Research Policy 55 (2026) 105495

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

The coevolution of financial and technological innovations☆,☆☆

ARTICLE INFO

JEL:
G00
N00
O30

Keywords:
Financial innovation
Technological innovation
Technological development
Coevolution
History

ABSTRACT

Financial and technological innovations are central drivers of economic growth, yet they are typically studied in isolation. This article develops an integrated perspective on financial and technological innovation coevolution, emphasizing the bidirectional feedback between financial systems and technological progress. Drawing on historical evidence and modern developments, we show how technological advances reshape financial intermediation, while financial innovations—through capital allocation, risk sharing, and market design—actively influence the direction and pace of technological changes. We take a broad historical perspective and highlight recurring mechanisms linking innovations in finance and technology, including complementarities in information processing, institutional dynamics, and feedback loops driven by data, platforms, and market structure. A key insight is that, in the current era, finance is no longer merely an enabler of technology but increasingly a driver of technological innovations itself. Moreover, we provide an overview of recent studies included in the special issue on "The Coevolution of Financial and Technological Innovations." Finally, we discuss the challenges, opportunities, and policy implications for future research, as illustrated by these papers and for this interdisciplinary field in general.

1. Introduction

In the modern economy, technological innovations are widely recognized as a primary driver of economic growth and social welfare (Solow, 1956; Romer, 1990). At the same time, financial innovations—broadly defined as new instruments, institutions, and mechanisms for resource allocation—have played a critical role in shaping economic activity and enabling investment and risk sharing (Tufano, 2003; Shiller, 2004). Despite their joint importance, these two strands of innovations are typically studied in isolation, with limited attention to how they interact and evolve together over time.

To introduce this special issue "The Coevolution of Financial and Technological Innovations," this paper develops an integrated perspective on the coevolution of financial and technological innovations. Rather than treating finance as a passive facilitator of technological changes, or technology as an exogenous driver of financial development, we emphasize the bidirectional feedback between the two. Technological advances reshape the production and delivery of financial services, while financial innovations, through capital allocation, market design, and risk management, actively influence the direction and pace of technological progress. Weber's introduction to his classic *Protestant Ethic* highlights the importance of rationalization and innovation in finance as a key promoter for the development of capitalism (Weber, 1930).[1] Schumpeter (1947, p. 153) similarly acknowledges the relevance of finance as an object of study for the innovation researcher: "*banking may be the object of entrepreneurial activity, that is to say, the introduction of new banking practices may constitute enterprise.*"[2] Understanding this coevolution is essential for interpreting both historical development and the emerging structure of modern economies. This special issue represents a pioneering effort to bridge the research communities of finance and innovation and to promote investigations of this crucially important interface from both quantitative and qualitative perspectives.

☆ This article is part of a Special Issue entitled: 'The Coevolution of Financial and Technological Innovations' published in Research Policy.

☆☆ This article has benefited from discussions with Stefano Baruffaldi, Ben Martin, Ammon Salter, Zacharias Sautner, and Scott Stern. Hsu acknowledges support from the National Science and Technology Council of Taiwan (NSTC 113-2410-H-007-008-MY3 and NSTC 114-2410-H-007-016-MY3) and the Mack Institute for Innovation Management of the Wharton School at the University of Pennsylvania.

[1] Tufano (2003, p. 309) commented "*History shows that financial innovation has been a critical and persistent part of the economic landscape over the past few centuries.*" From a historical perspective, William N. Goetzmann posited: "*Finance is a technology.*" (https://blogs.cfainstitute.org/investor/2017/09/13/finance-is-a-technology/).

[2] Moreover, Merton (1992, p. 12) commented "*Financial innovation is viewed as the "engine" driving the financial system toward its goal of improving the performance of what economists call the "real economy.*"

https://doi.org/10.1016/j.respol.2026.105495
Received 10 April 2026; Accepted 13 April 2026
Available online 20 May 2026
0048-7333/© 2026 Published by Elsevier B.V.

There have been many surveys on both types of innovations; however, to the best of our knowledge, there was not much about how they interacted with each other over history.[3] We hope that this special issue serves as a step forward to connect both areas of economics and even extend the link to other areas such as management, accounting, information systems, law, and operations management. Moreover, this special issue also highlights the journal's welcoming attitude toward research in all dimensions of innovations, including financial innovations.

Due to limited space, we do not intend to thoroughly review the literature on each side; instead, we will focus on their interactions and coevolution for which we have significant anecdotal or academic evidence to describe and discuss. This deliberate focus enables us to illustrate how those two types of innovations have been interwoven throughout history and to draw corresponding policy and managerial implications.

We believe that this review and all papers published in this special issue provide a timely contribution to the innovation research literature. The acceleration of both technological and financial innovations (thanks to AI) is likely resulting in more combinations and synergies, such as the FinTech wave we are currently experiencing. Moreover, we prepared this review article from *two* specific angles. First, we attempt to offer a long-term, historic perspective on these technological and financial innovation interactions. Specifically, we separate our discussions into three regimes: ancient times, modern financial markets, and the current FinTech era. Second, we focus on credible historical or academic evidence showing that particular technological innovations (directly) lead to financial innovations or the other way around, with the broader goal of highlighting the coevolution of these two streams of innovations.

Our broad overview of history suggests that finance and technology have long been developing in response to each other. However, more recently we can observe more direct linkages between these two fundamental drivers of economic growth, to the point where we can begin to talk about the coevolution of technology and finance. While not all technologies directly feed into finance, a broad swath of information and communication technologies (ICT)-related technologies are being implemented in finance to generate new products, processes, and forms of organizations. In the contemporary era, the coevolution of finance and technology is organized less around isolated inventions and more by a set of mutually reinforcing systems: digital ecosystems and embedded finance, data accumulation and crowd-based intermediation, decentralized on-chain infrastructures, AI-enabled decision-making, and increasingly technology-intensive regulation.

Indeed, in the current era, we have reached such a level of interdependence of finance with ICT technology that the concept of FinTech innovation might perhaps even be viewed as redundant, as financial innovations are now regularly built on the rapid advances in ICT. Reflecting this, modern financial firms increasingly consider themselves as high-tech firms (Hendershott et al., 2021). At the same time, innovations in the service sector serve as a growing component of overall innovations, and various innovations in finance serve as foundational conditions for many service innovations. In fact, the emergence of FinTech and its rich applications in other fields (such as supply chain management, manufacturing, and healthcare) have created a new field of research in finance and other academic disciplines.

Finally, we note that the coevolution of technological and financial innovations is heavily dependent on the institutional context (such as policy and regulation),[4] which itself is often shaped by this coevolution.[5] Because of the critical role of financial markets in the economy, the substantial impacts of many financial innovations, and the frequency with which radical innovations in this sector have exceeded the bounds of existing governance mechanisms, the history of finance innovations has been punctuated by governance challenges and institutional reforms in response to these innovations. One prominent example is the various reforms developed to regulate computer-mediated high-frequency trading (Poirier, 2012; Rojcek and Ziegler, 2016). Hence, this paper will conclude with a discussion of institutional context and policy implications.

The remainder of the paper is organized as follows. Section 2 briefly discusses the concepts and definitions of financial innovations, and how they interact with technological innovations. Section 3 presents several specific examples of the interactions between the two types of innovations in ancient and early modern times. Section 4 summarizes such interactions in modern financial markets, particularly since the 1970s. Section 5 provides an overview of the modern FinTech era. Section 6 summarizes accepted papers in this special issue. Section 7 concludes with a discussion of the challenges and opportunities for future research as well as setting out some policy implications.

2. Background information

2.1. What are financial innovations?

To acquaint the audience of *Research Policy* with financial innovations, we first summarize the definitions of financial innovations in prior literature to offer an overall picture of "what are financial innovations?" The most broad and inclusive definition is perhaps Tufano's (2003, p. 310): "*financial innovation is the act of creating and then popularizing new financial instruments as well as new financial technologies, institutions and markets*." Given the broad scope and variety of financial innovations and taxonomies, we do not intend to go into further detail here. Instead, we would refer readers to Finnerty (1988, 1992), Tufano (1995, 2003), Frame and White (2004), Duffie and Rahi (1995), Allen (2012), and Goetzmann (2017) for more comprehensive reviews of financial innovations.

Various definitions have been proposed in the literature to reflect different perspectives and changing features of financial markets. We classify those in three ways to capture the different ways of thinking and interpretation of finance scholars. The first group focuses on broad economic concepts, which often starts from existing limitations or regulatory environments. For instance, Silber (1983), Merton (1992), Duffie and Rahi (1995), Frame and White (2004), and Allen (2012) defined financial innovations as new ideas or methods through which financial tools may help to correct certain kinds of financial constraints, market inefficiency, imperfection, information asymmetry, tax, transaction costs, and risk. These concepts can be extended to cover the innovations driven by customer needs and competition pressure. For example, Tufano (2003) and Frame and White (2004) defined financial innovations as an ongoing process whereby financial service providers try to satisfy market needs and to differentiate their products and services to survive and maximize profits in a competitive business world.

The second group of definitions focuses on the format and specific goals of outputs, i.e., particular new products/services and applications

[3] One possible reason for this gap in the literature could be the specialization of economics research that resulted in certain language barriers or even segregation between industrial organization (IO) economists and financial economists (Frame and White, 2004). A limited number of prior publications touched on the coevolution of both innovation types, such as Silber (1983), Merton (1990, 1995), Berger (2003), Tufano (2003, pp. 321–324), Laeven et al. (2015), Frame et al. (2018), and Goldstein et al. (2019, Section 4.2).

[4] For example, the Bayh-Dole Act and the new regulation of pension funds in 1980 basically established the U.S. VC industry.

[5] For instance, after Black Monday, which was triggered by program trading, stock exchanges developed "circuit breakers" to halt trading temporarily in the event of sudden large price falls. In addition, the new accounting rule "FAS 123R" was enacted in 2005 to prevent the use of option grants, a common compensation structure in high-tech firms, from damaging shareholders' interest (Mao and Zhang, 2018).

to real-world financial problems. For instance, Finnerty (1988) defined financial innovations as new forms of financial instruments, securities, processes, or solutions for specific finance problems for individuals and organizations, and set out a comprehensive list of such innovations. Similarly, Lerner (2006) organized news stories in the *Wall Street Journal* to categorize financial innovations.

The third group of definitions focuses on the legal format of financial innovations. Some prior researchers define financial innovations in the form of patents when their documentation includes textual information related to financial innovations (Chen et al., 2019), when they are assigned to firms in the financial industry (Lerner, 2002), or when they are assigned in certain specific classes in a patent office classification scheme (Hall, 2009; Lerner, 2006; Hall et al., 2009).

2.2. How do financial innovations interact with technological innovations?

The effects of technological innovations on financial innovations are omnipresent, as summarized by Frame et al. (2018, p. 2): "*Financial intermediation has changed dramatically over the past 30 years, due in large part to technological change.*"[6] These effects can be discussed from both supply and demand sides. Innovations in technology space serve as a "supply side" shock to financial markets and may lead to financial innovations (Tufano, 2003; Frame and White, 2004). The combination of the Internet, semiconductors, and telecommunication technologies enabled the ATM, online banking, and FinTech. On the demand side, the uncertain R&D tasks undertaken by entrepreneurs with the rise of ICT and biotechnologies created special funding needs, which were greatly facilitated by the surge of venture capitalists (VCs). With the business success of those ventures, their equity issuance through initial public offerings (IPOs) also created opportunities for financial intermediaries to develop new instruments to bridge needs and diversify risk.

It is worth noting that technological innovations also broke down existing barriers, created new competitors for existing players, and changed the industrial structure of the financial sector (White, 2000; Goldstein et al., 2019). Silber (1983) and White (2000) discussed how new technologies enabled some players to circumvent existing regulatory restrictions, which is a special form of financial innovations. In more recent times, the launch of online peer-lending and of crowdfunding platforms both opened the door for individuals and penetrated traditional banks' and VCs' businesses.

The effects of financial innovations on technological innovations also work through both supply and demand side channels. The supply-side effect of financial innovations appears intuitive and has been discussed since Schumpeter (e.g., King and Levine, 1993; Bofinger et al., 2021). In addition, various inventions in modern financial markets that help transfer financial resources to productive firms contributed to technological development (Frame and White, 2004). On the demand side, financial innovations also expanded the need or even created new markets for technological inventions. Merton (1990, 1995) used the term "financial innovation spiral" to describe the phenomenon of how the launch of new securities creates more market demand, and the increased sales of such products reduce transaction costs and improve market liquidity, which further encourages related new products and the use of ICT. A more recent example is how the surge of cryptocurrency offered a growing market for Graphics Processing Units (GPUs) and fueled the growth of GPU manufacturers such as Nvidia and AMD, promoting their further development.

3. Ancient times

Some may think that the interaction between technological and financial innovations is a unique phenomenon in our time — but such interactions can be traced back to our ancestors' time. The connections between those two types of innovations were probably less close or pronounced due to a much slower pace in economic dynamics and technological development in ancient times. In addition, the interactions between technological and financial innovations may not be a major research topic for economic historians. Nevertheless, we have managed to gather representative anecdotal evidence to fill this gap, which may also bring us some new insights.

In the most primitive format of markets, ancient people had transaction needs and started to barter before the time of writing. Archaeologists discovered a financial innovation in Mesopotamia over 5000 years ago: a contract system that is based on a hollow clay ball called "bulla" containing various tokens in different shapes. The numbers and shapes of tokens reflect the units and types of goods involved in a deal, and are consistent with the notches and seals crafted by both parties on bulla — they verify each other to prevent falsification, just like blockchain does today (Goetzmann, 2017).[7] This discovery illustrated how ancient people could use clever designs with hand-carved signatures to create contracts, the most primitive form of financial innovation, even before the invention of writing. In fact, writing itself was a technological innovation that co-developed with financial record-keeping and business correspondence in ancient Mesopotamia (Oppenheim, 1964).

Agriculture is often considered as one of the most influential innovations of all humankind in the prehistoric period. In agricultural civilizations, people have crop reserves and settle to form a preliminary society that leads to the division of labor, exchange of goods, and the emergence of a ruling class — all leading to the development of contracts and currencies. The agricultural revolution resulted in an increasingly large population, in which a ruling class arose. The tax needs of the ruling class and the transaction needs of the increased population naturally led to the creation of official currencies that were legitimized by the rulers to store value.[8] One of the earliest official currencies was the "cowrie shell", which was widely used in many areas, and its related official government records can be traced back to the Shang dynasty in China before 1000 BCE (Yang, 2018).

An interesting technological development for recording a debt or credit was the tally stick, a notched stick split into two parts, stock and foil, that could be used to verify that the foil-holder owed the stockholder a given amount (signified through the markings across the matched stick pieces), where the unique features of the physical stick deterred counterfeiting, and where the stock came to serve as a form of money, greatly facilitating commerce. An additional benefit is that tally sticks could be used by illiterate people, helping to broaden access to this financial instrument. Tally sticks were used in many regions of the premodern world and were fully institutionalized in the British Isles from about 1100 until the 19th century (Rosenswig, 2025).

The introduction of cash notes, i.e., currency printed on a piece of paper, is another important financial innovation. This invention greatly enhanced the circulation and exchange of goods in the ancient world.

[6] Similar arguments have been made previously in the literature. For example, Finnerty (1988, p. 30) observed: "*It seems likely that further technological advances will lead to more efficient systems for effecting financial transactions and for managing cash balances.*" A few years later, Tufano (2003, p. 321) noted: "*Shocks to technology are thought to provide a 'supply-side' explanation for the timing of some innovations. Advances in information technology support sophisticated pooling schemes that we observe in securitization.*"

[7] Also see: https://www.bbc.com/news/business-39870485

[8] Aristotle stated in Politics I.IX.: "*When the inhabitants of one country became more dependent on those of another, and they imported what they needed, and exported what they had too much of, money necessarily came into use.*" (source: https://la.utexas.edu/users/hcleaver/368/368AristotlePolitics.html)

"Chiao-tzu" or "Jiaozi" was introduced in the (Northern) Song dynasty in China in the early 11th century (Sun, 2023).[9] The success of these first government-issued cash notes that were circulated at large scale can be attributed to the advanced copper-plate printing technique developed at about the same time that effectively prevented counterfeiting money (Zhang, 1998).

The Knights Templar, a Catholic military order which was established shortly after the First Crusade to protect safe passage from Europe to Jerusalem, set up the first international banking system. The system allowed pilgrims to travel between cities without physically carrying all their valuables (Ayres, 2020). The traveler could leave his valuables in one Templar house, receive a "letter of credits" and present this letter in another Templar house to withdraw the equivalent cash. This system was viable based on a cryptographic technology: the letters were encrypted with a cipher alphabet based on an encryption system devised by the Knights Templar to protect their communications.

Another important technological innovation in pre-modern Europe (13th to 16th century) was the adoption of Hindu-Arabic numerals, including their use in representing fractions (Danna et al., 2022). This was a substantial improvement over Roman numerals, particularly for business calculations. This innovation was a key enabling technology for a variety of process improvements in banking and commerce that came to be known as the "commercial revolution", including bills of exchange, distribution of profits and losses according to shares, and various insurance contracts. Danna et al. (2022) find that the adoption of this technology in schools of practical mathematics in particular towns was associated with significant local economic growth.

Later, the combination of the compass, naval architecture, cartography, and astronomy made long-distance sailing possible, which resulted in profitable global trade in the Age of Discovery (de Jong, 2016). The great uncertainty of long-distance voyages led to three major financial innovations for risk diversification: limited partnership, the issuance of "stock shares", and insurers (such as Edward Lloyd's coffee house) (Gelderblom et al., 2013; Maitland, 2019). Such innovations also encouraged more venture voyages, which promote related technologies and result in an upward spiral of finance and technology (Carlos and Nicholas, 1988; Acemoglu et al., 2005).

In the industrialization era, the birth of investment banks (sometimes called industrial banks) is certainly a key innovation in the financial sector that also led to technological innovations. Instead of traditional banks' role in financing and facilitating trades, investment banks focused on financing the capital needed, in both shareholding and lending formats, for entrepreneurs to adopt industrialization for mass production. In Germany, *Kreditbanken* started to play an active role in industrialization, supporting risky, innovative ventures through playing both commercial banks' and investors' roles from about 1850 onwards (Da Rin, 1996; Festré and Nasica, 2009). In the United States, John Pierpont Morgan, who spearheaded the investment banking industry beginning in 1861, was the first sponsor (albeit withdrawn later due to the escalating budget) of Nikola Tesla's Wardenclyffe station for trans-Atlantic wireless communication (Carlson, 2013).

Overall, this section gathers credible historical evidence to offer a long-term, historic perspective on the coevolution of technological and financial innovations. When we look back at history, most of the time it was seemingly technological innovations that motivated financial innovations rather than the other way around. This could be due to the slow rate of capital accumulation before industrialization, which makes it difficult for the government and society to establish financial markets, let alone for innovations to appear in such markets. Another possibility is that those participants in ancient capital markets mainly focused on monopolistic rents and economies of scale, and were unaware of the rents to be derived from technological innovations. Moreover, the lack of protection of intellectual property (IP) made entrepreneurs and financial market participants less interested in innovating or disclosing IP that is necessary for further advancement.

Nevertheless, we find strong evidence for financial innovations' influence on technological innovation as capital accumulated from global trade and industrialization. For the upward spiral between technological and financial innovations as discussed earlier, we show that the emergence and prevalence of trade and financial markets triggered such an upward momentum. In summary, our collection of anecdotal evidence highlights the following: first, technological and financial innovations started to interact with each other long before the modern era, and second, such interactions accelerated with capital accumulation and gained momentum as we move toward the modern economy.

4. Modern financial markets

We now move on to modern society with more developed financial markets for more evidence on the coevolution between financial and technological innovations. We primarily focus on their interactions from the 1970s to around 2008, and will discuss major developments in chronological order. It is noteworthy that we have much richer data and more academic research in this period, which allows us to discuss not only the co-development of technology and finance, but also their consequences and the roles of policies and regulations.

4.1. Venture capitalists (VCs)

The history of VCs can be traced back to the foundation of American Research and Development Corporation (ARDC) in 1946, which aimed at funding promising entrepreneurs mainly in new technologies. ARDC backed many firms that created important technologies, such as Digital Equipment Corporation, which pioneered the production of minicomputers (which were smaller than IBM's mainframes), and Teradyne, Inc., which led in automated testing equipment for electronic components in the burgeoning semiconductor industry.[10] VCs contributed to technological progress through their screening ability with respect to business plans and entrepreneurs, and their monitoring and steering roles in the management and strategies of startups (Hellmann and Puri, 2002; Kaplan and Strömberg, 2004; Laeven et al., 2015; Bernstein et al., 2016).[11] The VC industry has experienced a great expansion since the 1980s thanks to two major regulatory changes: first, in 1979, the U.S. Department of Labor relaxed the investment targets for pension funds, which allowed investing in VCs (Kortum and Lerner, 2000)[12]; and second, the Bayh-Dole Act in 1980, which simplified the patenting of university inventions supported by federal grants, and thus helped generate more patented seed technologies for VCs to invest in. Together, these combined to create significantly more commercialization opportunities for VCs to invest in (Fehder et al., 2025).

4.2. Electronic payment systems

The development of computing technologies continuously increased the availability and convenience of electronic payments and reduced the costs for financial firms and their customers (Berger, 2003). Beginning in

[9] In addition, there was "flying money", which was also printed on paper in the Tang dynasty; however, that money could only be used in exchanges between two particular merchants or offices and was thus not considered as a currency.

[10] https://historycambridge.org/innovation/Venture%20Capital.html.

[11] Laeven et al. (2015) view VCs as financial entrepreneurs who enhance technological innovation and earn rents from their screening ability; more importantly, as technological advancement occurs, old financial entrepreneurs gradually lose their rents and yield to new ones.

[12] In 1979, the clarification of the Department of Labor on the "prudent man" rule in the Employee Retirement Income Security Act (ERISA) explicitly allowed pension managers to invest in high-risk assets, including VCs.

the 1970s, Automated Clearinghouse (ACH) established the first electronic funds transfer network based on IBM mainframes and magnetic tapes. It enabled bank-to-bank electronic retail payments based on tape delivery. This capability was later transferred to the newly commercialized Internet in the 1990s. The integration and development of ACH networks, especially the use of the Internet, made online bill payment, credit cards, debit cards, and online banking all possible (Frame et al., 2018).

4.3. Automated teller machines (ATMs) and debit cards

The substantial reduction in the physical size and costs of computing power in the 1970s and 1980s gave birth to ATMs and debit cards (Silber, 1983).[13] ATMs were first introduced in the 1970s and diffused rapidly in the 1980s (Frame and White, 2014), and they had a great and lasting impact on retail banking even until today. This financial innovation not only dramatically lowered the transaction costs of customers, but also effectively expanded the accessibility of bank services (Berger, 2003; Tufano, 2003).

4.4. Portfolio construction

Portfolio construction includes index funds, exchange-traded funds (ETFs), and personalized portfolios–all of these portfolios were enabled by the advancement of information and computing technologies (Tufano, 2003). The idea of index funds can be traced back to Black and Scholes' (1974) masterpiece, which can be seen as the birth of "market funds" (Tufano, 2003).[14] Wells Fargo was the first to conquer the technical and regulatory challenges and to offer a privately placed equally-weighted S&P 500 fund in 1971. This was later followed by the launch of ETFs: Toronto Index Participations (TIPS) was introduced in 1990, followed by the American Stock Exchange's SPDRs (Standard and Poor's Depository Receipts) which was launched in 1993. The idea was further developed to personalize individuals' portfolios, such as folioFN.[15] All of those inventions are important to investors and society as they facilitate risk diversification and market efficiency, leading to improved resource allocation and financial democratization.

4.5. Online banking and stock trading

With the prevalence of personal computers and the accelerating adoption of the Internet in the late 1990s, online banking became a new arena for traditional banks to compete in (Berger, 2003; Frame et al., 2018). Online banking offers more efficient and less costly services to society (Tufano, 2003). In fact, the advancement of Internet web technology enabled some new banks to start their business as pure "internet banks" without physical sites, which first appeared in 1995.[16] Backed by similar technological infrastructure, online stock trading emerged in the 1990s: digiTRADE and K. Aufhauser & Company created the first online trading platform, WealthWeb, in 1994.[17] This financial innovation removed human brokers and personal contacts (phone or in-person visits) from stock transactions, significantly lowering transaction time and costs (Barber and Odean, 2002). Online trading through home computers connected to the Internet turned stock trading into a mass-market activity.

4.6. Securitization

Securitization is a broad concept and covers all the activities investment banks or other financial firms engage in to construct new securities based on existing ones in order to satisfy specific market demands, to solve information asymmetry problems (Shiller, 2013), or to circumvent regulatory restrictions (Calomiris, 2009). The preliminary format of securitization can be traced back to the 1920s, but its widespread adoption occurred in the 1970s and 1980s (Lerner and Tufano, 2011). For instance, the mortgage-backed security (MBS) was first issued by Ginnie Mae in 1970, and the tranched structure was first used in the collateralized mortgage obligation (CMO) issued by Freddie Mac in 1983. As the feasibility of securitization depends on efficient and timely calculation, the limit of securitization is bounded by (affordable) computing and information technologies (Merton, 1990; Tufano, 2003). It is thus the technological progress, together with regulatory limitations, that defines the boundary of securitization.

4.7. Derivatives

Merton (1990, 1995) discussed how advancements in ICT enabled real-time processing and valuation of contingent claims, which lays the foundation for various derivatives such as futures, options, and swaps. He also used the term "financial innovation spiral" to describe the positive loop: the creation and availability of new derivatives promote more custom-designed financial products; the sellers and buyers of those products hedge their exposures by trading more, which increases the market depth and reduces transaction costs; increased volume and lowered costs further encourage the development of new derivatives and trading strategies. This spiral also leads to higher demand and shorter learning cycles for financial institutions' adoption of new ICT technologies.

On the other hand, the use of derivatives prompts corporate innovations in two ways. First, the options have been widely used in high-tech firms to incentivize executives and rank-and-file employees to engage in risky investment in innovation (Chang et al., 2015). This prevalence of option-based compensation was, however, mitigated by a new U.S. accounting regulation, FAS 123R, in 2005 that mandated employee options to be priced at fair values to prevent them from diluting shareholders' interest (Mao and Zhang, 2018). Second, the use of derivatives shields firms from economic uncertainty and thus secures their long-term investment in activities such as R&D (Hsu et al., 2022).

4.8. Programmed and algorithmic trading

Automatic trading strategies prevail in modern financial markets thanks to a combination of developments in various areas including academic research (finance, mathematics, and statistics), communication systems (Internet and cable), and computing power (software and hardware). We focus on the earliest version of automatic trading strategies — the program trading in the 1980s. Such trading strategies include "portfolio insurance" and "index arbitrage" (Shiller, 1988; Carlson, 2006).[18] These trading strategies became popular given escalating computing power in the 1980s and were further facilitated by the automatic order processing systems of stock exchanges.

The prevalence of program trading, together with a series of negative

[13] As former Federal Reserve Chairman Paul Volcker (2009) puts it, although perhaps in a somewhat sarcastic way, "*The most important financial innovation that I have seen the past 20 years is the automatic teller machine, that really helps people and prevents visits to the bank and it is a real convenience.*" https://nypost.com/2009/12/13/the-only-thing-useful-banks-have-invented-in-20-years-is-the-atm/.

[14] The market fund denotes the creation of a portfolio that holds the whole stock market or tracking the index that captures the change of the total value of the market.

[15] https://www.forbes.com/global/2001/0205/066.html.

[16] The first internet bank website was introduced in 1995 (DeYoung, 2005).

[17] https://en.wikipedia.org/wiki/Electronic_trading.

[18] Portfolio insurance offers the theoretical possibility to create new financial instruments based on existing assets and securities, under certain economic and statistical assumptions (Shiller, 1988). The index arbitrage was designed to create profits from exploiting discrepancies between the value of stocks in an index and the value of the stock-index futures contracts (Carlson, 2006).

reports on macroeconomic conditions, led to the stock price crash on October 19, 1987 or "Black Monday" as it became known (Brady, 1988). The automatic trading strategies, together with selling pressure at opening on that day and different clearing and settlement timelines of stock, options, and futures markets, formed a perfect storm that resulted in a cascade effect (Shiller, 1988; Carlson, 2006). After the crisis, regulators revised trade-clearing protocols and introduced "circuit breaker" rules to halt trading in the face of exceptionally large price declines.

As an extension of program trading, a new class of traders who implemented "High-Frequency Trading" emerged, based on specific technological breakthroughs: high-speed hardware, algorithmic trading, low-latency cables, and physical "colocation" of trader servers within exchange data centers to minimize transmission time (e.g., Hendershott et al., 2021). Such trading allows some investors to arbitrage between markets, and has been considered by some as a contributing factor behind the Flash Crash on May 6th, 2010, although there is an ongoing debate about this (e.g., Poirier, 2012; Kirilenko et al., 2017; Baldauf and Mollner, 2020).

4.9. Special purpose acquisition companies (SPACs)

A SPAC is a modern form of "blank check" companies that started in the 1990s (Bryant and Schwert, 2024). A SPAC goes public to raise funding from investors with certain plans but at that stage does not have its own businesses. After its IPO, it hunts for a private startup to buy or merge with. After the merger, the startup instantly becomes a public company without going through the traditional IPO process. This instrument has been used by many high-tech startups to acquire large-scale funding. For instance, in 2021, Lucid Motors merged with Churchill Capital Corp IV (CCIV) having issued an IPO in 2020, enabling the former to immediately receive $4.4 billion in growth capital for the manufacturing of its luxury electric sedan.[19]

4.10. Platforms for lending and investment matching

Information exchange technologies enabled banks and potential creditors to share information (e.g., credit scores) and thus facilitated the financing of small business (Berger, 2003). The nascent development of online platforms and mobile devices (and apps) at the start of the new century created a new and efficient form of markets for fund-raisers and investors, especially for small-sized deals. Marketplace lending matches borrowers who need a loan to a group of people who are willing to offer a part of that loan (Frame et al., 2018), and crowd funding matches entrepreneurs to a group of investors who are willing to take a share of the ventures (Shiller, 2013). Such platforms design programs to simplify and standardize applications and exploit machine learning and AI tools to analyze the risk to borrowers and investors, all of these facilitating the financing of ventures and encouraging more entrepreneurial activities (Hendershott et al., 2021).

4.11. Summary

With rich data and analyses available in modern financial markets, we find abundant evidence for the escalating interactions between financial and technological innovations over the past half century. Our review can be summarized as the following. First, governments' interventions and influences are clearly observed and highlight the role of policies in the co-development of finance and technology. We also note that governments were more passive in terms of reacting to innovations that span across financial and technology sectors, which tend to be more complex and require cross-department coordination. Second, financial market participants were good at exploiting new technologies to create various financial products. The economic incentive of those participants greatly shortened the time lag between technological innovations and financial innovations, which amplifies both the benefits and negative consequences (if any) from the synergies between the two types of innovations. In addition, many of these technology-enabled financial innovations broadened market participation and access to financial services. Finally, despite the occurrence of bubbles, financial innovations exhibited strong and resilient growth in the past few decades and, in some areas, led and shaped technological changes. This observation not only confirms the increasingly important role of financial markets in technology landscape, but also echoes the "power of market forces." As financing activities basically reflect investors' prospects for the future, the flow of inventions in finance may actually enable financial markets to have greater influence on the trajectories of technological innovations than do consumers.

5. The FinTech and AI era

Since around the time of the 2008 global financial crisis, a new wave of FinTech innovations has transformed how financial services are produced and delivered. Compared with earlier waves centered on telegraphy, mainframe computing, or electronic trading, this wave is characterized by four intertwined technological developments: ubiquitous mobile devices and cloud computing, data-rich digital platforms, blockchains and programmable ledgers, and advances in machine learning and more broadly, Artificial Intelligence (AI). At the same time, new financial products and business models—ranging from services delivered through super-apps (which integrate financial services into traditional consumer goods market platforms) to decentralized finance (DeFi)—have fed back into the trajectory of these technologies by shaping demand for computing power, data, cryptography, and algorithmic tools.

Unlike the previous sections, where chronology is the most natural organizing principle, the contemporary FinTech and AI era is best understood through a set of cross-cutting mechanisms that now interact simultaneously. We therefore overview the core themes in this latest coevolution of finance and technology over the past two decades. We discuss the emergence of (i) digital ecosystems and super-apps, (ii) "data economy" and crowd-based platforms, (iii) decentralized and on-chain finance, and (iv) autonomous systems and intelligent machines that economic decision-making increasingly relies on. We then return to regulation and public policy in the FinTech and AI era, echoing the policy discussion in the prior section. Across the themes discussed below, a common pattern recurs: a new technological capability enables new forms of finance; those financial innovations in turn redirect technological effort, and new governance problems emerge as markets reorganize around the new technology.

5.1. Ecosystems and super-apps

The first salient theme is the migration of financial services into broader digital ecosystems. Rather than interacting with banks or brokers in isolation, many households and firms now access payments, credit, savings, and insurance through platforms that also provide shopping, transportation, communication, and other daily services, through so-called super-apps. The rise of these super-apps is especially prominent in emerging markets. On the technological side of these super-apps, smartphones, QR codes, digital identity, and cloud-based APIs make it feasible to authenticate users, route transactions, and integrate multiple services in real time. On the financial side, these platforms experiment with new contract forms and pricing schemes, such as small-ticket credit, loyalty-linked discounts, and "zero-fee" payments cross-subsidized by other activities on the platform. Economically, the building of ecosystems and the bundling of services constitute an important part of the business strategies for digital platforms.

[19] Source: https://ir.lucidmotors.com/news-releases/news-release-details/lucid-motors-and-churchill-capital-corp-iv-close-business/.

These developments have generated substantial increases in household participation in financial markets and formal economic activity in rural and less developed regions, as documented for example in the expansion of digital payments in India (Bachas et al., 2018; Alok et al., 2024). Specifically, the diffusion of ICT technology in developing countries has generated a burst of mobile phone-based financial services innovation (van der Boor et al., 2014; Lashitew et al., 2019). van der Boor et al. (2014) find that much of this is user innovation, suggesting that the coevolution of ICT and FinTech has not only spurred innovation, but has democratized it as well (von Hippel, 2005). Furthermore, Lashitew et al. (2019) show that the widespread adoption of these innovations can depend heavily on the co-development of a supportive institutional environment.

Ecosystem innovations illustrate how technological and financial innovations reinforce each other, be it for payment-credit or peer-to-peer risk sharing (Bian et al., 2022; Fang et al., 2024; Bian et al., 2025). More broadly, digital platforms increasingly serve as distribution channels for financial products: FinTech platforms have rapidly become a major intermediary for mutual fund distribution, reshaping investor behavior and competition among asset managers (Hong et al., 2025). Hence, China was able to leapfrog many developed economies in terms of digital payments and platform finance because private technology firms developed payment ecosystems in a relatively permissive regulatory environment during the early stages of FinTech development (Chorzempa and Huang, 2022; Han and Wang, 2025).

Closely related is the rise of embedded finance and API-based modularization. Technological advances in APIs and cloud infrastructure allow financial functions—such as accepting payments, offering installment credit, or providing basic insurance—to be "plugged into" non-financial apps and websites. Balance sheet capacity and regulatory licenses remain with banks or specialized intermediaries, but customer interaction, data generation, and product design increasingly occur at the edge, inside e-commerce, mobility, or software-as-a-service platforms. This modular structure feeds back into both sides: financial institutions invest in technology to expose their services via APIs, while technology firms adjust their architectures and business models to incorporate financial modules.

From the perspective of coevolution, ecosystems and embedded finance blur the boundary between "financial" and "technology" firms. Financial firms' competitive advantage depends not only on capital and risk management but also on control of interfaces and data flows. At the same time, the concentration of payments and credit inside a few large ecosystems raises familiar questions about market power, exclusion, and systemic risk, an issue we return to in the regulatory discussion.

As in earlier historical episodes such as the rise of merchant finance or venture capital, digital ecosystems illustrate how new technologies initially expand financial functions and, once established, reshape the direction of subsequent technological development through scale, data accumulation, and platform governance. Precisely because digital ecosystems organize payments, credit, and consumption within common interfaces, they also generate the dense behavioral and transactional data that become the key input into the next stage of coevolution: the data economy.

5.2. Data economy and crowd-based platforms

A second, and natural progression, is the emergence of a "data economy" that reshapes how financial services are provided. Digital payments, online lending, trading platforms, and usage-based insurance all generate large volumes of data about users' behavior and economic activity. Technological progress in storage, distributed computing, and machine learning has made it cheap to collect and process these fine-grained data, turning them into a central input to financial production.

Recent theoretical work treats data explicitly as a form of capital and a key production factor, highlighting its non-rival nature and broad welfare implications (Jones and Tonetti, 2020; Cong et al., 2021c). Related work highlights how the financial sector plays a central role in generating and utilizing large datasets, with financial institutions investing heavily in data technologies to improve forecasting, risk management, and asset allocation (Begenau et al., 2018; Farboodi and Veldkamp, 2021). In such models, data and financial activity reinforce each other: more transactions generate more data, which improves services and attracts more users and thus more transactions. The resulting feedback loops help explain why many FinTech platforms initially invest heavily in user acquisition and data infrastructure, sometimes at the expense of short-run profits.

More broadly, the digital economy literature emphasizes that data has become a central driver of innovation, competition, and market structure in modern economies (Goldfarb and Tucker, 2019). Because financial platforms generate high-frequency, high-stakes data, they create direct incentives for advances in privacy-preserving computation, secure identity, cloud infrastructure, and explainable AI.

Crowd-based financial platforms are a particularly vivid manifestation of this data economy. Marketplace lending sites, crowdfunding platforms, and communities of "financial influencers" rely on digital technology to match users and to extract signals from their behavior. Advances in machine learning, natural-language processing, and cloud computing allow these platforms to transform transaction records, social interactions, and user-generated content into credit scores, pricing rules, and investment recommendations. Financial innovations here consist not only of new contract forms—peer-to-peer loans, project-backed tokens, or performance-linked fees—but also of new ways to harness and monetize information.

Recent research highlights how crowd-based financial platforms aggregate dispersed information and generate platform-specific network effects. In marketplace lending, long-term contracts, default risk, and lender diversification create network externalities on both sides of the platform, though with some important asymmetries, in particular with lender-side network externalities being especially informative about platform adoption and survival. In crowdfunding, minimum funding targets change how information aggregates: early supporters effectively delegate to a gatekeeping mechanism, generating information cascades that affect pricing, project selection, and implementation outcomes (Cong and Xiao, 2024).

Crucially, the exponential growth of these crowd-based interactions generates unprecedented volumes of behavioral and financial data, creating a vital feedback loop to technological development. The need to process sensitive financial data at scale spurs research and the adoption of privacy-preserving computation, encryption, and secure identity solutions. Simultaneously, the regulation of data ownership, portability, and privacy—such as open-banking regimes and data-protection rules—shapes which business models are viable and where innovation efforts are directed. Thus, financial and technological trajectories are jointly determined by how data are produced, governed, and used in the context of specific policies and regulations.

5.3. Going decentralized and going on-chain

A third major development in the coevolution of finance and technology is the migration of core financial functions—record-keeping, settlement, collateralization, contracting, and governance—from institution-specific ledgers to shared digital ledgers, referred to as moving "on-chain". Bitcoin, born during the great financial crisis, showed that payments could be validated through decentralized consensus rather than a centralized operator; Ethereum extended this architecture by enabling programmable smart contracts, making it possible to build exchanges, lending protocols, stablecoins, asset-management protocols, and new forms of organizational governance directly on-chain. In this sense, the rise of cryptocurrencies, decentralized finance (DeFi), stablecoins, tokenized assets (off-line assets converted to digital tokens on a blockchain), and central bank digital currencies (CBDCs) and similar on-chain developments are best

understood as a broader reallocation of trust from a single intermediary toward code, cryptography, distributed validation, and new hybrid governance arrangements.

The tension between decentralization and centralization should be understood at four distinct levels: (i) consensus, (ii) asset and wealth, (iii) information, and (iv) governance. At the consensus layer, blockchains replace centralized book-keepers with miners or validators. Decentralized consensus can occur in equilibrium, altering the informational environment and competitive structure (Biais et al., 2019; Cong et al., 2021a). In terms of on-chain asset and wealth, it is unclear if blockchain-based systems are less concentrated than the real economy or traditional financial markets. At the information layer, blockchains depend on oracles[20] to import off-chain and cross-chain data (Cong et al., 2025b). At the governance layer, decentralized autonomous organizations replace boards and managers with token-based voting, yet voting power in practice is often highly concentrated and can reproduce blockholder-style control and insider conflicts within ostensibly decentralized organizations.

The emergence of decentralized finance also led to the development of a new economic design field known as Tokenomics (Cong et al., 2021b). Rather than serving merely as speculative assets, tokens can function as media of exchange, financing instruments, governance tools, and security mechanisms within blockchain ecosystems. They also form distinct categories based on their economic functions and empirically have different asset return dynamics (Cong et al., 2025c). Together, this literature shows that tokenomics is not just a matter of protocol design, but a core part of the economic architecture, asset pricing, and the industrial organization of digital-asset markets.

A closely related development is the migration of money and traditional assets to on-chain forms. Stablecoins, on-chain currencies that are pegged to external assets such as the US dollar, have become the primary settlement asset in many DeFi markets (e.g., USD-pegged stablecoins like USDT, USDC, and DAI are used in Uniswap and Curve, see Cong (2025b), not only because of their price stability and link to legal currencies but also due to their programmability and interoperability with smart contracts. More broadly, tokenization now extends to Treasuries, money market funds, gold, equities, and private credit (Cong et al., 2025d). CBDCs and tokenized deposits represent the public-sector counterpart to this trend: early evidence from China's e-CNY pilot shows increased wallet adoption and transaction activity but continued reliance on existing payment platforms, highlighting both the potential and the governance challenges of programmable public money (Bai et al., 2025).

As trading, lending, settlement, and tokenization moved on-chain, financial demand began to push advances in consensus design, oracle infrastructure, wallet security, and privacy-preserving verification. Viewed historically, the rise of on-chain finance parallels earlier episodes in which new technologies reconfigured trust, verification, and market access. The difference today is the breadth of the migration: payments, capital raising, settlement, collateral, governance, and asset ownership are all being redesigned simultaneously. The resulting system is neither purely decentralized nor simply a digital replica of traditional finance. It comprises a hybrid architecture in which technological innovation reshapes financial contracts, while financial demand in turn drives advances in consensus, oracle design, privacy-preserving computation, wallet infrastructure, and regulatory technology.

5.4. AI, automation, and machine decision-making in finance

The FinTech era is increasingly also an AI era. If blockchains reconfigure the architecture of trust and verification by creating programmable assets and contracts, AI reconfigures the architecture of financial decision-making. Machine learning, large language models (LLMs), and generative AI increasingly interpret information, recommend actions, generate content, and sometimes act on behalf of users or institutions. Finance is a particularly powerful setting for this transition because it combines large structured and unstructured datasets, rapid feedback, and relatively clear performance metrics in a largely digital environment. In fact, AI is now applied to credit underwriting, fraud detection, disclosure analysis, portfolio construction, trading, risk management, compliance, and customer service. Conceptually, the key shift is from static rules and narrow prediction tasks toward adaptive systems that learn from data and interaction. Accordingly, AI is not simply another digital tool layered onto finance; it is becoming a new general-purpose technology for financial intermediation and decision-making (e.g., Bartram et al., 2020; Kelly and Xiu, 2023; Berg et al., 2020).

One important strand concerns AI as a tool for financial information processing. Here, recent work by Wei Jiang and coauthors is especially instructive. Cao et al. (2024) show that AI can outperform most human analysts when the information environment is transparent, multidimensional, and voluminous, whereas human analysts remain relatively strong when institutional knowledge, soft information, or intangibles are central. Most importantly, the strongest performance comes from combining the two. A related feedback effect appears on the issuer side. Cao et al. (2023) show that as machine readership rises, firms adapt their disclosures to become more machine-friendly and to reduce linguistic cues that algorithms classify unfavorably. Finance therefore does not merely adopt AI; it also changes how economically relevant information is produced, formatted, and strategically communicated in response to AI.

A second strand goes beyond prediction toward machine decision-making. Cong et al. (2019) and Campello et al. (2022) introduce the earliest non-text-based GenAI models in finance to optimize (utilizing deep reinforcement learning and self-attention architecture that underlie modern AI) financial policies end-to-end from arbitrary economic objectives, for investments and managerial decisions. Smaller and more interpretable AI models for understanding heterogeneity in economic panel observations in a data-driven manner (as opposed to human-specified structures) has also been developed in parallel (e.g., Cong et al., 2025a). The broader implication is important for both practice and theory. The next generation of robo-advising and management think tanks are likely to be less about simple rule-based automation and more about mass customization under explicitly economic objectives. This line of work takes elements of generative modeling and large models to build toward Economic World Models—a simulation-based framework for counterfactual analyses that is different from extant approaches in science or engineering (Cong, 2025a).

AI is also reshaping intermediation workflows and operational decision-making in financially important markets. More broadly, AI often enters financial and quasi-financial services not by eliminating intermediaries but by changing how they search, process information, and coordinate across market participants. At the same time, machine-learning systems increasingly integrate internal operational data—such as inventories, logistics, and production capacity—with external market information on demand, prices, and macroeconomic conditions, enabling firms to coordinate procurement, production, and distribution in near real time and influencing internal capital allocation and transfer pricing across divisions and countries. In this sense, AI increasingly blurs the boundary between financial decision-making and operational management, turning supply-chain and organizational data into inputs for real-time economic optimization (Brynjolfsson et al., 2021; Agrawal et al., 2023).

A further frontier is the rise of AI agents as economic actors in their own right. This requires moving beyond standard forecasting metrics to understand the "behavioral economics of AI" (Bini et al., 2025). For example, aligning LLMs with ethical objectives can materially shift their risk preferences (Ouyang et al., 2024). Once AI systems are asked not

[20] Oracles denote the tools or services that determine which real-world information enters into a blockchain or smart contract system.

merely to summarize information but to advise, screen, allocate, negotiate, or trade, their behavioral properties become economically consequential. AI agents thus deserve to be studied not only as tools, but as a novel class of decision-makers with their own biases, objectives, and interaction effects, in effect, generating a behavioral economics of AI decision-makers. These developments also introduce new systemic risks: shared models and data pipelines can amplify herding and correlated errors, while AI agents may even learn collusive strategies in trading environments without explicit communication (Dou et al., 2025). At the same time, generative systems create new vectors for misinformation such as deep-fake financial news, even as AI also improves with regard to fraud detection and compliance monitoring.

In this sense, AI extends the financial innovation spiral described earlier in the paper, but with a qualitative change. Earlier information technologies mainly transmitted, stored, or accelerated information; modern AI interprets, generates, recommends, and sometimes acts. Finance is therefore becoming both a user of AI and a laboratory in which AI systems are trained, disciplined, and contested. Financial applications generate valuable data, demanding objective functions, and high-stakes settings that offer a testbed to train, discipline, and commercialize frontier AI systems; advances in AI in turn reshape underwriting, advisory services, disclosure, market making, and organizational design. The central research and policy challenge is thus not simply whether AI improves finance, but when it complements human judgment, when it substitutes for it, and when it creates new systemic risks or new and potentially deleterious concentrations of power.

5.5. Regulation of financial and technological innovations

An emerging theme in the FinTech and AI era is that regulation is no longer a background constraint on innovation; it has itself become part of the coevolutionary process. The same technologies that lower the cost of intermediation and experimentation also lower the cost of fraud, manipulation, and synthetic misinformation. Initial Coin Offerings (ICOs) illustrate this duality well: they opened a new channel for financing technological innovations, but also opened up new possibilities for misrepresentation and regulatory arbitrage (Fisch, 2019; Howell et al., 2020). Nevertheless, algorithmic trading systems may learn collusive behavior without explicit communication, and deep-fake financial news can distort investor responses, making purely ex post enforcement increasingly inadequate (Dou et al., 2025). Put differently, the older model of regulating mainly by learning from crises is too slow for markets whose risks propagate through code, networks, and automated content.

These conditions imply that regulation itself must become more technological. RegTech and SupTech denote technologies allowing firms and regulators, respectively, to automate compliance, process larger datasets, and monitor risk closer to real time; in addition, they also reshape market structure rather than merely lowering compliance costs. Charoenwong et al. (2024) show that compliance-driven RegTech raises IT spending, lowers profits, and increases acquisition activity and concentration. At the same time, sandboxes, controlled environments where firms and regulators can test new innovations under relaxed regulatory conditions, serve as experimentation tools for governments to learn. Cornelli et al. (2024) find that UK sandbox participation improved FinTech firms' access to capital and experimentation. Recent Financial Conduct Authority initiatives in the UK such as the Supercharged Sandbox and AI Live Testing make this shift explicit by moving toward data-rich, supervised experimentation for AI systems before large-scale deployment.

Regulation also has a strategic industrial-policy dimension. Clear rules can foster industry growth when they reduce classification risk and coordinate expectations. Ran et al. (2025) show that regulatory clarity boosts digital financing, while Auer and Claessens (2018) find that crypto markets react positively to the creation of tailored legal frameworks. The U.S. GENIUS Act is an instructive example. Enacted in July 2025, it created a federal prudential framework for payment stablecoins and established licensing, anti-money-laundering protections, and rulemaking obligations for implementation. Recent work on stablecoins and banking argues that this kind of framework can integrate stablecoins into the payment system more safely and steer innovation toward infrastructures with strategic public value (Cong, 2025b; Grennan, 2026).

More broadly, financial regulation, innovation policy, and digital governance have become increasingly deeply intertwined. Choices over data rights, interoperability, digital public infrastructure, and AI oversight will shape not only the evolution of financial markets but also the direction of technological progress in areas such as cryptography, cloud computing, and machine learning. Conversely, advances in these technologies will also determine what forms of regulation are feasible and effective. In this sense, regulation in the FinTech and AI era is not merely reactive: it both responds to financial and technological innovations and helps steer the business models and technological architectures that survive.

5.6. Summary

Taken together, recent developments suggest that the FinTech and AI era is characterized less by isolated innovations than by the emergence of interconnected technological–financial ecosystems. While finance played a supportive role in technological development in the past, it is now center stage in the FinTech wave. The surge of super-apps and ecosystems that integrated all financial services as well as collected and monetized user data led to more service technologies that are tailored for individual consumers. In addition, platforms, decentralized protocols, and AI agents simultaneously transformed how financial services are provided, how information is generated and processed, and how markets are designed and operated.

These innovations also “democratized” finance. Customers who were under-served by traditional financial institutes, especially those in emerging countries, were now able to use convenient app platforms to access various financial services. From the big picture, such accessibility has enhanced efficiency in capital accumulation and allocation, which leads to higher social wealth and welfare. Moreover, in addition to firms and regulators, customers also determine the trajectories of both types of innovations nowadays because their profiles and usages can be promptly fed into and analyzed by the systems equipped with AI. In addition, with the prevalence and regulation of DeFi, stablecoins, and central bank digital currencies (CBDCs), we expect more and more customers to be involved and their opinions will further shape the future landscape of finance and technology. On the other hand, the behaviors (and related biases) of users and customers are also important issues calling for further research.

Unlike earlier periods, when financial innovations largely responded to technological changes—for example through derivatives, securitization, or electronic trading adapting to advances in computing and communication—financial innovations today have become increasingly technology-based and technology-intensive. Digital platforms generate vast data infrastructures, decentralized finance stimulates advances in cryptography and distributed systems, and AI-enabled financial applications push progress in machine learning and computing architectures. As a result, finance is no longer merely a user of technology but increasingly a driver of technological innovations itself, creating a tighter feedback loop between financial and technological changes while raising new challenges for governance and regulation.

Our review also suggests several policy implications and challenges, which call for new solutions and create new technology opportunities. The rise and concentration of super-apps and platforms remind us of the necessity for monopoly regulation, which has been a perennial problem but needs new solutions for current technology-based finance. The collection, curation, and exchange of user data also involve privacy concerns and consumer protection, which, again, are subject to encryption and security technologies. The opposite side of the privacy

consideration is the pressing need for anti-money-laundering prevention, taxation, and ownership protection, which require expanded monitoring. Finally, as discussed earlier, regulation has become part of the coevolution of finance and technology, and can function as an important part of industry and technology strategy if policymakers make good use of new technologies (e.g., RegTech, SupTech, and central bank digital currencies) and experimentation tools (sandboxes) to generate needed information and to facilitate learning mechanisms.

6. Summary of papers in this special issue

This historical review brings us to the present special issue. The goal of this initiative is to build from this historical background and explore the co-development of financial and technological innovations, taking advantage of the new data and methods, new research questions and new findings this co-development is generating for the study of innovation.

We can broadly categorize the contributions into the following categories: (i) how technological innovations shaped financial innovations; (ii) how financial innovations facilitated technological innovations; (iii) on-chain financial innovations (i.e., in blockchain-based networks); and (iv) participants' behaviors using FinTech.

6.1. How technological innovations shaped financial innovations

As discussed in our earlier sections, the financial industry has been accelerating in their adoption of new technologies. In this direction, Chen and Samaniego (2026) examine how social networks influence banks' adoption of technologies through shaping customer demand. They show that U.S. banks with more operations in counties of higher social media connectedness (based on Facebook data) are more likely to provide online banking services. Their quantitative analysis thus substantiates the role of spillovers on the customers' side in the development of financial innovations and highlights the importance of "users" in technology diffusion. On the other hand, Yu et al. (2026) investigate how banks' adoption of digital innovations factors in their riskiness using data from China. They find a negative effect and attribute it to improved bank transparency and loan quality based on digital innovations. Their empirical evidence is largely consistent with our discussions on how technological innovations can enhance the efficiency of the finance sector.

Also focusing on the banking industry, Ozcan et al. (2026) adopt a qualitative approach to understand how new entrants and incumbent banks react to the entry of digital banks and platforms in the U.K. Their analyses suggest an important trade-off in different banks' platform strategies: ownership (whether to build the platform in-house) and curation (the platform's degree of openness to external participants). Overall, they present banking-based evidence for the classic "openness-versus-control" issue in the innovation literature, and add new insights to the development of ecosystems. Having said that, the choices between openness and control may not be exclusive. Yang (2026) finds strong, positive stock market reactions to Chinese public firms' releases of open-source inventions. More importantly, such reactions increase with firms' proprietary innovation measured by patents. Her research highlights the key role played by shareholders and equity-financing in technological innovations and sheds light on firms' intellectual property (IP) strategy that bundles various types of IP forms.

Nevertheless, the relation between technological and financial innovations may not always be complementary. Chen et al. (2026b) examine how technological innovations influence financial innovations by analyzing two mechanisms: knowledge spillovers and resource crowd-out. They find an aggregate-level crowding-out effect in 2005–2016 by showing U.S. firms' shift of research focus and corresponding changes in the inventor labor market. Their empirical evidence suggests a substitution effect between the two types of innovations given aggregate resource constraints and highlights the blurred boundary between financial and non-financial innovations.

6.2. How financial innovations facilitated technological innovations

Several studies in this issue provide empirical evidence for the increasingly important role of financial innovations in promoting firms' technological innovations, along various mechanisms. Dimitrova and Eswar (2026) show that U.S. firms' use of foreign exchange (FX) derivative products spurs their technological innovations by mitigating their financial constraints and enhancing their risk management. Using the data of Chinese public firms, Chen et al. (2026a) examine the effect of debt financing capacity on firm-level technological innovations. They exploit a new law in China that increased firms' tangible asset pledgeability as an exogenous shock to firms' debt financing capability, and find stronger increases in corporate innovations among firms with higher asset tangibility. On the other hand, Thakor and Lo (2026) focus on the design of optimal financing contracts for R&D-intensive firms developing new drugs. They propose a novel combination of equity and put options to provide bilateral insurance to firms and investors: investors insure firms against R&D failure and firms insure investors against high R&D payoffs not being realized. This novel financing design receives support from their interviews with industry experts. All these studies highlight how financial innovations alleviate firms' resource constraints and thus spur their technological exploration that eventually promotes technological advance.

However, corporate managers may also act myopically or opportunistically in response to financial innovations. Zhou (2026) discovers a dark side of commodity futures trading in Chinese financial markets: when an industry has been listed in commodity futures markets, firms in that industry innovate less. He attributes such a negative impact to managers' speculation and corporate myopia. Also in the Chinese context, Fan and Huang (2026) show that government involvement in VCs negatively explains target firms' green innovations, a pattern that is more pronounced when those firms are funded by government-supported VCs associated with higher-level governments and located in regions with greater government intervention. They attribute this negative effect to decision makers' career concerns and political capital. Both studies illustrate financial innovation as a double-edged sword and highlight the importance of institutional environments for positive interactions between finance and technology.

6.3. On-chain financial innovations

Harvey et al. (2026) discuss the benefits, risk, and regulation of decentralized exchanges (DEX) based on blockchains, which allow investors to exchange digital assets conveniently. The benefits include ease of trading, transparent pricing terms, simultaneous trade settlement, interconnected exchanges, and market liquidity. On the other hand, potential risks include known blockchain risk, lags in price reactions, and front-runner risk due to the publicity of actions submitted, creating regulatory challenges on DEX users, market places, and participants in block creation process. Overall, their paper explains how DEX are similar to traditional stock exchanges and how they differ.

Malinova and Park (2026) explore how to "tokenize" traditional financial assets, particularly equities, on public blockchains. They highlight the challenges in tokenization of stocks, especially in attributing ownership and related investor rights on blockchain networks without compromising user privacy or usage of decentralized applications. In addition to discussing how current token standards do not yet fully resolve those issues, they also provide some insights on potential effects of such tokenization on traditional financial markets.

Similar to parallel systems in technological innovation, there are also multiple blockchains in DeFi. Due to existence of multiple blockchains, Li and Wu (2026) propose a solution for the arbitrary message passing (AMP) problem; that is, to allow any generic information of a user's choice to be communicated across blockchains. In their paper, the

authors delineate the scope of the AMP problem, develop an analytical model, and explain how their model can be applied to currently emerging projects. This research illustrates how the parallel-system problem, a long-lasting issue in the innovation literature, can be solved from the financial perspective.

6.4. Participants' behaviors in FinTech

Several studies in this issue focus on economic agents' behaviors in FinTech and the resultant managerial and regulatory implications. Using data from programmers' communities (DAppRadar and GitHub), Hu et al. (2026) find that more intensive open-source software (OSS) activities lead to better on-chain performance of decentralized applications (DApps), which is measured by higher user engagement and transaction volume. This study not only substantiates the importance of community interactions and transparency in FinTech ecosystems, but also illustrates a new way to analyze the development of ecosystems in the FinTech era.

While blockchain technologies are widely used by firms, such as for carbon footprint calculation and source certification, they are not immune from strategic behaviors of economic agents. Flor et al. (2026) analyze how firms may use blockchain to disclose information, about their demand signals in particular, to their product market rivals. The authors derive models to account for the effect of competition on firms' information disclosure from joining or setting up a blockchain, and discuss how such disclosure may fail given firms' strategic behaviors.

One common issue with decentralized systems with anonymous identities is how to prevent deviations such as misbehavior. On this front, Braun and Haeusle (2026) discuss new governance mechanisms that ensure different network participants take suitable collective action along the common goals of the networks. They first use a static model to show that conventional majority voting is ineffective in preventing collusion and bribery, and then propose new voting schemes that are both incentive-compatible and bribery proof. On the other hand, Falk et al. (2026) examine the economic impact of crypto wash trading, which aims to manipulate market activity and to exploit these distortions for profit. The authors use public on-chain NFT data for a more direct and granular estimation for such wash trading across exchanges, and show a large volume of trades are likely to involve manipulation. Their empirical evidence calls for a critical reassessment of existing indirect estimations and delivers rich regulatory implications.

7. Taking stock and looking forward

7.1. Scope and limitations of our review

We acknowledge that there are many different types of financial and technological innovations, and it is impossible to cover them exhaustively. Our review therefore selectively focuses on broad categories of financial innovations that either emerged from technological advances or, in turn, stimulated technological development. This focus implies three filtering principles. First, we concentrate on broadly defined financial innovations—such as derivatives, venture capital, decentralized finance, or digital payment systems—rather than specific instruments or option trading strategies (e.g., straddles or butterflies), so as to emphasize their systemic economic roles. Second, we primarily discuss financial innovations whose feasibility and diffusion are closely linked to new technological capabilities, such as computing, telecommunications, distributed ledgers, and artificial intelligence; innovations that could have been implemented with existing technologies, such as incremental portfolio strategies or optimization algorithms, fall largely outside the scope of this review. Third, we focus on innovations that reshaped the structure of markets, institutions, or infrastructures rather than the particular inventions of individual firms or entrepreneurs.[21] Accordingly, while we occasionally reference specific examples to illustrate mechanisms, our goal is to highlight widely diffused innovations and the broader economic processes of coevolution.

7.2. Challenges and opportunities for future research

For researchers in the technological innovation area, a major challenge to understanding financial innovations is how to measure the innovation input, output, and process in financial industries. Their knowledge in traditional metrics such as academic publications, patents, R&D, projects, and scientists may not be applicable or available for financial firms' innovation activity. This challenge may be attributed to the lack of organized data or reliable indicators for the inputs and outputs of financial inventions (Martin, 2016). Creative researchers have started to exploit newly available data, such as financial patents, Github records or the launch of new products, to track financial innovations. Nevertheless, these data and metrics are often available only in some particular sectors and only cover a short period. To promote research in FinTech, we recommend pooling resources from finance researchers, business organizations, and regulators to construct and maintain a platform to promote data sharing and publicizing in this area. Moreover, advances in AI may facilitate the search for new innovation-related metrics appropriate to the financial sector.

We also notice that, while technological innovations have been well-studied from an international perspective, most prior studies of financial innovations focus very heavily on US experiences (Allen, 2012). This situation has gradually changed given the emergence of online banking and FinTech apps in Asia, Europe, and even Africa. Some non-US companies, such as Alibaba, have been willing to share their data with researchers, which greatly enhanced the visibility of financial innovations in mainstream finance journals. We believe that more and better-quality data in non-US areas will enrich our perspectives and deliver richer insights and policy implications, especially for emerging countries.

We can also further develop research in this area by asking which technology-based financial innovations broaden access to financial services, and under what conditions. For example, tally sticks, on-line trading, and mobile banking all seem to have provided access to financial tools among those who were largely excluded from those activities in the past. In contrast, some technologies, such as AI-based price setting in the rental real estate market, seemed designed to undermine competitive markets and disadvantage consumers. Financial innovations have the potential to broadly affect large segments of the population, either directly as in the cases above or indirectly as in the cases of the negative repercussions of credit default swaps, collateralized debt obligations or automated high-velocity trading going badly. As technology-based finance innovations develop, they raise new questions related to equity and governance. We encourage more research in this area as well.

While we have strived to collect anecdotal evidence and academic research, we find a lack of quantitative analyses of the interactions between financial and technological innovations as well as their consequences. This gap in the innovation literature has motivated us to bring together the papers in this special issue, but more investigations are still much needed.

7.3. Policy implications

Financial markets have long been an important pillar of national and regional innovation systems (NIS), yet most work in this area focuses on the level of financial development rather than on the innovation of

[21] This issue is related to an extensive strand of literature on "Who innovates?" (e.g., Ahuja et al., 2008; Hall and Lerner, 2010; Kerr and Nanda, 2015; Block et al., 2017).

financial markets themselves (Furman et al., 2002; Fagerberg and Srholec, 2008). Our review suggests that this distinction has become increasingly important. In the FinTech and AI era, financial innovations should be understood not simply as an outcome of technological changes, but as part of the broader innovation system that shapes how new technologies are financed, scaled, governed, and diffused. This implies that financial regulation, innovation policy, and digital governance can no longer be designed in isolation. Decisions about data rights, interoperability, digital public infrastructure, regulatory sandboxes, AI oversight, and payment architectures now influence not only financial-market development but also the direction of technological progress itself.

From this perspective, an important policy priority is institutional capacity-building. Because many contemporary financial innovations involve novel technologies and business models, regulators often cannot rely on settled rules alone. They must develop the expertise, data, and organizational tools needed to evaluate new activities under uncertainty. This calls for closer coordination across finance, competition, technology, and industrial-policy agencies; greater investment in technical talent within regulatory bodies; and more adaptive instruments such as supervised sandboxes, pilot programs, and data-driven monitoring systems. At the same time, the promotion of financial innovations must be balanced against familiar but evolving concerns over concentration, exclusion, redistribution, and systemic risk. As finance and technology become more tightly coupled, cross-sector spillovers may intensify, making it increasingly important to move beyond purely *ex post* crisis management toward more forward-looking governance that supports experimentation while containing fragility.

7.4. Conclusion

Our historical review suggests that the influence of financial innovations on technological innovations was limited in earlier periods but became increasingly important with the development of modern financial markets. In the contemporary FinTech and AI era, this reverse channel has become broader and more direct. Financial innovations not only create new mechanisms—such as venture capital, SPACs, and ICOs—for financing technological progress, but also generate demand for advances in cryptography, distributed systems, data infrastructure, privacy-preserving computation, and AI itself. In this sense, financial innovations now affect technological progress not only through capital allocation but also by shaping the technological frontier, with regulation increasingly becoming part of this evolving system.

We also note that the coevolution of financial and technological innovations is subject to regulatory and institutional changes. For instance, the relaxation of pension funds' investment in VCs and the Bayh-Dole Act led to a rapid expansion of the VC industry in the 1980s by providing funding and commercialization opportunities, respectively. A more recent example is the implementation of the General Data Protection Regulation (GDPR) in Europe in 2016 that greatly enhanced the protection of users' personal data. While this regulation advocates privacy protection, it also restricted companies' use and sale of their user data, which has been shown to dampen the creation of startups in data-related and business-to-customer industries in Europe (Jia et al., 2021).

We acknowledge the potential peril of the coevolution of financial and technological innovations. History has proven that all kinds of inventions come with experimentation costs and uncertainty. The dark side of financial innovations has been reviewed in Tufano (2003) and Allen (2012). Some financial innovations may be used to exploit innocent consumers. For instance, Henderson and Pearson (2011) show that 64 securitized products issued by Morgan Stanley in the 2001–2005 period provided lower returns than the risk-free rate without carrying any other benefits. Similar products were also found in Asia and Europe (Bergstresser, 2008). In addition, some financial innovations led or contributed to economic crises including the LTCM crisis, the subprime crises, and the flash crash.[22]

The dynamics between financial and technological innovations offers a channel for a potential risk on one side to penetrate into the other, which could create greater or more long-lasting impact on the society. Such cross-dimensional risk spillover is beyond that found in the adoption of a general-purpose technology (GPT) which tends to stay in the "real" sector, and is worthy of further investigations.

We also highlight that the acceleration of financial innovations opens up more research opportunities to scholars and presents challenges to regulations and policy design. The research on financial innovations, especially FinTech, has developed into an important sub-field in the financial literature. Moreover, given its broad applications to various economic activities and academic disciplines, FinTech may also branch out to other existing research fields, such as information systems and operations management. Given their emergence and economic influence, financial innovations deserve more attention from innovation studies researchers (Martin, 2016).

CRediT authorship contribution statement

Lin William Cong: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. **Po-Hsuan Hsu:** Conceptualization, Project administration, Writing – original draft, Writing – review & editing. **John P. Walsh:** Conceptualization, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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[22] Nevertheless, many financial crises were driven by human being's behavior or flawed market designs, and could have happened without financial innovations. For instance, the real estate bubbles listed by Reinhart and Rogoff (2009) suggest that many financial crises were driven by investors' speculation rather than financial innovations.

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