International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

Effect of Technology Innovations toward High-Frequency Trading (HFT) in Equity

Neha Khadelwal, Ankur Jain

Assistant Professor, Dr. MPS College of Business Studies, Agra
Assistant Professor, Dr. MPS College of Business Studies, Agra
Corresponding author: Neha Khandelwal

Submitted: 05-04-2022 Revised: 14-04-2022 Accepted: 17-04-2022

ABSTRACT: Financial advances built on technology in the last four decades have resulted in financial market revolutions. Understanding information system (IS) and technological advances was complex for technical advisors and the finance industry Practitioners, though, because of the fundamental nuances. We suggest the biodiversity in this article Study method by applying the influential paradigm of the ecosystem technology (Adomavicius et al. 2008) to combine stakeholders' activities with both supply and demand in mind. Our model ecosystem puts together three primary factors: components, service and business infrastructure powered by technology. A fourth new component in the stakeholder research method is also included. We examine new developments in the field of high-frequency (HFT) trade as a framework to validate the presence of many distinct patterns empirically in the historical course of technological development. Our analytical findings indicate that supply and demand forces affected HFT's technological advances and led to financial market developments. This article is one of the first to study technological advances at the technology and stakeholder levels of financial market technology. It also provides a helpful and realistic tool for managers and analyzers to consider the existence and relationship between technology-based financial technologies and financial markets that enable their emergence.

Keywords: Algorithmic trading, financial markets, financial innovation, High-frequency trading, Technology-based innovation, Paths of influence, Technology ecosystems.

I. INTRODUCTION

Information technology is a significant engine of commodity, service, and industry innovation in finance and financial services markets (Wriston, 1988 and Teixeira, 2007). When we analyze the effects of these securities and other financial instruments on trading over the past four decades, it is dramatic and far-reaching to see the scale of IT-enabled inventions and transformations (Mishkin and Strahan, 1999; Stoll, 2006). There was also a fast pace for market participants for changes in the main algorithmic and higher frequency (HFT) trading. Starting in the 1980s, algorithmic trading started, and machine trades were placed on the market, thus decreasing trading on the ground (Hasbrouck et al., 1993). In the late 90% of the trading site in the NASDAQ and New York Stock Exchange, other fully electronic trading sites, in particular electronic communication networks (ECNs), were created more (Weston, 2002). This lead to the increased use of algorithm trading and, ultimately, HFT (Aldridge, 2013). HFT uses computerized tools to track market data, find openings for lucrative businesses and place vast volumes of orders on the markets (ESC 2010). In addition, HFT is used to provide the market with a high-frequency trader.

Rival trading companies in stock markets have been competing intensively. In 2005 the US Securities and Exchange Commission (SEC) (2005) issued a National Market System (NMS) to improve price show and fair trade, promoting prices in pennies rather than democratizing market access to market data. These regulatory changes lay the groundwork for today's electronic trading frameworks and lead to the quick creation of HFT technology and new trading strategies. HFT is defined by: high speed, sophisticated computer software dependency, ultra-low Late delivery of orders to a server of an exchange Systems; multiple orders can be sent Cancelation immediately following application; limited shelf-life of the trade algorithms used; and various trading Asset groups of several exchanges (McGowan, 2010). High-frequency traders found it necessary to invest in

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

Hardware, Software, and Network technologies to minimize latency in response to the automatic process and winner-taking of HFT to continue to improve their business programs and algorithms, upgrade their technological infrastructure and succeed in the associated 'arms races.'

Moreover, the transformations of operational processes and certain technical advances were sponsored. The modifications concerned included Securities immobilization and dematerialization, the development of financial intermediation in multitasks, and Central depositary securities like the Depository Trust and Corporation Clearing (DTCC, 2012). They provide for the same infrastructures to be shared between various kinds of entities — retail and pension funds; institutional investment funds; hedge funds; international and domestic brokers; commercial savings and investment banks; and local and global custodial providers (Chan et al., 2007; Russo et al., 2002). This causes the shares to be stored digitally instead of physically at a single place where they can be cleared and settled. It also avoids the need to exchange physical certificates expensive after completing the transaction to improve reliability and security and increase a probability of an intraday settlement (DTTC, 2012b). Additional new technologies sponsored HFT broadcasting. Including the deposit of securities with the DTCC (2014): via fully automatic direct agents, on temporary lending awaiting approval of agents, and on immediate lending.

The specter of software errors in HFT operations leading to drastic, quick, and uncoverable losses is an associated growth. Examples of such projects were the May 2010 "flash crash," which caused a US$460 million loss in a millisecond and microsecond trades in Kirilenko et al., 2014. The Knight Capital 2012 software failure caused a loss. It happened when Knight Capital had a 15%-20% market share of all HFT operations in the United States, and eventually, it was acquired by another company (SEC 2013) in Knight Capital. The latest study from the DTCC (2013) contains a quote from the Indian Mahatma Gandhi saying: "Life can only increase its tempo." Regulatory authorities and financial intermediaries, including the American SEC and the US DTCC, have responded by addressing potential demands for HFT companies to send fast-trade data near-real-time and not allowing for a procedure known as pre-netting (SEC, 2013). Companies will no longer selectively retain the exchange of data on network trades in technological problems. This activity dramatically undermines the capacities of public financial intermediaries responsible for market surveillance. They need to track quality and efficiency in the markets to maintain justice and accountability while avoiding significant risks. For example, in fixed revenue stock trading since the 1990s (fixed income clearing corporation, 2014), these items contributed to the promulgation of specific laws.

Managers and industry analysts have found it impossible to evaluate the most significant trading technological advances in the capital markets. While signs have marked technological advancement in the high-tech industries, it was not easy to describe their origin or level of influence. The main questions are: How have the technical breakthrough pathways in capital markets been historical? What is their form, and what patterns do they appear to be? Can it be established based on observational findings? Is it possible to use an approach to reduce dynamic interactions between infrastructure, financial markets, and stakeholders to understand the evolution of the ecosystem? Is it helpful to look ahead and see if potential improvements to ecosystems are going to occur?

This article follows an approach that concentrates on technological elements, technology-related utilities, and business infrastructure based on technology. In research carried out into pathways of influencing modeling in technological environments, Adomavicius et al. (2008) provided an early picture of the vision. We use this perspective to discuss challenges faced by financial policymakers and investors as they consider what drives the core developments within the technological environment of the financial industry. The core elements for analysis that we provide are components, facilities, and resources in financial IT. Furthermore, by applying the methodology to some other powers linked to future influences and activities of several players in the capital markets, we make a new contribution. These powers serve as accelerators or decelerators of transition when new IT-enabled technologies transform the structure of the economic exchange. The expanded approach aims to be general, enabling all industries and technologies, diverse stakeholders, and competitive environments to be handled.

This research has twofold contributions to the literature on innovation in technology and capital markets. We propose to contribute to the development of technological progress on the financial market, which emphasizes stakeholders. Technology is a supply-side force; but, stakeholders acting as demand-side innovation forces have more dynamic concerns. Little analysis has investigated the dynamic link between financial and technological markets (Franke, 1987; Saint-Paul, 1992). Exemptions include corporate analyses of technology-based financial advances (Fichmann and Kemerer, 1999; Lyytinen and Rose, 2003).

Additionally (Adomavicius et al. 2008, 2012) gave an ecosystem perspective on technology which examines how the processing of information systems (IS) and IT changes technology based on the interactions of different types of technical objects. This strategy stresses innovation's supply-side powers only: It reflects how emerging inventions can be introduced and developed to initiate and disseminate innovations. The technological innovation's demand-side powers were not, however, considered. Key stakeholders highly influence the direction, speed and directions, and technological advancement in financial market technology environments such as financial institutions, regulators, and others. Supply and demand forces may act together or in opposition to each other, leading to different results. In order to retrospectively observe and evaluate how technical developments in financial markets should be viewed, we suggest a supply-and-demand view focused on behavior, relationships, and reactions of stakeholders.

Empirical research is the second part of our work. In order to confirm and sustain our methodology, we have performed an empirical evaluation by adapting it to a multi-stakeholder HFT technological ecosystem. We found out the different roles of the relevant technologies in the HFT phase of innovation and examined the various actors in the HFT ecosystem and their effects on the historical development of HFT technology. We also compiled and studied 13 activities for this aspect of the study, including the historical development of technological transition and intervention by stakeholders. Our research established various trends of innovation that seem to be linked to how these emerged: supply-side forces, demand-side forces, or forces from both sides.

The following articles are organized. Section 2 reviews the corresponding literature, including financial advances dependent on technology, environments of technology, and models of the impact of technological development. It also offers the necessary knowledge of the history of HFT. Section 3 suggests the more comprehensive pathways of control that take stakeholders'behaviors from our understanding of technological development across supply and demand. Section 4 applies the proposed paradigm for the evaluation of the HFT ecosystem's historical developments. The data set, interested parties, and data evaluation information and the results are discussed. Section 5 proposes the effects of our study on scientific findings. Section 6 ends and provides comments on restrictions and planned activities.

II. LITERATURE REVIEW

Our literature is based on current financial innovation literature, the direction depending on technological transition, the technological environment pathways of impact, and HFT innovations. We address the role of both supply and demand powers in financial innovation dependent on technology in the first place. We would examine the hypothesis and how it affects capital markets and technological developments. We will then explore the technologies and impact paradigm for the ecosystems and apply principles for scientific study. Finally, the literature on HFT would be introduced.

2.1. Supply and demand-driven forces for financial innovation

Financial innovation supply-side strengths are derived from technological know-how advances, which create innovations or recombine existing technologies and provide them with new uses in organizations (Tornatzky and Fleischer, 1990). Currie and Seltsikas (2001) concluded that entrepreneurial attempts at developing emerging technology lead to technical transformation and organizations' adoption.Gatignon and Robertson (1989) the value proposals companies can bring to their customers have been affected by technological advances in financial markets. They promote market management and are vital and integrated into the core technology solutions (Swanson, 1994). Understanding technology-based growth streams and exploiting the acquisition and business prospects are essential to the success of a financial institution on the market. This innovative development benefits innovators and developers (Tufano, 1989) and benefits the entire business (Frame and White, 2004). Most based on financial innovation literature was on: diffusion; the features of adopters; and the impact of innovation on corporate viability, improvements in institutions, and financial market efficiency (Merton, 1995; Miller, 1986; Kavesh et al., 1978). It did not focus on understanding how operational creativity affected developments in financial market technology. This will build demand-side powers. However, that will help financial developments (Lerner &Tufano 2011; Lyytinen& Rose 2003).

The need to shape and shift forces in innovation acceptance was recognized (Zmud,

1984) – a need to reflect supply/demand efforts. We noted that when the appetite for technologies by the financial market players is high, technology providers are encouraged to make more effort for innovative solutions for new goods and services. If the stakeholders cannot take in emerging technological advancements in the industry, improper solutions may be used, and financial risks for early adopters are inevitably caused. If demand tug, supply thrust, or a mixture of both is the real motive power, it remains to be determined by the literature (Adner and Levinthal, 2001; Arthur, 2009; Sahal, 1985). A mixed outlook is adequate to analyze the distribution, development, and interplaying of the supply and demand sides of technological developments on the capital markets. Therefore, there seems to be a crucial incentive for actively using stakeholder research to expand the current thought.

2.2. Technology evolution and the paths of technological change

Research has discussed the development of technologies and the creation of inventions. Is the transition seamless because of a phase of continuous technological development (Basalla 1988; Henderson and Clark 1990)? Other than the technical revolution, does it entail a discontinuous evolution of significant improvements (Tushman and Anderson 1986; Eldredge and Gould 1972)? Even if literature is not concluded, a philosophical view of the directions of the change mechanism must be taken over time to consider the technical impact on the capital markets (Boland et al., 2003; Sood et al., 2012).

Regulators exercised caution as emerging innovations reach the capital markets. Innovations in technology will stimulate commercial performance breakthroughs, destabilize the general marketplace and economic climate and in certain drastic circumstances also generate financial crisis for the dark side of that latest financial progress (Diaz-Rainy and Ibikunle, 2012; Thakor, 2012; Fostel and Geanakoplos, 2012). Furthermore, the rivalry between market players often leads to a host of minor enhancements instead of hikes over time. We take the pursuit-driven view of Paul David (2007, page 92), which reflects "a complex mechanism whose development is guided by its own past" as changed by a financial system and technologies.

Gartner's (Fenn et al., 2000) excitement period for new technologies explains technical advances in many evolutionary process trends. These are connected to changing market and social analysts' views and aspirations—from the original realization of increased ability to exaggerated hype and decreased and more rational expectations. Worlton (1988) noted that technological change occurs in four phases: creation, innovation, distribution, and transition of scale; the company has described the fundamental developmental trends of the various stages of technological change in Sahal (1981, 1985). Baldwin and Clark(1997, 2000) observed that owing to improved modularity, architecture rules made invention trends repetitive. Such items encouraged us by studying historical evidence to recognize developmental trends in the technological transition process and provide valuable management insights on events.

2.3. The technology ecosystem and paths of influence perspective

Lyytinen and Rose (2003) highlighted the interconnection between system architecture technologies, IT services, and the associated IT base deployed. They examined how disruptive ITs enter the modern computer, solution creation, and service providers. This work encouraged studies on the environmental view of the technology. Adomavicius et al. (2007) considered and discussed an ecosystem approach to represent relationships between various technologies as a dynamic framework for determining developmental outcomes in products and services application settings. An ecosystem is a series of inter-related technology functions and overlaps of hierarchical technology. The concept "ecosystem" highlights the organic character of developments in technology and the relationships between stakeholders and techniques.

To identify past IT inventions, Adomavicius et al. (2008a, 2008b) have created valuable tools in digital music and Wi-Fi technology for IT analysts and decision-makers. Cross-leading effects of wireless networking were illustrated and influencing pathway for the impacts of technologies through the ecosystem's technological functions confirmed by Adomavicius et al. (2012). This method only models the supply powers of the current IT materials, goods and infrastructures, but does not take account of the demand side and is thus less generalized. Stakeholders play a crucial role in the development of technology in financial IS and technology situations. We also take into account the influences and behavior of many financial market players. They serve as accelerators or decelerators for improvements in the market.

2.4. High-frequency trading technology

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

The use of computer algorithms to automatically make trading decisions, send orders, and handle the orders following submission is widely known as algorithmic. Algorithmic trading has increased market liquidity and improved market information (Hendershott et al., 2011). HFT is a type of algorithmic trading that differs from other trading systems due to the use of information processing technology which supports very rapid trading and exchange strategies that lead to daily trading (Brogaard et al., 2014; SEC, 2010).

In recent years, HFT has attracted interest from academics. Their papers are based on the effect of HFT on conditions such as liquidity, price discovery (Brogaard et al., 2014), liquidity, and price (Hendershott et al., 2011, Hendershott and Riordan, 2013) (Hagstromer et al., 2014), etc. Brooks (2012) has stressed the need for more thorough research for increased volumes of HFT technology. It is changing over time and can be a deceptive indicator of the stock market's stability. Furthermore, there has still not been a thorny study of the veiled link between electronic trade technologies and business success. We fill the gap with stakeholder research and apply it in a historical evaluation of HFT technology development by increasing technology ecosystem theory.

III. ANALYSIS APPROACH AND KEY CONSTRUCTS

Next, we are defining a more thorough financial IS and infrastructure environment.

3.1. Financial IS and technology ecosystem

The challenge of evaluating technology developments in financial markets is contributed by uncertain trends in technology and dynamic industry hierarchies. We also created several innovations interconnected to one another by such functions or utilities and several stakeholders such as clients, financial institutions, or regulators to solve these issues. Stakeholders are influenced by each other's activities and advances in technology. They are not unique to financial IS and technology ecosystems but rather play a role in many technological advancement environments. They are significant. For the broader commitment of this work, that is significant.

3.2. Technology roles

In an environment, technology has three roles: component, service, and business infrastructure.

3.2.1. The component role

The modules are technologies that enable financial services functionality. Where diverse technology (encryption algorithms, access controls) serve as components in the financial market, electronic commerce only requires those components: the order book, computer systems, algorithms, telecommunications network support, etc. The distinction between the elements of technology and the utilities is that they operate as the subsystems. Designers integrate various elements and modules into services designed to respond to the financial needs of consumers.

3.2.2. The service role

The customer-faced support function of technology offers consumers access to a wide range of financial services. In the finance industry, we usually see focus technology and other similar innovations directly competing. An example of HFT in e-commerce. It represents more than half of all financial markets in the US (McCrank, 2014). HFT is consumer-oriented and facilitates low latency arbitration, front-running and reimbursement of liquidity, and management trades depending on press reports, order flux, or another commercial signal (McGowan, 2010). Another is competition with HFT and competing for ecosystem for the other e-trading technologies such as program trading and manual trading with automated data tracking and consolidation.

3.2.3. The business infrastructure role

This feature recognizes technologies that add value to the service role or functionality. The business infrastructure technologies provide the foundation for customer care provision. E.g., ECNs act as financial trading systems in this capacity. They are used during business hours in primary markets and after hours and foreign currency trade. Capabilities of business networks often increase functionality and provide consumers with extra value-added capacity and services.

An example of this is market-wide risk management systems, which allow companies and regulators to control and monitor business operations. VaR is focused on risk management systems. Another example of the HFT environment is social media online. It is not mandatory for algorithmic commerce, but it offers a new platform for newsfeeds in real-time.

3.3. Paths of influence

Influence pathways will reflect the effect of financial innovation based on technology through technical roles (Adomavicius et al., 2008a). Innovation in technology that plays either of these three roles may cascade through the other roles and lead to further developments. Take the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

practical acceptance of ECNs, for instance. NYSE declared on 20 April 2005 its intention to become a publicly held corporation with a profitable ECN to Archipelago. This changed the activity of the US financial markets and contributed to the introduction of emerging e-commerce platforms, lower bidding and acquisition costs, and higher execution effectiveness and annual turnover. This is a modern technology that affects the growth of emerging innovations and services.

In our part, operation, and business infrastructure activities, we use C, S, and I to reflect the latest technological developments. For the future state of a technological position, we use an asterisk. In order to recognize technology-based financial innovation patterns, this note enables us to explore interdependence over time and address the dynamics of relationships within them. For example, the advent of VaR-based financial risk management and data analysis in the industry. These innovations began in the 1990s at Bankers Trust and J.P. Morgan, which gradually applied across the industry in 1998. (Han et al., 2004). The paths of influence in this area are:

$C \rightarrow C^* \rightarrow (C^*, S^*) \rightarrow (C^*, S^*, I^*)$

3.4. Stakeholder actions

To have complete information about what we found, modeling the supply-side growth pathways alone is inadequate. As Van derValk et al. (2011) and others pointed out, interactions between entities and individuals in the environment affect the directions of technical development. The earlier methodology would be enlarged to incorporate a viewpoint on stakeholder activity. Stakeholder behavior could affect technological advancement positively or negatively, often leading to improvements in benefits, loss of benefits, beneficial network effects, goodwill, and social welfare (Au and Kauffman, 2008). Successful innovation pathways require the collaboration and coordination of several coalition actors to create shared norms in institutional, process, and technology. In order to chart the routes of power and trends of change, it is essential to consider stakeholder behavior relevant to technical advances. Given the impact of the technical transformation plans of various stakeholders, the four stakeholder activities should be identified: to advance, pull and build strategic partnerships for pace and stop developments.

3.4.1. Push-forward

This is where a stakeholder is involved in technological advancement, establishing a norm, or investing in business infrastructure development. On October 27, 1986, Big Bang was an example of a leading player – a government authority – advancing and accelerating creativity development, The London Börse (LSE) (Clemons and Weber, 1990). The screen-based application of the LSE Dealing Scheme was implemented with comprehensive regulatory reform. The use of technological innovation based on regulatory demands enabled the LSE to run continuously and smoothly. The introduction of comprehensive and long-awaited legalization of technology support has furthered the development of technical progress on the capital market in the UK, benefiting many stakeholders.

3.4.2. Pull-back

This is where a player chooses not to follow any technological advancement or create a new or competing level of technology. This usually slows or even blocks the direction of power in technological development. E.g., gate-array chips and high-speed telecommunications protocols such as InfiniBand and 10/40 GB of Ethernet (10 billion bits per second) would be available in the region exchange at high speeds and direct consumer access at low latency. You build hardware acceleration out of software. Advances in IT serve instructions, data transfers, and confirmations in 10 milliseconds, quicker than before and less costly (Mellanox Technologies, 2013). (Durden, 2009). The downside is that the economic demands for implementation are less strict on risk management (Chakraborty, 2012). The October 2009 hearings of the US Senate (2009) were held to examine the efficiency of computational and algorithmic trading sites in dark pools, flash orders, and HFT systems. HFT market practices started to shift, resulting in an HFT share in the USA dropping from 61% in mid-2009 to 51% by the end of 2009. (Popper, 2012). The regulator, a stakeholder, has slowed the growth.

3.4.3. Strategic alliances

When a single stakeholder does not move enough to push or reverse an idea, companies pursue strategic partnerships to speed or stop the innovation. However, coalition difficulties arise: partners have varying capacities, different market models, and different priorities. Alliances encourage collaborative advantages rather than individual ones. Various players work together to improve operating and mutual benefit alliances (Dai and Kauffman, 2004).

Strategic partnerships provide partners with ways to deliver value-for-money projects to reduce construction costs as well. ECNs for exchange dealing is an example. The merger of NYSE with Archipelago in 2005, NASDAQ and Instinet, has expanded e-commerce across the market (Stoll, 2006). Competition and regulatory demands from ECNs and regional trade pushed them to take co-opetition on board (Brandenberger and Nalebuff 1996; Teece 1992). Business leaders' strategic partnerships helped them find ways to accelerate the appeal of technologies and make this acceptable.

However, stakeholders do not necessarily agree on the importance of technical advances. This may cause an idea to be stalled by a strategic alliance. Given uncertainties and unpredictable consumer responses that could follow technology innovation, key players may collaborate to delay or obstruct mutual opposition to technology implementation. However, it will not hold back a long time in the industry a valuable technical breakthrough. It can allow stakeholders to rapidly consolidate and adapt their investment strategies and technology plans and consider experimenting with the latest technologies and identifying ways of partnering with the technological innovator.

The OptiMark Trading System that was developed in the mid-1990s was an example. OptiMark gave the institutional traders a modern "three-dimensional" marketing environment, allowing the standard price and quantity quotations to be augmented by the trader's option for buying or selling. The response of the industry was nevertheless deceiving. Twenty months after its initial launch in 1999, OptiMark could not draw enough traders' command; the GUI and algorithm were criticized for their difficulty (Clemons and Weber, 1998). Its closed in 2000 reflects the challenge of bringing innovative IT technologies into line with the needs of consumers, traders, and regulators, in order to drive them forward.

IV. PATHS OF INFLUENCE ANALYSIS FOR THE HFT ECOSYSTEM

We are now analyzing ways in which electronic trading technology can affect evolution.

4.1. The HFT technology ecosystem

By incorporating stakeholder analysis and extending it to the HFT technology ecosystem, we expand the four-step technology analysis of Adomavicius et al. (2007). We aim to understand the effect on technological developments within the HFT environment of the various stakeholder groups and the interaction between technologies with distinct positions in providing commercial electronic solutions. This provides an understanding of how the industry has evolved and continues to develop:

Stage 1 (Identification of stakeholders). For this assessment, all stakeholders important to particular financial advancement focused on technology must be listed. Investors and issuers, retailers, Infomedia companies, brokers, financial intermediaries, marketers, commerce, financial information systems, technology service providers, and government regulators are involved in the HFT technology ecosystem.

Stage 2 (Identification of focal technology and context). A focus technology identification is the point of departure for mapping the environment and a particular sense of use. HFT technologies embody the ecosystem's focal technology and promote the electronic trading sense, the production and delivery of services for issuers, investors, and intermediaries.

Stage 3 (Identification of competing technologies). It is also necessary to identify other forms of technology, which are directly competitive with the focus technology or provide related services or functionalities in the context of interest. Competitive innovations within the HFT context are program trading (index arbitration, mass trading, etc.) and manual trading solutions with automatic data tracking and information consolidation.

Stage 4 (Identification of component technologies). The next step is to identify the systems used as components of focal and rival technology for operation. In the HFT ecosystem, microchips, telecom networks, data processing and storage, program code and algorithms, high-performance calculation, and data analytics are all component technologies.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

Fig: 1 – Stakeholders in the HFT technology ecosystem

Stage 5 (Identification of business infrastructure technologies). Finally, we must define the technologies which work together to increase the value for investors and other stakeholders on the global services platform in connection with services position technologies. Among other aspects, this range of technology can include ECNs, online social media assistance, and financial risk management systems.

We will also expand this viewpoint on two issues: stakeholders and technology.

4.1.1 Stakeholder analysis

We first describe how the behavior of stakeholders could impact the ecosystem's pathways. Identification of the various impacts of stakeholders helps explain how an HFT environment develops and how it is linked to our ways of thinking about control. Fig. 1 illustrates and defines possible impacts of the behavior of stakeholders in the HFT ecosystem.

The compass points are ranked by different stakeholders (Au and Kauffman, 2008). The north is suppliers of financial systems and infrastructure services, mostly technology firms, but may also be high-frequency traders and financial intermediaries or exchanges. Microchip manufacturing suppliers and semiconductor producers are good examples. Good examples. Fixnetix has built a microchip to make nanoseconds trades — one billionth of a second (Stafford, 2011).

In the South, some investors and emitters are customers and utilities at the other end. In innovation-creating meaning creators, they serve as values (Kauffman and Walden, 2001). The issuance of inventories or bonds creates capital. Retail and institutional investors provide the share capital. With the Fixnetix case, it is essential to consider the length of time the technology providers have spent supporting the "weapon race," as we mentioned earlier. However, the reader should be aware that advances like this include a game feature of zero sums and that confident investors and issuers will not receive again but may instead be affected. If certain advances in technology help empower some buyers and traders, their profit is directly attributed to losses from others.

Table: 1 – Technology roles in the HFT ecosystem

Role	E-Trading Related Technologies	Comments
Component	Microchips, Telecom network support, Data collection and data storage, Computer programs and algorithms, High-performance computing, Data analytics	Different combinations or a synthesis of component technologies support different trading practices. HFT-related innovations involve development of cutting-edge computing, hardware, and telecomm network technologies.
Service	High-frequency and program trading, Manual trading with automated data, monitoring	HFT and other technologies co-exist with services to issuers and investors, who adopt e-trading strategies to support profits.
Business Infrastructure	Co-location center for HFT firms to provide appropriate infrastructure - Electronic trading venues and ECNs, Online social media support, Financial	Business infrastructure are widely used in trading. They supply data feeds with news and information for traders, minimize trading risks and

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

	risk management	execution latency, and assist in creating competitive advantage.

The use of intermediaries is an integral part of the financial services sector. There are intermediaries such as HFT merchants, financial newspapers, couriers, market makers, and trade to the east. They provide routing facilities, mixing services, and settlement services. It also supports HFT technologies; it is smoothing the acceptance and dissemination in this landscape of transformative trading technology innovations. The intermediaries, issuers, and investors do not demarcate since certain intermediaries operate as investment banks who deal with themselves. We see government regulators tracking HFT activities in Western economies, monitoring market quality, regulating participants, regulating market laws, and increasing market effectiveness and liquidity through a range of markets and public policy. On the other side of the system, intermediaries and regulators appear because intervention from one side can lead to impacts and strategic action from the other.

The system shows two contrasting stakeholder effect ratios on developments using full circles. There are micro-level effects within the circle. The efforts of intermediaries to use HFT reduces the tender differentiation, increases trade speed and volume, and reduces transaction costs. HFT promotes market liquidity and productivity concerning five financial market microstructural properties: tightening, immediate response, scope, breadth, and resilience (Ibikunle, 2012; Sarr and Lybek, 2002). Moreover, exchange price efficiency also rises: a liquid market improves price-discovery efficiency (O'Hara, 2003; Chordia et al., 2008). The participation of the financial IS and the technology service providers in the new round of technological developments rivalry will if only for a period, provide a small or substantial competitive advantage for adopters of these innovations (Josefek and Kauffman, 1997). Investors and issuers can gain a higher degree of information in their markets while carrying lower investment risk and generate higher profits from their HFT activities.

The external concentrated circle is the macro-impact of the government regulatory authorities. They supervise the use of emerging technical technologies and develop regulatory measures and revisions to tax policies that affect the actions of other stakeholders. In April 2012, the SEC and the Commodities and Futures Trading Commission (CFTC), for example, released comments on the social media usage for public company announcements following the adoption of social media streaming as news sources (CFTC, 2010).

Generally speaking, as new technological advances have entered the capital markets, more excellent value for most parties involved is created. Network authorities have to introduce new rules and legislation to restabilize the market and direct stakeholders to generate investment markets' trust, however, as problems such as bribery and unexpected crashes occur.

4.1.2. Technology ecosystem analysis

The next aspect of the HFT technology ecosystem we consider is technologies that perform modules, utilities, and market infrastructure. See table 1. Table 1. The theoretical interactions between these functions of technology are seen in Figure 2.

Fig. 2 Regard the middle-level as the service part of innovations specified, focal technology, HFT and competitive technologies, manual and program trade. Two additional layers exist enterprise technology linked to the networks in the environment and the technology components that sustain it. Although this representation is restricted in its richness of the framework of the HFT technology ecosystem, it is still surprisingly complete. The fact that modules, utilities, and infrastructures played different functions at some point in time than they do today can also be reflected.

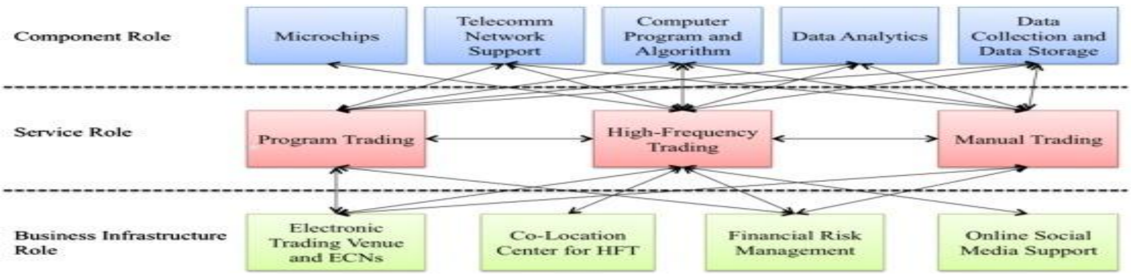

Fig: 2 – Interactions among the three technology roles in the HFT ecosystem

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

4.2. A paths of influence analysis for the HFT technology ecosystem

We would also provide an analytical validation of influencing routes of developments in the HFT technology environment to substantiate our strategy. Since the 1980s, there have been electronic trading developments. Over the following years, this landscape has undergone several technical changes. They cover capital and commodity markets in financial services and other sectors that produce equity and trading capital (investment management, hedge funds, algorithm traders). Our empirical validation aims to classify technological development trends through coding technology relevant to commerce into three distinct positions, using a state transformation scheme to reflect the technological changes.

4.2.1. Data collection and description

Between the 1980s and 2010, we collected specific data on industry announcements, multi-sector news, government reports and surveys, and historical data on electronic trading technology, which were openly accessible. We have conducted interviews with professionals, managers, and researchers to obtain relevant knowledge.

We received announcements on about 20 HFT technologies. We also coded it into three different roles: the component, operation, and business infrastructure. We also clarified technological developments using details on the timing of and implementation, production, and rollout of relevant technology launches. One example is implementing the 1976 DOT scheme and then SuperDOT in 1984 at NYSE (Hasbrouck et al., 1993). SuperDOT has allowed direct orders for shares to be routed to trading floor specialists and increased the industry's productivity.

We have gathered knowledge about the activities and technological developments of the stakeholders. We identified them as various creativity driving forces. Bloomberg, for example, installed the first computer system in 1983 to provide accurate time market data with an investment of US$ 30 million from Merrill Lynch. Since then, the capability to procure, track and consolidate information on orders of different financial instruments through computerized applications has been emphasized by financial advisors and Wall Street analysts. In the 1990s, ECNs and ATS Regulation promoted the construction of electronic off-exchange trading venues that fit the purchaser and the seller for transactions. HFT technologies and procedures were moved ahead. In 2005, the release of Regulation-NMS, and continued advancements in computational technology, started to fuel consumer appetite for more advanced algorithms and efficiency in the performance of these algorithms. In 2005, HFT accounted for 35% of US stock trades, and by 2012, this proportion rose to about 70%, although the share declined later. In the evolution of HFT technology, Table2 displays our selection, listings, and events.

4.2.2. Categorizing paths of influence in HFT

The development of electronic trading technology was motivated by a convergence of the powers of supply and demand. The launch of new technology or the enhancement of existing technology in the markets may impact both impact routes and stakeholder behavior. For example, since 2005, technology and the step forward intervention of regulators and the other stakeholders have influenced the advent of low-latency arbitrages and trading based on news reports, order flows, and other trading signals.

Table: 2 – Key event in the development of the HFT technology ecosystem

Year	Event
1980s	The replacement of floor trading with automation of the trading process; and the emergence of program trading.
1983	Bloomberg built the first computerized system for Wall Street firms
1990s	Emergence of ECNs
1998	SEC introduced Regulation Alternative Trading Systems
2000	Fast trades had an execution time of several seconds, accounting for only 10% of all trading
2001	Stock exchanges started quoting prices in decimals, encouraging algorithmic trades by ECNs
2004	Facebook was launched and online social media emerged
2005	Regulation National Market System established; HFT made up 35% of equity trades in the U.S.
2006	Twitter was launched and wide adoption of online social media occurred, affecting securities info sharing

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

2009	U.S. Senate held a regulatory hearing on dark pools, flash orders, HFT and other e-trading issues
2010	HFT execution time decreased to microseconds; HFT made up 56% of equity trading On May 6th, the "Flash Crash" occurred: Dow Jones Industrial Average down by 1000 points
2011	Fixnetix launched nanosecond trading technology for super-fast trade execution
2012	In May, a glitch associated with HFT struck Facebook's initial public offering, creating chaos for valuation In June, the SEC approved a "limit up-limit down" mechanism in Release 34-67091 In August, Knight Capital incurred losses of US$440–460 million due to software errors in algorithmic trading In September, Dataminr used software to turn social media streams into trading signals HFT was responsible for about 70% of all U.S. equity trades, the year its share in the market peaked In November, FBI began to look into social media as a form of securities fraud
2013	In April, Bloomberg incorporated live tweets into its economics data service SEC and CFTC announced restrictions on public company announcements through social media Data were transmitted at the speed of light via superfast microwave transmission services In September, Italy became the first country to launch a trading levy on HFT trading, discouraging usage

We systematically categorized their impacts on one another to interpret the relationships between stakeholder activity and technical developments. For instance, the opportunity to trade with low-latency access to the market has promoted advancement in microwave communication technologies for speed-of-light. This integration part and development innovation is a $C \rightarrow C^*$ course. Regulation NMS establishes the stage for the growth of HFT after 2005, and its commercial and algorithmic systems and market players began to improve. This can be seen across creativity to create components that are motivated by operation, $S \rightarrow C^*$. Moreover, the convergence of social media sources into trade signals has inspired the emergence of modern stream data analysis algorithms for social media data, expressed via the innovation direction of the infrastructure-driven components, $I \rightarrow C^*$. There are all directions of power based on components.

Likewise, service-oriented impact pathways include: progress on nanosecond commercial execution microchips became feasible by developing new trading innovations, which mark the growth and enforcement direction of innovation, $C \rightarrow S^*$. The decimalization of inventory quotes in 2001 has moved the algorithmic trading practice, as shown by the convergence of services and creation of innovation direction $S \rightarrow S^*$, ahead. In financial risk management, the use of risk-adjusted capital return (RAROC) led to trading strategies, $I \rightarrow S^*$, as an infrastructure leveraging service innovation direction. $I \rightarrow S^*$.

Finally, we defined avenues of impact for company infrastructure. The automation of trading procedures resulted in the implementation in 1998 of the ATS Regulation and later the advent of ECNs, reflected in the innovation route $C \rightarrow I^*$ to advance standards and infrastructure. New services for infrastructure placement have been designed to minimize communication latency to a computer-based exchange system as represented by a direction of innovation for diffusion and adoption $S \rightarrow I^*$ where higher-speed trade execution is sought. The emergence of new business infrastructure, particularly the launch of social networks such as Facebook and Twitter, has given new impetus for other ways of promoting electronic trading through innovation and integration (see Table 3).

4.2.3 Identifying evolutionary patterns for HFT

The events in the HFT technology ecosystem also show the patterns of innovation evolution based on roles of technology and pathways of thought. We will then visually map

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

these changes using a status transition diagram to illustrate the developments in this ecosystem and map the HFT evolution over time (see Fig. 3).

The number indicates 13 times in the schedule. The arrows reflect how the relevant technologies have been defined since being coded into functions. In each period, the arrows reflect the HFT evolutionary patterns' empirical observations. Hollow and strong arrowheads distinguish the drivers of the technology and its stakeholders. As in Fig. 3, five patterns (#1-#5) have been identified.

4.2.4. Service development

The first is the trend of service production, where inventions are grouped into the fields of component and service technology; (Adomavicius et al., 2008a). Part and operation technologies were streamlined, and more focus was paid overtime. The development of HFT began in the 1980s with the automation of the safety trading process. The advancement of the technological evolution of services is complemented by the advent of program trade, the decimalization of stock market quotations, and the development of computer chips and trading algorithms.

4.2.5. Service and infrastructure alignment

Secondly, the model for the alignment of services and infrastructure. Alignment patterns of services and facilities are the drive for the ATS and NMS regulations. The empirical evolution was observed because of existing core technology in service and industry infrastructure, but not components. They advocated the transition to decimal quotes and encouraged the advancement of service and component technology.

4.2.6 Feed-forward, feedback

We propose the existence of forwarding and feedback patterns from other observational findings. A new service that becomes possible with a new component or infrastructure is usually part of the feed-forward pattern. In comparison, the retroactive pattern includes a new service driven by a new corporate infrastructure that improves it. The construction of corporate infrastructures and utilities will make new components feasible. We witnessed the progress of the HFT feedback mechanism as the algorithms and techniques of the commercial trade were made usable for new infrastructures and services, including financial danger and social media news sources.

Table: 3 – Examples of paths of influence for HFT technology evolution

	Component Oriented Paths - C*	**Service Oriented Paths – S***	**Infrastructure Oriented Paths – I***
C	Component integration and evolution - Data transmitted at speed of light via microwave transmission	Design and compliance - Development of microchips to support new nanosecond trade execution	Standard and infrastructure development - Automation of trading processes encouraged the emergence of ECNs
S	Service-driven component development - Increase in HFT led traders to refine their trading programs and algorithms	Service integration and evolution - Decimalization of price quotes pushed forward algorithmic trading	Diffusion and adoption - Super-fast trade execution supported emergence of co-location services
I	Infrastructure-driven component creation - Integration of social media streams as new data feeds for HFT	Infrastructure-leveraging services creation - Widespread use of RAROC assessment in equity trading services	Support integration and evolution - Emergence of social media-led news to support equity trading

4.2.7. Incremental evolution

The third, the progressive trend of technology development, happens where current components enable developments from subsequent components to be made, or when new services are subsequently introduced in service innovations, etc. In order to guarantee stability and preserve market efficiency, the regulator can apply technologies. The reverse intervention of 2009 to delay the broad

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

acceptance of the HFT and the growth of social media in 2013 are gradual trends.

We assume that data exists from demand and supply factors that have influenced influencing routes. The model that uses the part is impaired whether leading technology is stopped or slowed by stakeholder intervention. Stakeholders will slow down implementing new services, modify technological trends, alter their evolutionary trajectories on their behalf or in coalitions. Similarly, stakeholders will drive forward technical progress and grow partners or try to develop programs more rapidly.

As in Fig. 3, the visual depiction of evolutionary trends enabled us to interpret and analyze future-oriented HFT developments. New innovative components and services technology, which support sophisticated features and features, will undoubtedly define the future state of HFT technology. High-frequency traders, for instance, now compete to create speedy and advanced computer programs to generate and route commands. They also attempt to reduce network and other kinds of latencies by using colocation and data feeds provided by exchanges and other networks. These improvements allow HFT traders to submit several orders that can be canceled shortly after submission.

V. DISCUSSION AND MANAGERIAL IMPLICATIONS

Based on a history review, we discuss several influences affecting HFT innovation and the development of the electronic trading technologies mechanism, based on our analysis and assumptions about the paths of control and technological advancement in the HFT environment. We also have management implications that help management decision-making. Our effect analyses indicate that HFT technological developments in the late 1980s and 1990s were much quicker. The new developments have improved their efficiency, which has given rise to many more technological advances. Incentives and constructive feedback from customers, particularly the leading activities of regulatory authorities, have provided a favorable framework to accelerate developments focused on emerging technologies in the financial markets. Not all that we noted – including innovations relating to clearing and settlement, pre-netting, and trade retention – was conducive to faster growth. Instead, the focus in recent years is on healthy growth to help the potential spread of HFT capacity.

Our empirical findings reveal a significant conclusion: that technological policies and benefits and stakeholder parties have been relatively matched, typically speeding up the historical evolution of technology in the HFT ecosystem. The relative novelty of technology is a significant explanation for the recent speeding up of technological progress in the HFT region. With constant advancement, the associated impacts will increase or exceed "breakthrough" transition speeds (Zhou et al., 2005).

This argument is supported by certain past events from the timeline in Figure 3. The first ECN, Instinet, was established in 1969, but electronic trade was not generally accepted until the 1996 NYSE-Archipelago merger. Twitter was founded in 2006 and was adopted by high-frequency traders soon afterward. To measure the development of business news that reflects the exponential spread of emerging technologies, they have used live tweets in trade algorithms since 2012.

Innovations have also increased their success in contrast to previous ones, with a substantial effect on acceptance, spreading, and creativity in many environments (Sood et al., 2012). First, the growth of existing technologies may be delayed by stakeholder activity after critical mass acceptance or gradual progress inefficiency and may also be mature or inadequate for the new investment (Brown, 1992). Secondly, emerging developments generate increased demand and acquisition interests and businesses opportunity the increased current value that new technologies will produce for growth opportunities. Thirdly, users would undoubtedly benefit similarly from new standards of efficiency. As a result of recent technological developments in performance enhancements, trading efficiency, rate of transactions, and market liquidity have risen considerably since 2006, and HFT now accounts for a considerable portion of the stock trades in the world's markets.

The efforts of demand-side players to promote creativity have also led to the rapid evolution of HFT. They helped to create a welcoming atmosphere to encourage funding and to disseminate financial innovation in a quicker time. The capital economy has shifted in recent years to create an ecosystem of growing investments in technology and R&D, the participation of new players in diverse market operations across different markets, and continued progress with existing technologies and the introduction of new technologies. As a result, Darwin's present market offers various financial goods and services, reduced cost and greater liquidity, more efficient market

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

surveillance, and regulatory frameworks than ever before.

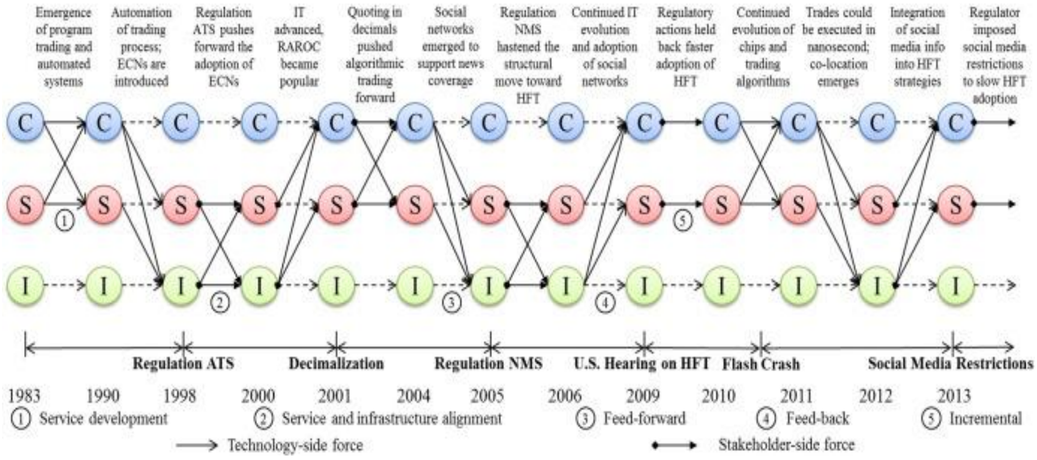

Fig: 3 – Graph-based state transition diagram for HFT technology (1983-2013)

Now let us move on to another problem. How has competition between technology suppliers influenced HFT technology developments and performance? MacCormack et al. (2013) indicated that competition for the availability of technologies also causes breakthrough ideas and stimulates new developments. This was the case in Financial IS and HFT-related capital markets.

However, we believe that a more substantial claim is possible: supply-side rivalry and demand-side support enabled more and more technological efficiency advancements that have led to transformative advances for the HFT industry. First, competition between technology suppliers has traditionally promoted collaboration between a large stakeholder pool with different strengths and abilities. Secondly, several stakeholders are prepared to invest in HFT innovation, and in R&D. Third, as the number of competing innovations grows, proponents must work more to encourage them and show higher capacity. As a result, innovation would be quicker. Fourth, emerging technology-based developments will also include improvement opportunities not accessible from previous technologies. Finally, the return on investment is more significant than in a monopoly industry in an oligopoly that supports emerging technological companies, introduced in an environment that challenges current market owners (Fellner, 1961). As a result, increased competitiveness and higher prospects have brought more resources into the provision of innovations in technologies and services, which have led to a quicker rate of evolution.

On the part of the parties concerned, regulators depend on technical competence, and they encouraged it to deal with the misuse which took place in the earlier period of floor trade. The rivalry among different trading locations, promoted by Regulation NMS, has, for instance, allowed alternative venues to remove the NYSE and NASDAQ volumes. The entry of HFT capable marketers and associated innovations was also made possible (Menkveld, 2013). The market has seen lower settlement rates, increased market volume, and reduced spreads of bid requirements as advanced electronic trading technology have become viable. This shows that similar technologies have increased their efficiency.

Changes in the technology in the HFT were comparatively smoother nowadays, although developments were discontinuous in earlier years. Many more beneficial technological advances have been opened up through fast and higher-impact creativity. Where an excellent pay-off is possible, the efficiency of current systems also increases. The race for technologies and stakeholders think they have the right kind of technological solutions to affect and cash in.

While irreversible investments in technology pose risks and uncertainty, companies also have the flexibility to choose between and when to implement new technology (Dixit and Pindyck, 1994). They will also be motivated to delay adoption until later when technical risks are overcome and the potential benefits of adoption are more apparent. However, HFT technology has a winner of all kinds. This offers a clear first-mover advantage, with the adopter having a big profit chance as emerging technologies can support quicker placing and implementing trade orders. This means that a company will stick to investing in an immature technology, reducing its flexibility to invest in further acquisitions (Mason and Weeds, 2010).

We have seen the emergence of several new HFT-related technical problems that resulted in failures, errors, theft, and financial damages in the historical timeframe of the HFT environment that we have researched. Remember the example we mentioned briefly earlier for this purpose. On 1 August 2012, Knight Capital, one of the biggest traders in U.S. stocks, launched a new trading algorithm without adequately testing its electronic order routing scheme. In 148 NYSE stocks, it had accrued prominent positions for approximately 45 minutes due to a technical failure, which caused estimated losses in the range from US$440 million to US$460 million, leading to the takeover of Knight Capital by another company (SEC, 2013a). Consider here again the zero-sum game: The losses of Knight Capital had gained others.

Another example was the first Facebook stock public bid (IPO) on 18 May 2012. NASDAQ has major computer problems: the software could not manage human traders' and computer algorithms with the rate of order submissions and cancels until 2 p.m. (Popper, 2013). This caused the investors and their broker-dealer's millions of dollars in damage. These concerns have led to the need for regulatory regulation to ensure that technological advances do not affect the overall industry quality. Regulators in the HFT sector are required to provide stakeholders advice to recognize and benefit from genuinely valuable technologies. Thus, technical risks and complexities in the HFT sense tend to establish freedom for a broader range of technologies and the consequent need to conduct regulatory surveillance. These comments also highlight the critical role of regulators in ensuring equal, well-ordained, and social welfare financial markets as stakeholders of high interest.

Industry professionals must consider the trends of technological transition, developments in electronic trade, and future technologies. Recent progress in social networking, data mining, and trading technologies online and the possibility that regulatory reform will continue creating problems for future financial markets. Concerns are raised. Our conclusions report are based on the findings in this section. We agree that more structured data than important past market events would enable maximum analytical validity. Nevertheless, our study is a significant step in building practical instruments for managers and technology prediction and forecasting ecosystem changes even if this additional potential has not yet been achieved.

VI. CONCLUSION

It was a difficult but necessary challenge to analyze and quantify technical developments within the financial services industry. We proposed a financial IS and environment technology viewpoint helpful for this reason, integrating positions on technology and recommending the latest implementation of the activities of the stakeholders. Considering its position and possible effects, we were able to characterize some of the factors affecting the pathways of control in the environment of HFT technology. As a basis of our research, we use a graphical coding approach describing technology elements, utilities, and infrastructures and their positions in technical innovation. We also added various types of stakeholders and their behavior to be pushed and pulled inside the ecosystem. We also found evolutionary dynamics in which dynamic connections between technology and the financial market restructuring can be studied. This methodology thus creates a theoretical and procedural framework for assessing the potential status of the environment of electronic commerce technologies and analyses the consequences of various stakeholder measures.

The thesis leads two aspects to new insights. First, a new scientific viewpoint was suggested. It stresses supply and demand forces as primary factors of technological developments and competition in markets for financial services. We particularly highlighted the forces created by various stakeholders that could influence the results observed. We also developed an approach to supplement the technology ecosystem approach, which blends demand and supply dynamics. Our analysis fills the divide between previous research on innovation in operational and technological terms by leveraging the impact of technologies on both sides. Secondly, this research shows the methodological applicability in the context of the HFT ecosystem of our historical review methodology. Throughout this work, we used the term ecosystem to stress that we consider it to be composite: this is about IT, but it is also about the corporate, institutional, relational, and regulatory environments.

Our graphic mapping strategies to code historically complicated events occurring in HFT technology evolution enabled us to confirm various influential trends. We also looked at the rate of technological development, competitiveness, and risk and uncertainty, all based on observational findings from the HFT paths of the impact study.

The method suggested also serves to analyze such non-technologically based financial

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

advances. In the financial services product ecosystem, applying principles and modeling methodology aligned with the pathways of impact prospects is a reasonable extension of current work. Remember, however, that several different variables in different market and industry environments will impact observed pathways of influence for technical innovation. It may not be possible to catch any of these approaches. Thus, there are enough opportunities to expand our framework, apply it to other contexts, and deepen scientific research rigor.

The estimation of potential technology-based financial advances supports an analysis of stakeholder behavior and historical developments witnessed. While this is a good idea and much new information was provided by the study, we also warn the reader. At least now, our proposed strategy cannot gain a strong influence in future-oriented forecasting. Different dynamic variables such as technology, competitiveness, public policy, finance institutions, and business regulations have complex relationships. The lack of qualitative fidelity and analytical wealth will lead to the exclusion of essential variables and powers and reduce the possibility of making valuable forecasts for possible technical developments.

In addition, the limitation of the number of predictive structures considered implies the compromise between sophistication and tractability. However, thinking about these topics helps: it promotes more emphasis on facets of customers, the market environment, and observable technical developments that fuel technological growth and ecosystem development at the next level. The position of foreign forces such as dynamics of the industry, demand environments, regulatory bodies, and society and culture can also be considered in our approach.

REFERENCES

[1]. Adner, R., Levinthal, D., 2001. Demand heterogeneity and technology evolution: implications for product and process innovation. Manag. Sci. 47 (5), 611–628.

[2]. Adomavicius, G., Bockstedt, J., Gupta, A., Kauffman, R.J., 2007. Technology roles and paths of influence in an ecosystem model of technology evolution. Inf. Technol. Manag. 8 (2), 185–202.

[3]. Adomavicius, G., Bockstedt, J., Gupta, A., Kauffman, R.J., 2008a. Making sense of technology trends in the IT landscape: a design science approach for developing constructs and methodologies in IT ecosystems analysis. MIS Q. 32 (4), 779–809.

[4]. Adomavicius, G., Bockstedt, J., Gupta, A., Kauffman, R.J., 2008b. Understanding evolution in technology ecosystems. Commun. ACM 51 (10), 117–122.

[5]. Adomavicius, G., Bockstedt, J., Gupta, A., 2012. Modeling supply-side dynamics of IT components, products, and infrastructure: an empirical analysis using vector autoregression. Inf. Syst. Res. 23 (2), 397–417.

[6]. Au, Y.A., Kauffman, R.J., 2008. The economics of mobile payments: understanding stakeholder issues for an emerging financial technology application. Elec. Comm. Res. Appl. 7 (2), 141–164.

[7]. Baldwin, C.Y., Clark, K., 1997. Managing in the age of modularity. Harv. Bus. Rev. 75 (5), 84–93.

[8]. Boland, R.J., Lyytinen, K., Yoo, Y., 2003. Path creation with digital 3D representation: networks of innovation in architectural design and construction. Sprouts 3 (1), 1–28.

[9]. Brogaard, J., Hendershott, T., Riordan, R., 2014. High-frequency trading and price discovery. Rev. Financ. Stud. 27, 2267–2306.

[10]. Brown, R., 1992. Management “S” curves of innovation. J. Consum. Mark. 9 (1), 61–73.

[11]. Chakraborty, S., 2012. High Frequency Trading: Enforcing the Right Controls. White paper, Tata Consultancy Services, Mumbai, India (Available atwww.tcs.com/SiteCollectionDocuments/White%20Papers/Consulting_Whitepaper_High-Frequency-Trading_1212-1.pdf).

[12]. Chellappa, R., Saraf, N., 2010. Alliances, rivalry and firm performance in enterprise systems software markets: a social network approach. Inf. Syst. Res. 21 (4), 849–871.

[13]. Chordia, T., Roll, R., Subrahmanyam, A., 2008. Liquidity and market efficiency. J. Financ. Econ. 87 (2), 249–268.

[14]. Clemons, E.K., Weber, B.W., 1990. London's big bang: a case study of information technology, competitive impact, and organizational change. J. Manag. Inf. Syst. 6 (4), 41–60.

[15]. Clemons, E.K., Weber, B.W., 1998. Restructuring institutional block trading: an overview of the OptiMark case. J. Manag. Inf. Syst. 15 (2), 41–60.

[16]. Cunningham, S.W., Kwakkel, J., 2013. Innovation forecasting: a case study of the

management of engineering and technology literature. Technol. Forecast. Soc. Change 78 (2), 346–357.
[17]. Currie, W.L., Seltsikas, P., 2001. Exploring the supply-side of IT out-sourcing: evaluating the emerging role of application service providers. Eur. J. Inf. Syst. 10 (3), 123–134.
[18]. Dai, Q., Kauffman, R.J., 2004. Partnering for perfection: an economics perspective on B2B electronic market strategic alliances. In: Tomak, K. (Ed.), Economics, IS and e-Commerce. Idea Group Publishing, Harrisburg, PA, pp. 43–79.
[19]. David, P., 2007. Path dependence: a foundational concept for historical social science. Cliometrica 1 (2), 91–114.
[20]. Diaz-Rainey, I., Ibikunle, G., 2012. A taxonomy of the dark side of financial innovation: the cases of high frequency trading and exchange traded funds. Int. J. Entrep. Innov. Manag. 16 (1), 51–72.
[21]. Eldredge, N., Gould, S.J., 1972. Punctuated equilibria: an alternative to phyletic gradualism. In: Schopf, T.J.M. (Ed.), Models in Paleobiology. Freeman, Cooper, San Francisco, CA, pp. 82–115.
[22]. Fellner, W., 1961. Two propositions in the theory of induced innovations. Econ. J. 71 (282), 305–308.
[23]. Fichman, R.G., Kemerer, C.F., 1999. The illusory diffusion of innovation: an examination of assimilation gaps. Inf. Syst. Res. 10 (3), 255–275.
[24]. Fostel, A., Geanakoplos, J., 2012. Tranching, CDS, and asset prices: how financial innovation can cause bubbles and crashes. Am. Econ. J. Macroecon. 4 (1), 190–225.
[25]. Frame, S., White, L., 2004. Empirical studies of financial innovation: lots of talk, little action. J. Econ. Lit. 42 (1), 116–144.
[26]. Franke, R.H., 1987. Technological revolution and productivity decline: computer introduction in the financial industry. Technol. Forecast. Soc. Change 31 (2), 143–154.
[27]. Gatignon, H., Robertson, T.S., 1989. Technology diffusion: an empirical test of competitive effects. J. Mark. 53 (1), 35–49.
[28]. Hagstromer, B., Norden, L.L., 2013. The diversity of high-frequency traders. J. Financ. Mark. 16 (4), 741–770.
[29]. Han, K., Kauffman, R.J., Nault, B.R., 2004. Information exploitation and interorganizational systems ownership. J. Manag. Inf. Syst. 21 (2), 109–135.
[30]. Hendershott, T., Riordan, R., 2013. Algorithmic trading and the market for liquidity. J. Financ. Quant. Anal. 48 (4), 1001–1024.
[31]. Hendershott, T., Jones, C.M., Menkveld, A.J., 2011. Does algorithmic trading improve liquidity? J. Financ. 66 (1), 1–33.
[32]. Henderson, R.M., Clark, K.B., 1990. Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. Admin. Sci. Q. 35 (1), 9–30.
[33]. Josefek Jr., R.A., Kauffman, R.J., 1997. Dark pockets and decision support: the information technology value cycle in efficient markets. Electron. Mark. 7 (3), 36–42.
[34]. Kauffman, R.J., Walden, E., 2001. Economics and electronic commerce: survey and directions for research. Int. J. Electron. Commun. 5 (4), 5–116.
[35]. Kavesh, R.A., Garbade, K.D., Silber, W.L., 1978. Technology, communication and the performance of financial markets: 1840–1975. J. Financ. 33 (3), 819–832.
[36]. Lyytinen, K., Rose, G.M., 2003. The disruptive nature of information technology innovations: the case of internet computing in systems development organizations. MIS Q. 27 (4), 557–595.
[37]. MacCormack, A., Murray, F., Wagner, E., 2013. Spurring innovation through competition. MIT Sloan Manag. Rev. 55 (1), 25–32.
[38]. Mason, R.,Weeds, H., 2010. Investment, uncertainty and pre-emption. Int. J. Ind. Organ. 28 (3), 278–287.
[39]. Menkveld, A.J., 2013. High frequency trading and the new-market makers. J. Financ. Mark. 16, 712–740.
[40]. Merton, R.C., 1995. Financial innovation and the management and regulation of financial institutions. J. Bank. Financ. 19 (3–4), 461–481.
[41]. Miller, M.H., 1986. Financial innovation: the last twenty years and the next. J. Financ. Quant. Anal. 21 (4), 459–471.
[42]. O'Hara, M., 2003. Presidential address: liquidity and price discovery. J. Financ. 58 (4), 1335–1354.
[43]. Robinson, D.K.R., Huang, L., Guo, L., Porter, A.L., 2013. Forecasting innovation pathways for new and emerging science and

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 600-617 www.ijaem.net ISSN: 2395-5252

technologies. Technol. Forecast. Soc. Change 80 (2), 267–285.
[44]. Sahal, D., 1985. Technological guideposts and innovation avenues. Res. Policy 14 (2), 61–82.
[45]. Saint-Paul, G., 1992. Technological choice, financial markets and economic development. Eur. Econ. Rev. 36 (4), 763–781.
[46]. Sood, A., James, G.M., Tellis, G.J., Zhu, J., 2012. Predicting the path of technological innovation: SAW vs. Moore, Bass, Gompertz, and Kryder. Mark. Sci. 31 (6), 964–979.
[47]. Stoll, H.R., 2006. Electronic trading in stock markets. J. Econ. Perspect. 20 (1), 153–174.
[48]. Swanson, E.B., 1994. Information systems innovation among organizations. Manag. Sci. 40 (9), 1069–1092.
[49]. Teece, D.J., 1992. Competition, cooperation, and innovation: organizational arrangements for regimes of rapid technological progress. J. Econ. Behav. Organ. 18 (1), 1–25.
[50]. Thakor, A.V., 2012. Incentives to innovate and financial crises. J. Financ. Econ. 103 (1), 130–148.
[51]. Tufano, P., 1989. Financial innovation and first-mover advantages. J. Financ. Econ. 25 (2), 213–240.
[52]. Tushman, M.L., Anderson, P., 1986. Technological discontinuities and organizational environments. Admin. Sci. Q. 31 (3), 439–465.
[53]. Van derValk, T., Chappin, M.M.H., Gijsbers, G.W., 2011. Evaluating innovation networks in emerging technologies. Technol. Forecast. Soc. Change 78 (1), 25–39.
[54]. Weston, J.P., 2002. Electronic communication networks and liquidity on the NASDAQ. J. Financ. Serv. Mark. 22 (1–2), 125–139.
[55]. Worlton, J., 1988. Some Patterns of Technological Change in High-Performance Computers. In Proc. 1988 ACM / IEEE Conf. on Supercomp. IEEE Comp. Soc. Press, Washington, DC, pp. 312–320.
[56]. Wriston, W.B., 1988. Technology and sovereignty. Foreign Aff. 67 (2), 63–75.
[57]. Zhou, K.Z., Kin, C., Tse, D.K., 2005. The effects of strategic orientations on technology- and market-based breakthrough innovations. J. Mark. 69 (2), 42–60.
[58]. Zmud, R.W., 1984. An examination of “push–pull” theory applied to process innovation in knowledge work. Manag. Sci. 30 (6), 727–738.