony up for NPA's in the tiny Mudra segment where borrowers numbering in crores, are from the poorest strata of society?

Which segment of the tax payers is ultimately picking up the tab for defaults from the corporate promoters and potentially from the Mudra scheme borrowers? It is the few honest corporate tax payers and the vast segment of the middle class salary earners who have no choice in paying taxes on account of it being deducted at source. Maybe the middle class too should figure out a way of going hand in hand to the government for tax payer funded handouts, thereby balancing the scales now heavily tilted towards both crony capitalists and tiny borrowers at the opposite ends of the spectrum!

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VOICE OF AMERICA

When a Computer Scientist Wins a Computer Science Award for Research in Economics

Ayan Bhattacharya

Ayan Bhattacharya is Assistant Professor of Finance at The City University of New York, Baruch College. He has a PhD from Cornell University and his research focus is financial economics, especially financial market design and asset pricing.

MIT's Constantinos Daskalakis was awarded the Rolf Nevanlinna Prize by the International Mathematical Union last month, the highest recognition for computer scientists under 40, awarded once in only 4 years. The award was for fundamental results that he and his collaborators had proved in economic game theory. Interestingly, to most researchers in economics and finance, Daskalakis' name hardly rang a bell when the award was announced! So what exactly did Daskalakis do and why do computer scientists think it will fundamentally change economics and finance?

1. The Origins of Modern Economic Theory

Finance and economics have been practiced for hundreds of years, and the history of these fields is replete with seminal books of persuasive prose making heuristic arguments. Kautilya's Arthashastra or Adam Smith's Wealth of Nations or John Maynard Keynes' General Theory were all epoch making books in one way or another, yet to any well-trained modern economist they would read like the Aesop's fables—astute observations, but with foundations that are vague at best. The origins of the rigor that make economics a modern science are usually traced to Leon Walras, a French economist in the late 1800s, but the most important contributions came in the early 20th century from a group of academics working at Princeton. Led by the polymath John von Neumann, this school included luminaries like Nash, Shapley, Bellman, Blackwell, Kuhn, Tucker, and others not physically present in Princeton but inspired by similar ideas nevertheless, like Arrow, Debreu or McKenzie. In a span of 3 to 4 decades, this group not only revolutionized economics, but many related disciplines too, like operations research and industrial organization.

A key approach advocated by adherents of this school was proving existence of equilibrium results—rigorously. Till this time, economists argued about what might or might not happen in various economic situations without ever bothering to check if the situation they were arguing about could actually ever come to be. So, for instance, economists would say that an "invisible hand" would balance out the forces in the market—without any clear notion of why this must be so. Often the predicted situation never came about, and economists were at a loss. Existence results showed clearly if economic forces balanced out and there was a consequent equilibrium. Only when one could first show that there existed an equilibrium for a situation under study was economic analysis meaningful and worthwhile.

Among the earliest of equilibrium existence results was von Neumann's minimax theorem for zero-sum games. This was followed by existence proofs in many other domains—most famously Nash's results for non-cooperative game theory and Arrow and Debreu's general equilibrium results. Most top PhD programs in economics or finance nowadays begin their coverage of the field only at this point. The main tool for showing equilibrium existence was (and continues to be) what are called fixed-point theorems. These theorems were first discovered in the early 1900s in an area of mathematics called Topology.

Now, most fixed point theorems are, by nature, non-constructive. To see what this means, let's imagine a simple example. Suppose I wrote numbers from 1 to 100 on pieces of paper, folded them, and asked you to choose any 10 pieces. Then, without allowing you to unfold and see the numbers, suppose I asked you two questions: 1. Is there a maximum value among the 10 pieces you selected; 2. What is the maximum value among the 10 pieces you selected? The first question you can answer without opening the folds and seeing the actual numbers. Because you know, of course, that there is going to be a maximum number in a set of 10 numbers, and you don't need to know the actual numbers to be sure of that. This is analogous to the situation with non-constructive techniques in math—one can make claims without actually constructing anything explicitly. However, to answer the second question you need to open the folds and read the numbers. That is analogous to constructive techniques in math. In other words, constructive techniques not only make claims, but also give you an explicit way to make a construction that verifies the claim.

Thus, since fixed point theorems were non-constructive, the existence results which used them also ended up being non-constructive. In effect, economists had many situations where they knew that there must be an equilibrium, but weren't sure how the economic forces actually got us there. Over the years, a number of constructive techniques were discovered for many equilibria. However, some equilibria remained stubbornly out of reach of constructive techniques. Chief among them was the Nash equilibrium, the bedrock of modern economic theory immortalized in the scene at the bar where Nash's friends want to ask girls to dance, in the movie "A Beautiful Mind".

2. Computational Hardness

John von Neumann, the brilliant polymath we met in the last section, was a pivotal figure not only in economics, but also in computer science, quantum physics and mathematical logic, among others. Princeton University was a leader in all these areas since the early 1900s, and many of the best minds in the world in these fields congregated in Fine Hall—the venue of the math department—every evening for tea. A distinct presence in that group was a PhD student named Alan Turing. Regarded by many as the father of modern computer science and immortalized in the movie "The Imitation Game", Turing in those years was an awkward graduate student working under Alonzo Church, one of the giants of mathematical logic. Building on Kurt Godel's earlier research, Turing, in his ground-breaking work, showed that there were problems that were inherently unsolvable. In other words, mechanical devices could only be expected to solve a limited subset of the problems that humans could formulate; outside of this subset, problems were undecidable and hopeless.

Over the years, computer scientists extended Turing's results in many different directions, creating a vast sub-field of computer science called Computational Complexity. In fact, the last Rolf Nevanlinna Prize was awarded to an Indian computer scientist at New York University, Subhash Khot, for his fundamental work in this very area. Research in computational complexity classifies various problems according to their inherent complexity. Certain problems are easy to solve, others might take longer than the age of the universe! Work in this area has led to detailed dictionaries that tell us how to identify the complexity of a problem from tell-tale signs. Despite tremendous advances, however, many questions in this area still remain open; for instance, the famous P versus NP question.

3. Daskalakis' Contribution

Christos Papadimitriou, Daskalakis' PhD adviser at Berkeley, had already made many fundamental contributions to theoretical computer science when Daskalakis joined the graduate program in the early 2000s. Kenneth Arrow, the famous economist at Stanford was a good friend of Papadimitriou's, and it was Arrow who introduced Papadimitriou to the peculiarities of economic equilibrium construction in the 1980s. Over the years, Papadimitriou had created a number of beautiful tools to address many open problems about the complexity of equilibrium constructions. However, the computational complexity of finding Nash equilibrium had continued to evade him, and when Daskalakis sought a problem to work on, it was this question that Papadimitriou posed to him.

The precise insights that led to Daskalakis' result are hard to explain without advanced mathematics: in technical terms, he showed that finding Nash equilibrium is PPAD complete. In simple terms, this means that Nash equilibrium is very, very hard to compute.

4. Why Computational Complexity Matters

Large parts of economics and finance depend on the computation of Nash equilibrium and General equilibrium in realistic time-frames. For example, the area of Asset pricing in finance starts by assuming a general equilibrium framework and builds on it. Following Daskalakis' work, other researchers showed that computing many types of general equilibria were also extremely hard. If it takes a computer longer than the age of planet Earth to compute the equilibrium, obviously human traders cannot compute them in real time in the din of financial markets! What, then, is the steady state that ensues during trading? How must traders price financial products if it's not an equilibrium that they find themselves in? How should regulators create policy if they don't know whether markets can ever be nudged to an equilibrium? It is these sorts of questions that Daskalakis' beautiful result has suddenly made open. One thing is for certain: the coming few years promise to be an exciting time for researchers in finance, economics and computational theory, as they grapple with the many implications of Daskalakis' work.

MARKET WATCH

A Curious Case in Indian Taxation: When not to Exercise an In-the-money Option?

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Options trading on BSE and NSE began in June 2001, with both exchanges launching options on stock indices as well as individual stocks the same year. Three years later, the Union Budget of 2004 (UPA-1's first) introduced the Securities Transaction Tax (STT) in a bid to curb tax avoidance through the simple technique of taxing every single purchase/sale instead of just the profits (if any) earned from the securities. The launch of this indirect tax was accompanied by the dilution of 2 related direct taxes: the Short Term Capital Gains (STCG) tax (which was reduced from 33% to 10%) and the Long Term Capital Gains (LTCG) tax (which was abolished and not seen again till its reintroduction through the 2018 Union Budget).

After the latest revision in 2016, the tax rates for STT on options stand at[1][2]:

Situation	Tax Rate	Amount Applicable	Who pays
Option sold	0.050%	Spot option price	Option seller
Option expired (i.e. auto-exercised)	0.125%	Last traded price of underlying just before expiry	Option holder

This tax structure often presents very interesting scenarios whereby exercising an in-the-money option (which, by definition, should lead to a positive cash inflow upon exercise) is not optimal. Let me explain this through an example. Assume there's an in-the-money European Call option on Nifty 50:

	Quantity	Value
Values fixed when contract was bought	Strike price	**10500**
	Cost price of option	**150**
Values fixed by law	Tax Rate 1	**0.125%**
	Tax Rate 2	**0.050%**
Live values	Spot Price of underlying when choice is made	**10680**
	Spot option price	**175**
Assumed value	Last Traded Price of underlying before expiry	**10650** (it is ASSUMED that the last traded price of the underlying just before expiry will be equal to what its spot price is when the choice is made)

Now, there are 2 choices:

(all profits below have been calculated per unit of the underlying)

Choice 1: The option is allowed to expire and get exercised automatically

Gross Profit = Last Traded Price of Underlying before Expiry - Option's Strike Price

= 10680 - 10500 = 180

PBT = Gross Profit - Cost Price of Option

= 180 - 150 = 30

PAT = PBT - STT = PBT - (Tax Rate 1 * Last Traded Price of Underlying before Expiry)

= 60 - (0.00125 * 10680) = **16.65**

Choice 2: The option is sold just before expiry

Gross Profit = Spot Option Price = 175

PBT = Gross Profit - Cost Price of Option

= 175 - 150 = 25

PAT = PBT - STT = PBT - (Tax Rate 2 * Gross Profit)

= 25 - (0.0005 * 175) = **24.9125**

Clearly, **24.9125 > 16.65** – thereby making Choice 2 better.

Generally speaking, let :

Strike Price = K

Expected Last Traded Price of underlying just before expiry = S_T

Cost Price of Option = C_0

Spot Option Price (at the time of choice) = C_t

Through calculations similar to the ones done earlier for the example:

Choice 1 PAT = $(S_T - K) - C_0 - (0.00125 * S_T) = 0.99875\ S_T - K - C_0$

Choice 2 PAT = $C_t - C_0 - (0.0005 * C_t) = 0.9995\ C_t - C_0$

Hence, selling off the option instead of letting it expire (Choice 2) is better than Choice 2 if:

$0.9995\ C_t - C_0 > 0.99875 * S_T - K - C_0$

⇨ **$S_T < (0.9995 * C_t + K) / 0.99875$**

The above derivation thus gives us a simple condition to decide whether to exercise the option or not. The value of K will be known at the time of option purchase itself and the value of C_t will be available from the markets at any given time 't' when the choice is to be made. All one needs to do is *take a trade view* on the 'Last Traded Price of underlying just before expiry' (S_T) and check if that's below the cut-off value defined by the condition derived above.

In August 2017, a third choice was introduced by BSE and NSE, wherein one could hold the option till expiry and still not exercise it. This choice could be used by someone who isn't keen on *taking a trade view* on S_T and just wants to wait (till expiry) and watch – but doesn't want to run the risk of a massive, unanticipated loss either. Once selling the option early (Choice 2) is ruled out, expiry-but-no-exercise (Choice 3) will turn out to be better than auto-exercise-upon-expiry (Choice 1) if:

$-\ C_0 > 0.99875 * S_T - K - C_0$

⇨ **$S_T < K / 0.99875$**

Let me take the example of the same option that was used earlier. Hence, K = 10500 and C_0 = 150.

For all values of S_T < 10513.15 (i.e. 10500/0.99875), the trader who picks Choice 3 will be happy about not having exercised the option. But, for all values of S_T > = 10513.15, the trader will be left regretting.

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[1] https://www.nseindia.com/products/content/derivatives/equities/sec_tranc_tax.htm

[2] https://www.nseindia.com/products/content/derivatives/equities/settlement_price.htm