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Innovation and Co-evolution in Stock Market Trading

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Abstract

The stock market trading has undergone various innovations by co-evolving with the inventions in the information and communications technology (ICT). This paper, quantifies the impact of ICT in the stock market in various countries by empirical analysis, demonstrates the ICT driven disruptive business model (IDBM) in the context of stock market and also the growth of stock markets in selected countries with and without consolidated challenges of social demand (CCSD).

Keywords

Stocks, Principle Component Analysis, Regression, ICT, Information and Communications Technology, Stock Market, Disruptive Business Model, Innovation, Co-evolution, Trading, Social Demand

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1. Introduction

Stock market or the equity market provides access to capital in the form of shares for companies or organizations in return giving the investors or traders a wedge of ownership in the organization. The publically held company shares are traded through exchanges or over the counter markets. The ICT innovations has tremendously changed the way data is stored, retrieved, manipulated, analysed, transmitted or received in the digital form. The stock exchanges/market has seen greater development and growth by adopting to and co-evolving with Information and Communication Technological inventions. The stock exchanges in the world has continuously evolved by innovation from yester year open outcry trading methodology to today's high frequency trading by adopting to the ICT innovations.

The paper is structured into 7 sections. While Section 1 is the introduction, Section 2 the objectives of the study, Section 3 explains the co-evolution of ICT innovation and Stock Market, Section 4 empirical analysis, Section 5 ICT driven disruptive business model, after which Section 6 presents the future work, Section 7 presents the conclusion and Section 8 presents the references.

2. Objective of Study

The objective of this paper is to study the innovation in stock market, co-evolution of ICT and stock market, ICT driven disruptive business model and consolidated challenges to the social demand, stock market growth with and without CCSD and also to study impact of Information and Communication technology (ICT) on the development and growth of stock market which lead to innovation and co-evolution in stock trading methodologies by empirical analysis.

The intended outcome of this study is to understand the perception of different countries such as Australia, United States, United Kingdom, Singapore, China, India and Japan etc. in terms of adoption of ICT and its impact on stock market with the help of analytics techniques. Also how these countries innovated and co-evolved by adopting to ICT.

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3. Co-Evolution of ICT Innovation and Stock Market

Information and communication technology is no longer just a functional resources. It has been fabricated as an integral part in many of the industries and services and stock markets or stock exchanges are no different to it.

3.1. Institutional Innovation

The inventions in ICT have become a great innovation by leveraging the technology in the form of electronic trading products. Such products have become very successful satisfying the traders and investors to a great extent. In the forthcoming paragraphs, it is described how the ICT enabled inventions have led to innovations in stock market and brought changes in the trading methodology in stock market as it was extremely important for the survival.

The first Stock exchange dates back to early as 17th century in Amsterdam which followed open outcry methodology for trading communications but changed in the latter half of the 20th century by the introduction of the telephone trading. In the beginning of 1980's electronic trading system started to replace floor trading. The e-trading created a virtual market for the buyers and sellers. As of 2010 most of the trading is done only electronically due to technological advancement.

In later part of 19th century, the electronic trading became little advanced by the program trading methodology in which computer programs were used to for trading simultaneously a group of 15 to 20 stocks based on some pre-determined conditions. Later due to the advancement in analytics and other high technologies, the algorithmic trading came which used statistical/mathematical models were programed and used for trading in order to generate profits at a speed and frequency that is impossible for human traders. Currently the stock market has adopted to High Frequency trading which capitalizes by placing voluminous trade orders at a very high speed across multiple markets based on multiple decision parameters and analytical techniques by computer programs.

Thus the dramatic advancement in information and communication technology has led to institutional innovation in trading methodology changes from traditional floor trading to High frequency trading.

3.2. Resilience

ICT has made the stock market more efficient by providing all participants with faster and more effective means of exchanging information, provision to place buy or sell orders in huge volume across markets without the intervention of human sentiments and can act automatically for any market changes thus leading to more gain and lesser loss. Evidently, stock markets can be more resilient with the intervention of ICT.

For example, in 2013, London stock Exchange in partnership with NexxCom Wireless launched the first directly connected wireless communication link between its City of London data center and the Equinix data center campus in Slough by leveraging the millimetre-wave wireless technology which is similar to microwave than the traditional fiber-optic networks. This new wireless service provides channels in bandwidths of 1 gigabit per second. Also it has maximized the reliability for the wireless network by shortening the distances between the links that allows you to better manage the signal attenuation, which makes it a lot more robust in terms of adverse weather conditions. The extra links build in added resilience [1].

3.3. Three Dimensional Structure of Stock Market

Stock market form the important part of a countries economy. It is an institution with a social purpose of raising capitals for organizations which in turn contributes for the economic development of the nation and hence influencing the quality of life of its people. The three dimensional structure of the stock market exchanges as an institutional system is depicted in the below figure 1.

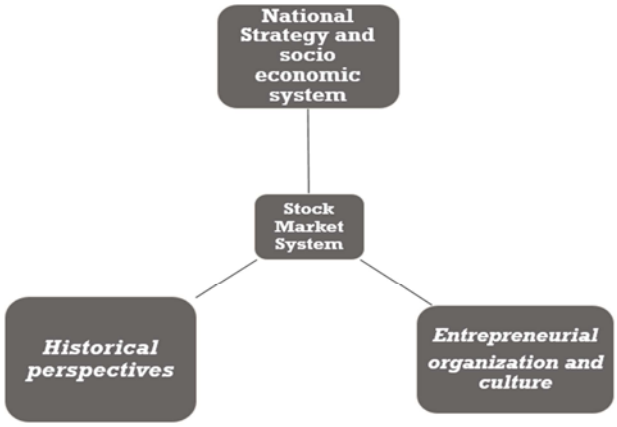

Figure 1. Three dimensional structure of Stock Market.

The organizations raise capitals with the help of stock markets in the form of equities. There by development of business and thus creating lot of employments.

Governments raise capital for the nation's development project in the form of bonds in the stock market. Also the stock prices rise and fall which is the barometer for the country's economy. Also when people invest in stock instead keeping their money as saving deposit in the bank, it helps the government for public project development or the companies to develop their businesses.

In the historical perspective, it shows a very good growth in

the development both in society and economy. It gives liberalized opportunity for the investors as the market is diversified. This leads to cultural change in the society [2].

3.4. Co-evolutionary Nature with Interacting Partners

New technological inventions such as trading algorithms have been contributed by financial engineering academicians which was commercialized by banking and financial institutions by partnering with technology consulting companies. Such technological adoption is not only adopted by few stock market exchanges which exist in advanced countries such as US but it is prevalent world over stock exchanges such as India, China, and Japan etc. Thus there exists a vertical interaction of various institutions which proves the co-evolutionary nature.

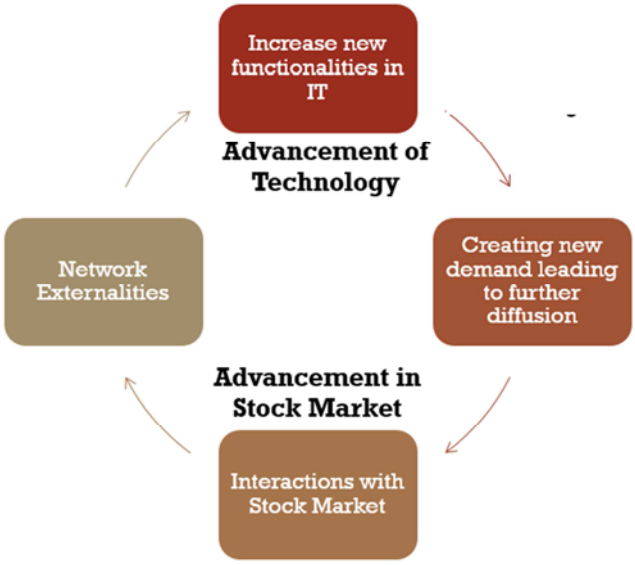

Figure 2. Co-evolution of ICT and Stock Market.

The above figure 2, illustrates the coevolution of ICT and stock market. High technology inventions lead to development of new functionalities and features that are leveraged in the stock market. For example advanced high speed servers to handle voluminous trades simultaneously across various markets with the help of analytics and machine learning algorithms.

Continuous innovation is required in the stock market to sustain in the business with high profitability. By adopting new technological inventions in the stock market the trading information are available at a much faster rate in milliseconds. Because of the innovation in the stock market such as high frequency trading the cost of trading as reduced. Buying and selling of shares as become online and hence accessible to everyone.

The government and organisations can raise capital for their projects easily by utilising the technology in the stock market. Investors and traders also gain profits because of the wide increased opportunities.

All these create new demands in the market and economy and hence lead to further diffusion of technology. So continuous innovation and coevolution of ICT and stock market becomes a fundamental requirement.

3.5. Two Faced Nature of ICT

Technological innovation is the major factor in the exponential growth of algorithmic trading, due to (1) enormous amounts of numbers can be computed in a fraction of a second, (2) increased software sophistication software allows for more and more complicated calculations, and (3) there is greater access to and ability to process vast amounts of data from disparate sources. As a result, big data analyses that would have been nearly impossible a few decades ago (and even then only with a number of supercomputers) can now take place on one's iPad with a few swipes [3].

Advancement of ICT leads to decrease in the trading (transaction) costs. Decrease in the trading cost provides opportunities for more trading and hence increase in the trade volume thus leading to virtuous cycle in the stock market trading in the ICT growing economies.

But at some point the marginal cost of deploying new HFT technologies will exceed the marginal benefit available from HFT-based trading strategies especially in the ICT advanced economies which may lead to vicious cycle.

3.5.1. Virtuous Cycle

Technology has led to automation of not only trade execution but also back-office functions and post-trade services such as clearing and settlement. The ability to submit orders electronically to exchanges directly rather than through brokers has been an important innovation in lowering the cost of trading.

Liquidity can be defined as the ease with which market participants can buy or sell financial instruments or securities. HFT provides liquidity in markets, which is essential to their functioning. Also the time taken to complete a trade is almost immediate. HFT narrowsbuy and sell spreads and lowers the cost of trading.

The efficiency of financial markets can be defined as the speed with which markets incorporate new information in asset prices. The increased velocity of trading through HFT ensures that market prices reflect new information more quickly. Much of the innovation in financial markets historically has been driven by the desire to profit from bringing information to market more quickly.

Figure 3. Virtuous Cycle.

Reduction in transaction costs through innovations such as HFT will lead to a permanent increase in asset prices and a positive wealth effect from the increased value of investors' portfolios. Higher asset prices also lower the cost of capital for firms, increasing investment, the capital stock, productivity, real wages and living standards. This is the real societal value.

In stock markets in the case of high frequency trading, technology is the enabler of the virtuous cycle but cost is the driver. Technology enables higher volumes of trading which lead to profit.

3.5.2. Vicious Cycle

As financial markets become more efficient, the profitable trading opportunities available to HFT firms are reduced which lead to stagnation. As in any other industry, the competitive entry of HFT firms exploiting new technologies can be expected to reduce profits available to HFT or algorithmic trading over time.

HFT are not neutral as it is not available for each of the investors or traders. Also ICT driven stock market operations are having risk of fraud. Also capturing HFT opportunities requires use of advanced technology. Development of such high technology and algorithms require specialized skilled man power as well as high end system capability which in turn lead to increase in the cost of technology. At some point, the marginal cost of deploying new HFT technologies will exceed the marginal benefit available from HFT-based trading strategies which lead to vicious cycle especially in the ICT advanced countries.

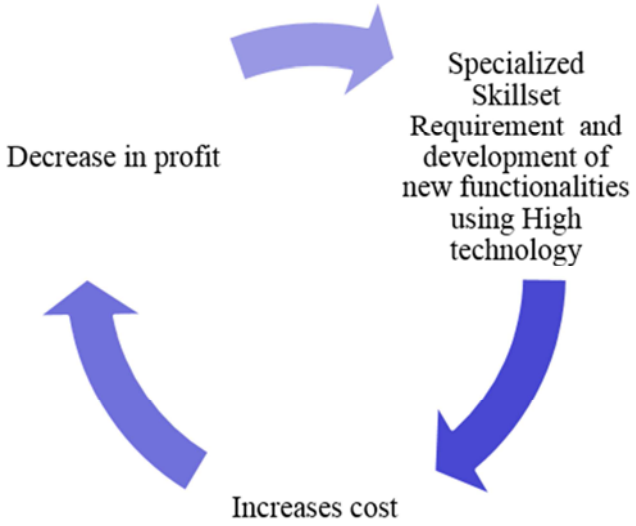

Figure 4. Vicious Cycle.

3.5.3. Co-evolutionary Acclimatization

In order to overcome the stagnation, the ICT advanced and HFT matured economies such as US can focus on harnessing the virtuous cycle of ICT growing or HFT budding economies.

Algorithmic traders are entering into China, Singapore, Malaysia, South Korea, and Indonesia and other developing countries as new regulations are implemented in Europe and US.

3.5.4. Enablers for Coevolution of ICT and Stock Market

There are several reasons that account for the rise of HFT practices. One is the development of new technologies that have made high-speed program trading possible, with lower and lower costs for the implementation of such trading systems over time. The other reason is that the major exchanges, including NASDAQ, the Better Alternative Trading System (BATS) market, and the NYSE, have responded to the demand from traders by offering faster access to their trading infrastructures and direct connections to their trade data transmissions. There are other reasons as well. The SEC adopted decimalized prices in 2000. This decision directed stock exchanges to quote share prices in decimal form instead of using the traditional fractions, which supported wider spreads (Securities and Exchange Commission 2012). This made traditional market-making less profitable, reduced the size of securities trades, and enhanced the demand for more sophisticated computerized trading.

The stock exchanges operates in a technology transformed environment providing new features for itself and also to its affiliations of investors, regulators and government.

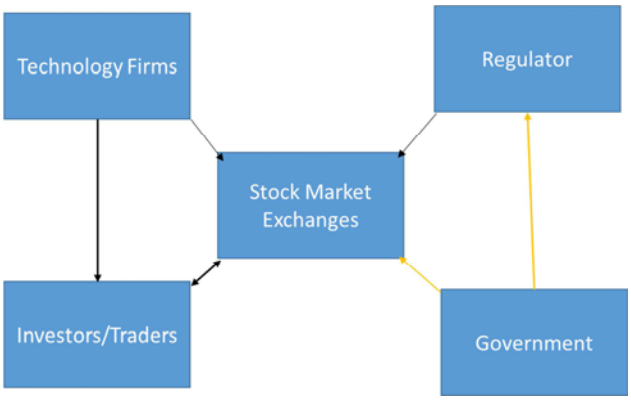

Figure 5. Stock Market and its affiliations.

The regulator of an exchange is responsible for setting rules and regulations for trading like fees for trading. The government directs the regulator by its laws. The regulator directly impact the stock exchanges whereas government impacts indirectly. Technology firms provides high technology infrastructure, sophisticated software and also historical data for the operation of exchanges and also to customers to decide their investment strategy and place buy and sell orders.

Technology is the enabler of high frequency trading for investors and exchanges.

3.5.5. Impediments to Coevolution of ICT and Stock Market

One of the impediments for the coevolution of ICT and stock market is the cost of data infrastructure and colocation. The high frequency trading firms were quite slow to emerge due to the high cost of fiber optic cable installation and colocation. It is a fact that time meant money. The time taken for the trade orders from Chicago Mercantile Exchange to the NASDAQ stock exchange is estimated to be 12 milliseconds via fiber optic cables in contrast to 17 milliseconds via traditional telecommunication providers. The estimated cost to connect New York to Chicago via fiber optic lines which support 200 traders, would cost each trader $14 million, or $300,000 a month. This corresponded to a grand total of $2.8 billion dollars for a mere five-year lease on the line.

Also the colocation obsession of the HFT firms to be in very close proximity to the stock exchanges in order to shave microseconds of trading time also lead to cost increase.

3.5.6. Institutional Elasticity

The technological inventions becomes societal value when it diffuse and drive innovation in the institution such as stock exchanges. This is possible only when exchanges are flexible and adopt to the changing market conditions. The elasticity of the institutions in integrating the new technological advancement plays a key role.

Around the year 2010 and 2011, various exchanges such as Toronto Stock Exchange (TSE), Australia Stock Exchange (ASX), Hong Kong Stock Exchange (HKEx) and Singapore Stock Exchange (SGX) has invested in next generation low latency trading platform with match engine processing of only few milliseconds per million orders and also colocation service.

4. Empirical Analysis

In this empirical analysis we aim at analysing quantitatively the impact of ICT in the stock market in different countries.

4.1. Methodology Design

The widely used methodology Cross Industry Standard Process for Data Mining is followed in this study. The technical strategy to be followed is depicted in the below figure 6.

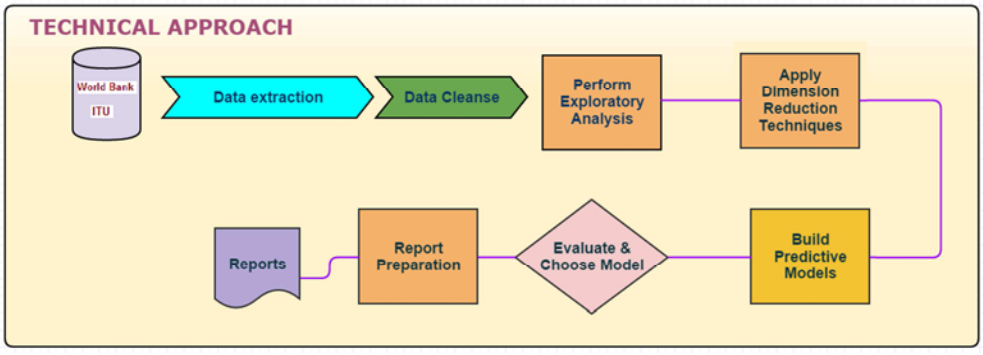

Figure 6. Empirical Analysis Approach.

Data acquisition was done from open datasets available from World Bank and International Telecommunication Union. Once the data is acquired from these two sources, data quality checks and necessary transformations were done as part of data cleaning. Data was merged as a single input file for further analysis.

Exploratory analysis of the data was done to bring the trend in ICT leveraging and stock market growth among the

various selected nations.

Principle component analysis, was done to identify the important factors contributing for the stock market and ICT.

Multiple linear regression was used to build the statistical model to quantify the stock traded in terms of impact of ICT.

4.1.1. Data Acquisition & Understanding

Twelve different files such Listed companies in stock market, Market Capitalization, Stock traded in total value of GDP, Stock traded in USD, Stocks traded turnover ratio of domestic shares, Fixed broadband connections, Secure internet servers, Internet users, Mobile subscription, ICT goods export, ICT goods import and ICT service exports has been downloaded from the World Bank [6] and International Telecommunication Union [7].

4.1.2. Data Cleansing and Merging

The acquired data has been put under various quality checks such as check for null values and removed from analysis. All of the files are merged as a single dataset with the help of country code using R programming.

4.1.3. Exploratory Analysis

The cleansed data was analysed in order to understand the main characteristics of the ICT trend in few selected countries, comparison of ICT and stock market among selected countries.

4.1.4. Statistical Modelling

R programming was used to merge the various datasets into a single dataset for analysis.

The IBM SPSS Statistics 22 standard software was used to perform the Principal Component Analysis (PCA), Reliability Analysis and Multiple Linear Regression. Tableau is used for plotting the perpetual maps.

4.2. Principal Component Analysis

Principal components analysis is a procedure for identifying a smaller number of uncorrelated variables, called "principal components", from a large set of data. The goal of principal components analysis is to explain the maximum amount of variance with the fewest number of principal components.

In the dataset we have several variables related to ICT and stock market. PCA is used to find a smaller number of uncorrelated variables that are easier to interpret and analyse the relationship between ICT and stock market.

4.2.1. Results of PCA

Bartlett's sphericity test (shown in Table 1) is significant and indicates that the data can be reduced to form factors with at least two variables loading onto each component. Further, the KMO measure was also computed as 0.627 which indicates that the sample size is sufficient for the application of principal component analysis.

Table 1. KMO and Bartlett's Test.

Kaiser-Meyer Olkin Measure of Sampling Adequacy		.627
Bartlett's Test of Sphericity	Approx. Chi-Square	341.385
	df	21
	Sig.	.000

According to the results of PCA (Table 2), there were 3 factors resulting with eigenvalues greater than 1. The first 3 factors explained 89.397% of the total variation. 53.141% variability is explained by the ICT related variables and 36.256% variability is explained by the stock market related variables.

Table 2. PCA variance Explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Tatal	% of Variance	Cunulative %	3.302	47.171	47.171	2.538	36.256	36.256
1	3.302	47.171	47.171	1.888	26.972	74.143	1.889	26.985	63.241
2	1.888	26.972	74.143	1.068	15.254	89.397	1.831	26.156	89.397
3	1.068	15.254	89.397						
4	.317	4.522	93.919						
5	.212	3.022	96.941						
6	.135	1.931	98.872						
7	.079	1.128	100.22						

Extraction Method: Principal Component Analysis.

We have used the varimax rotation as we were able to achieve simple structure of uncorrelated components. According to the Rotated Component Matrix (Table 4), the first component is named stock market as the variables related to stock turnover ratio, stock traded and list of domestic companies got loaded. The second component is related to ICT Internet factor as the variables related to Internet usage and secured internet servers got loaded. The third component is named as ICT trade factor as the ICT goods import and exports got loaded.

Table 3. Rotated Component Matrix.

	Component		
	1	2	3
Log_str2014	.916		
Log_st2014	.893		
Log_lc2014	.874		
Log_iu2014		.964	
Log_si2014		.956	
Log_ictge2014			.915
Log_ictgi2014			.913

4.2.2. Reliability Analysis

The Cronbach's alpha coefficient helps to measure the internal consistency of the data. Once we are satisfied that the extracted factors are meaningful with high loadings, also explaining maximum variability of the underlying data for the adequate sample, we need to measure the reliability of the factors. The expected Cronbach's alpha coefficient value should be greater than 0.7 in order to confirm that the factors are reliable and consistent.

4.2.3. Results of reliability Analysis

For Cronbach Alpha, the closer the value is to 1, the better the reliability of the factor. The Cronbach's Alpha coefficient value for the stock market factor is 0.861, for the ICT internet factor is 0.730 and for ICT trade factor is 0.771.

4.2.4. Perpetual Map

The computed principle components are plotted in order to visually understand the perception on impact of ICT on stock market among the few selected important countries.

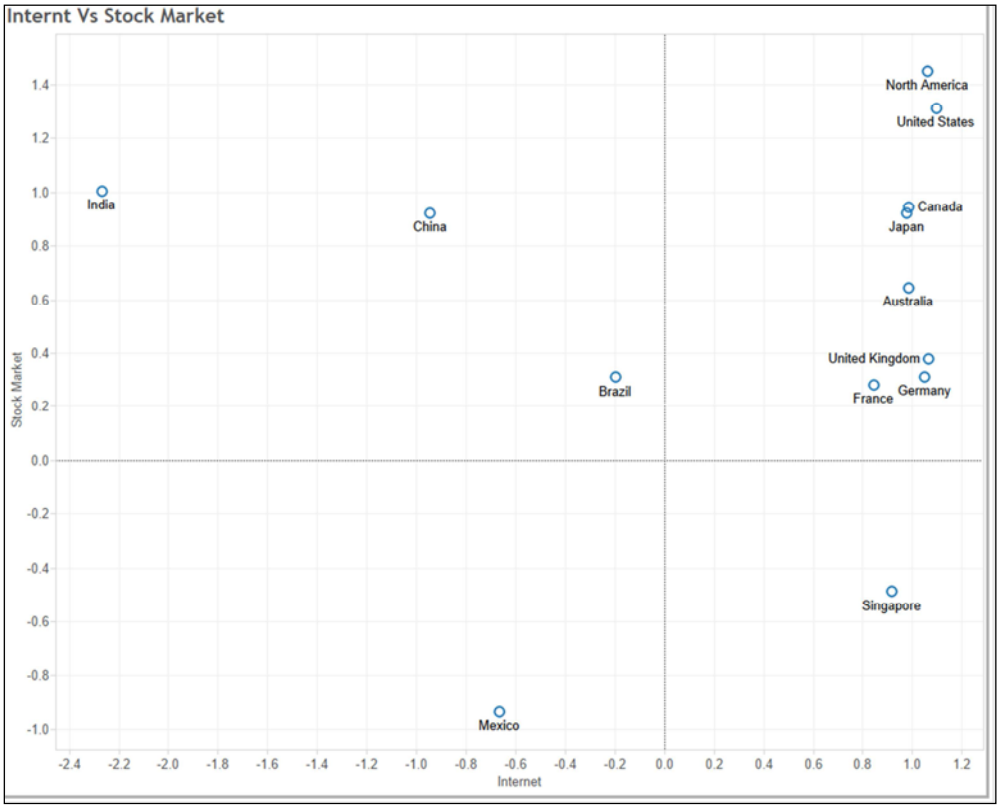

Figure 7. Perpetual Map - ICT Internet Vs Stock Market components.

The perpetual maps illustrates the perception on countries stock market based on ICT infrastructure. Countries having a very good ICT infrastructure and having very good stock market fall in the 1st quadrant. Countries belonging to North America and European Union are much matured in High frequency trading and this is captured in the above perpetual map. Countries like Japan and Australia are very open to HFT and in fact have very less restricted regulations and hence Japan and Australia are also in the 1st quadrant of the perpetual map.

On the other hand Singapore is very well developed in ICT infrastructure but still it is not so much attractive to HFT being a small nation with single stock exchange and hence it falls in the 4th quadrant of the perpetual map.

Mexico and Brazil are potential markets for Algorithmic trading attracting HFT traders from the matured economies and have recently invested heavily in technological infrastructure to support HFT.

India and China has still need to cope with the technology mainly the speed of data transfer required for HFT. But they have very good stock market returns and trading and hence they are present in the 2nd quadrant.

4.3. Multiple Linear Regression Model

The following multiple regression predictive model was fitted for the 2014 dataset with stock traded as the dependent variables and all other variables as listed in the section 4.1.1 as independent variables. Logarithmic transformation was done to both dependent and independent variable in order to satisfy the assumptions of linear regression. Many regression models were fitted and the final model chosen based on the statistical significance is illustrated below.

The following table 5 shows that the dependent variable stock traded is significantly highly correlated with listed companies in the stock market, stock turnover ratio, secured internet servers and ICT goods imports.

Table 4. Correlation Analysis.

		Log_st2014	Log_lc2014	Log_str2014	Log_si2014	Log_ictgi2014
Log_st2014	Pearson Correlatation	1	.719”	.876”	.244’	.520”
	Sig. (2-Tailed		.000	.000	.037	.000

The following table <> gives the multiple linear regression model summary. The adjusted R^2 is 0.845 hence turns out to be a very good model which explains that ICT impacts the stock market significantly.

Table 5. Regression model Summary.

Model	R	R Square	Adjust R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.924[a]	.855	.845	.23535	.855	93.969	4	64	.000	2.172

The following table illustrates the co-efficient of the regression model and also it shows all of them are highly significant.

Table 6. Co-efficient of the regression model.

Model		Unstandardized Coefficients		Standardized Coefficitnts	t	Sig.	90.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std.Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-1.081	.155		-96.961	.000	-1.391	-.771					
	Log_lc2014	.149	.048	.215	3.093	.003	.053	.245	.747	.361	.147	.469	2.133
	Log_si2014	.139	.034	.199	4.148	.000	.072	.206	.244	.460	.198	.992	1.008
	Log_ictgi2014	.470	.140	.178	3.349	.001	.190	.750	.520	.386	.160	.805	1.242
	Log_str2014	.810	.090	.633	9.041	.000	.631	.989	.874	.749	.431	.464	2.153

Stock traded in total value of GDP =

[10-1.081 * (listed companies in stock market+1) 0.149 *

(secured internet servers+1)0.139 * (ICT goods imports+1) 0.470 *

(stock turnover ratio+1) 0.810] - 1

5. ICT Driven Disruptive Business Model (IDBM)

Automated trading has leveraged the advancement in information and communication technology to accomplish high profit by generating high volume of trading by taking advantage of the market information much earlier at the right time. A good high frequency trading delivers liquidity and makes more money but at the same time HFT can be disruptive by extracting liquidity and loss money due to volatility.

5.1. Social Demand (SD)

The technology has improved the accessibility to the stock market. This means that an investor need not go through the hassle of brokers’ involvement and influence for executing the trade. For example, in a traditional trade execution methodology, when an investor wants to buy a security, he needs to get in touch with a stock broker. The stock broker will decide which exchange the order goes to, and they’re going to execute the order where it’s best for them. They’re going to buy it at the best price they can and then sell it to you. HFTs, on the other hand, can choose the exchange that they want to trade on. They can look at all the prices for a given stock on all of the exchanges and make their own decision, rather than having a broker make it for them.

HFT have a major speed advantage by putting the servers in colocation to the exchange servers and using high end sophisticated algorithms, big data and analytics so that trading can be done in much faster than humans.

HFT understand the market microstructure in a better way such as once order is placed how it is prioritized and where it exactly get executed.

Also the cost of trading as tremendously decreased due to the elimination of the friction created by working through

intermediary brokers which lead to more profit. This savings had benefited the society as a whole through the increased performance of pensions and annuities.

HFT has given greater liquidity for the broadest spectrum of investors by allowing long-term and short-term investors direct implementation of their risk intentions [8].

Since the trading is automated based on rules and algorithms, it is not influenced by the personal choice or sentiments or emotions of the investor. It allows the traders to stick the plan. This reduces panic and anxiety among the investors.

Usually HFT is blamed for volatility of the market, but to my opinion it is not the technology actually disrupts the market but it is the fear of losing or the ambitious look out for profit which investors possess make them to take hasty decisions such as not participating in a forth coming profitable trade due to the experience of losing a couple of previous trade or waiting for more profit and losing a great profit. With the help of ethically coded programmatic algorithms, it is actually possible to bring more discipline and consistency in the market [9].

5.2. Consolidated Challenges to Social Demand (CCSD)

Some investors argue HFT strategies improve market liquidity. The amount and volume of the trades taking at a very high speed ensure a liquid market. HFT traders act as makeshift market makers who buy and sell when no one will by getting better access to the market information and hence make more profit.

5.2.1. Spoofing

However some investors argue that the liquidity is just a mirage and there are lot of risk of market manipulation because some HFT firms can place lot of orders for a particular security without the intention of actually following them in order to create an impression that lot of activities are happening in a particular security which induce other traders to engage in trading activities of the same security due to the false demand and supply created by HFT firms. Once the real trade has happened the HFT firms would cancel their orders and attain profit with limited orders. A HFT firm known by name “Trillium Capital” was engaged in a similar kind of unethical trading activity. This is known as spoofing.

5.2.2. Unfair Trading Opportunity

Also HFT denies equal opportunity for trading for small investors as they are not having market information in the same phase as of HFT firms thus creating a market inequality or unfair trading environment [10].

5.2.3. Cascading Effect

Another important disruption created by HFT is the cascading effect of HFT. There were a series of global events that made investors nervous about equity markets. This unease contributed to the dramatic fall. Initially, the Greek debt crisis led to a market decline early in the afternoon. Other traders bet on a continuous decline in the market by executing short trades on the market. The wave of activity triggered HFT models that track this kind of activity resulting in a further sell-off. The large number of orders overloaded the exchange systems. Information became delayed, which caused many trading firms to exit the market altogether. The simultaneous exit caused a serious liquidity problem. The last straw occurred when a trade for securities known as E-minis was entered, causing the stock market to crash. This is called the notorious “2010 Flash Crash”.

The joint investigation by United States Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CFTC) concluded the reason as the code modified trading software used by the trader to place and cancel orders rapidly.

The flash orders is one of the controversial topics in HFT in which the traders are able to view orders from other market participants a fractions of a second before others in the market because of some reason that the best price was not quoted. This is considered unfair as few responders get information before others. Exchanges prematurely “flash” critical market information about buy and sell orders to preferred traders who pay the exchange a fee. The market information has not been made publicly available at the time of the “flash.” This clearly gives specific traders a sustainable competitive advantage to ultimately outperform the traders without the market information.

5.2.4. Dark Pools

Another controversial topic in HFT is the dark pools. Dark pools are similar to stock exchanges but the access is restricted for the public and allows only bulk order pacing buyers and sellers. By 2009, USA had around 50 dark pools and Europe had around 30. The most notable dark pools are the Goldman Sachs dark pool known as “Sigma X” and the Credit Suisse dark pool known as “Crossfinder”.

The following excerpt illustrates the actions of a high frequency trader in a dark pool (Lewis, Flash Boys: A Wall Street Revolt, 2014): “The pension fund trying to buy 100,000 shares of Microsoft could, of course, specify that the wall street bank not take its orders to the public exchanges at all but simply rest it, hidden, inside the dark pool. But an order hidden inside a dark pool wasn’t very well hidden. Any decent HFT who had paid for a special connection to the pool would ping the pool with tiny buy and sell orders in every listed stock, searching for activity. Once they’d discovered the buyer of Microsoft, they’d simply wait for the moment

when Microsoft ticked lower on the public exchanges and sell it to the pension fund in the dark pool at the stale, higher 'best' price."

Dark pools had become a source of income for banks among competing high frequency traders. Clearly big banks as well as high frequency traders were making profits at the expense of traditional traders and investors. Illicit activity could easily be covered up. The primary reasons institutional clients prefer dark pools are because of high liquidity, improved order pricing, and low transaction costs.

5.2.5. Quote Stuffing

Also quote stuffing is another major risk in HFT in which the thousands of small, unimportant offers are placed for trading involving quickly entering and withdrawing a large number of orders in an attempt to flood the market producing a flood of information creating confusion in the market. The other HFT programs lose valuable milliseconds and respond too late to the interesting offers thus losing profit.

5.2.6. False Trending Movement

Also some HFT firms create trending movement in the stock market by deliberately moving a stock price up or down for its own benefit. For example, a computer can submit an overwhelming number of sell orders, knock the price of a stock down a few percentage points and then buy the stock back cheaply.

5.2.7. Software Glitches

Apart from the above risks HFT creates, there are also few other software related glitches such as programs are not always bug free and two algorithmic programs get into a loop and react to each other.

Algorithms are not cognizant of when to stop or change a trade and thus can continue to pile money and exaggerate a trade well beyond what the market would consider a correct response leading to trade exaggeration.

Algorithmic HFT has a number of risks, the biggest of which is its potential to amplify systemic risk. Its propensity to intensify market volatility can ripple across to other markets and stoke investor uncertainty. Repeated bouts of unusual market volatility could wind up eroding many investors' confidence in market integrity. Strong inter-linkages between financial markets by operating across markets transmit shocks rapidly from one market to the next.

5.3. Risk Mitigation for Disruptive Nature of HFT

As discussed in the previous section algorithmic trading creates market volatility. In order to mitigate such risks the following few strategies were suggested to be in place.

5.3.1. Kill Switch

Kill Switches can stop all trading activity under certain circumstances such as when a pre-set risk exposure level is breached. Nasdaq OMX Group introduced a "kill switch" for its member firms that would cut off trading once a pre-set risk exposure level is breached and also additional level of safety to counter rogue algorithms.

5.3.2. Circuit Breakers

Circuit breakers automatically pause trading if there are violent price swings kicked in only once the entire market reached a certain threshold. Introduced after "Black Monday" in October 1987, and are used to quell market panic when there's a huge sell-off.

5.3.3. Regulations

Regardless of the benefits of high-frequency trading, perception dictates regulation in order ensure that markets function fairly by slowing down certain activities in the market when necessary. For example charges for cancelling the orders which are in good stand, certain time gap requirement before the announcement of quote in order to save investors from high frequency traders.

5.4. Growth of Algorithmic Trading Driven IDBM with and Without CCSD

High frequency Trading has put forward two different perspectives (good and bad) to the investors and traders. This lead to contrast between the countries in adopting and supporting HFT. Some countries like Japan are very open for HFT whereas some countries like UK have brought in regulations to control HFT which lead to co-evolutionary dynamism and disengagement respectively.

5.4.1. With Consolidated Challenges to Social Demand

(i) European Union

The main reasons behind regulations in European union is to have in place effective systems and risk controls' to ensure that their trading systems are resilient and have appropriate thresholds and limits to prevent erroneous orders or any other problems that create or contribute to disorder in the market. The firms must also put in place business continuity arrangements in the event of a failed trading. These provisions aim to facilitate the smooth functioning of HFAT practices and make clear the responsibilities of the firms to provide risk controls. Such regulations should therefore stop malfunctioning algorithms, such as the one created by Knight Capital in the US, from causing havoc on the European markets.

Markets in Financial Instruments Directive II (Directive

2014/65/EU) ('MiFID II') and Markets in Financial Instruments Regulation (Regulation (EU) No 600/2014) (MiFIR) provide a number of general regulations that will affect High frequency trading. These include:

a) Regulation of hitherto unregulated trading venues (including dark pools, voice brokers and interdealer brokers). Article 2 MiFR defines what venues qualify for regulation, Article 20(2) MiFID II requires venues to be authorized by national regulators and Article 20(3) MiFID II requires these venues to abide by the same transparency rules as regulated venues.

b) Prohibition of financial products or activity that may lead to systematic market instability and gives rise to investor protection concerns, as outlined by Articles 31 and 32 MiFIR.

c) The extension of pre- and post-trade transparency (as outlined by MiFID), relating to the details of orders submitted to a trading venue, to cover more than just shares and include bonds, structured finance products, emission allowances and derivatives, as outlined by Articles 8 and 10 MiFIR.[11]

In Germany, the parliament has passed "High frequency Trading Law" which imposes more restrictions on HFT like pausing trading when more price fluctuations occur, imposition of higher cost on HFT firms France has passed some special tax laws targeting HFT firms.

(ii) North America

Even though HFT is very well established and profitable in US but declining in the year 2009 due to changes in regulations. The Canadian government has implemented a financial transaction tax and executed an alternative trading system that taxes away HFT profits.

(a) Canada

HFT in Canada is estimated to account for approximately 34 percent of trades, 24 percent of value, and 16 percent of volume. This represents a decline in HFT from 2011 when the numbers were 42 percent, 32 percent, and 22 percent, respectively [12].

In Canada only moderate importance is given to HFT unlike in other countries as the regulators take research based measured approach towards HFT. In 2012, Canadian regulators begin charging firms for all the orders they cancel, not just those they execute.

Investment Industry Regulatory Organization of Canada (IIROC) published an academic paper on impact of HFT in 2015. They want to address the sharp disputes on HFT whether it is positive or negative benefits to the market. The Universal Market Integrity Rules by IIROC ensure fair and orderly trade implemented message-processing and trade-volume fees based on trades and order submissions, cancelations, and modifications.

(b) United States of America

The following are the some of the important regulations brought in US year wise to regulate algorithmic trading.

1998 - Regulation of Alternate Trade Systems - restricted the monopoly of a few exchanges, giving rise to a number of electronic trading platforms serving as alternative trading systems.

2005 - Regulation National Market System - 2005 enabled traders to leverage HFT to exploit the momentary differences in prices between exchanges.

2010 - Joint committee was formed between the SEC and CFTC (Commodity Futures Trading Commission) to provide advice on emerging regulatory concerns on HFT.

2012 - S.E.C approved a rule to establish a uniform system for tracking all orders and trades across the country. S.E.C started to fine exchanges regarding "compliance failures" that allowed certain customers to receive stock prices and other data milliseconds, or even up to multiple seconds, before the broader public.

2015 - CFTC released a proposed rule, Regulation Automated Trading (Reg AT), governing certain HFT practices in response to ATS' growth and particularly financial regulators' concerns regarding the impact of such systems on market volatility and market fragility.

(iii) Asia

Several parts of the Asia-Pacific region are taking a different approach to HFT than Europe and North America by encouraging its growth. Much of the HFT taking place in Asia is the result of 19 US and European firms establishing the technology in the region in an effort to expand their global presence as the United States and EU consider implementing regulatory restrictions on HFT.

(a) India

In India, the HFT adoption competition began when the third exchange "Metropolitan Stock Exchange of India" began its operations along with the other two existing exchanges namely Bombay stock exchange and National stock exchange. So these three exchanges has invested largely in ICT to attract the HFT firms by providing colocation servers to achieve low latency for algorithmic trading in order to increase their business and enhance the liquidity. However it still lags on the speed for handling trading. The Securities and Exchange Board of India (SEBI) has become the latest domestic regulatory body to launch an investigation into

high-frequency trading following an incident of perceived manipulation in order ensure effective risk management system is in place always.[13]

(b) Japan

As per Bank of Japan, 45% of equity trading is done by HFT as of 2011 and it is the leading venue in Asia for algorithmic trading. Japan is the only major market in the world that's not concerned about HFT and has no plans to put any constraints on HFT. It is also one of the cheapest stock market. The Tokyo Stock Exchange (TSE) has made upgrades to its trading systems in an attempt to encourage an increase in HFT. The Japan exchange (JPX) is improving the Arrowhead trading system to expand electronic trading and attract HFT by partnering with Cyan and KVH so that it can increase the trading volume and diversify products. These technological partners provide integrated communication and software solutions for data transformations.

The regulations and financial market structure are also favourable for HFT growth. Rather than attempting to regulate away HFT, Japan has embraced it while monitoring it and putting systemic limitations in place. [14]

(c) Australia

In Australia, HFT trades represented 27 % of Australian trading volume in 2012. The Australian financial markets exhibit a number of favourable characteristics for HFT growth, such as the low latency in network communications and low transaction costs. There is difference in approach adopted by the two major exchanges namely Australian Stock Exchange (ASX) and Asia Pacific Stock Exchange (APX). ASX is open for new specialized products in order to increase the revenue thus supporting HFT whereas APX which specializes on Chinese and other Asian companies which is not traded in ASX, will introduce shorter pauses in trading to hinder HFT as it needs to satisfy the Chinese retail investors. [15]

There are also other HFT traders which route to dark pools and regulators have difficulty in understanding the HFT activity. The launch of own low latency platform PureMatch, enhancement in colocation facilities, reduction in trading fees based on provide / demand liquidity has made Australia a more attractive place for HFT.

Australian Securities and Investments Commission (ASIC) has imposed certain rules for HFT trading for achieving a more balanced approach in order to provide market transparency, diminish the likelihood of trading irregularities, and cleaner market operations. But at the same rejected certain suggestions such as a to implement a pause of 500 milliseconds for small orders of $500 or less as the study by the Australian Securities & Investments Commission (ASIC) determined that HFT was not a threat to Australian markets. [12]

(d) Singapore

Singapore accounts to close to 30% of HFT trading in the form of derivatives and unfortunately 0 % in the equity market. Even though SGX is the largest financial market in the South East Asia and adopted new technological improvements such as ultra-fast trading engine called "SGX Reach", provided colocation services to its clients by partnering with Commerce International Merchant Bankers Berhad (CIMB) it has not been successful in attracting orders from HFT traders. The reason being relatively higher trading cost compared with ASX and also lack of fragmented market as Singapore being a tiny dot with only one stock exchange.

In order to attract the HFT traders, friendly regulatory environment has been set in the form of adjustments as offering rebates of ownership transfer fees and liquidity provisions to HFT traders. [12]

(e) China

China is another unattractive market for HFT due to the regulations which restricts the selling of the stocks on the same day, very high trading cost in the form of stamp duties and also the poor network infrastructure. In the future, HFT will gain the opportunity to develop further in China only as more assets come to market, and as trading restrictions and costs diminish. But on the other hand due to very strict regulations in EU algorithmic traders are interested to enter other markets like China. [12]

5.4.2. Without Consolidated Challenges to Social demand

The following paragraphs illustrates the growth of algorithmic trading without consolidated challenges in social demand.

New Zealand is actively wants to attract more HFT players as its market NZX is largely populated by small players and hence largely illiquid. So HFT can bring liquidity.

Brazil although have 10% of trading happening by HFT, in order to attract more HFT traders it is upgrading on the ICT technology required for market. Also added new computer system "PUMA" to support high speed trading where the order execution time length is just 1 millisecond. Also removed 6% tax on financial transactions.

Mexico being the second largest exchange in Latin America, has invested nearly 20 million dollars in technology over the past few years to attract HFT. It is also open to dark pools making it more attractive as an HFT destination. [12]

6. Future Work

The following are the future analysis planned

•Empirical analysis on Individual countries will throw more light on influence of ICT on stock market.

•Analysis of tying up the social demand which lead to challenges and reason for disengagement or adoption in different countries.

7. Conclusion

This study helped to understand the innovation and co-evolution in Stock market in various countries. Also empirical analysis brought out the perception of different countries on the impact of ICT in stock Market. This serves as an additional evidence for the certain countries brining regulations while certain countries remaining open to HFT. The disruptive business model and the mitigation to overcome also have been discussed.

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