Investing in Fintech Equity and Bank Innovation*

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Abstract

We investigate whether equity investing in fintech startups enhances banks' own innovation and how this relationship varies across domestic and international partnerships. Using a panel of 160 banks and 772 fintech funding rounds from 2005 to 2023, we match Crunchbase deal data with trademarks and patent filings. We find that bank investments in the equity of fintech firms are associated with more bank innovation capabilities. Effects are strongest for domestic investments, consistent with information advantage. The relationship is also stronger when the target firm is fin-native (lending or payments) versus tech-native (data analytics or reg-tech). These findings suggest that strategic equity stakes may serve as a technology-sourcing channel, informing ongoing debates on bank–fintech partnerships and international diffusion of financial technology. Our findings carry significant implications for policymakers, bank executives, and entrepreneurs alike.

Keywords: Bank innovation, Fintech financing, Equity investment, Strategic alliance

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1 Introduction

Financial technology (Fintech) startups provide innovative ways to perform traditional financial services. As a result, many banks seek to foster their innovation through equity ownership in fintech firms (Drasch et al., 2018). Such an investment in innovation, whether done directly by the bank or indirectly through a venture capital firm that the bank owns, might also help to modernize the bank's product suite. For example, in a recent study, Babina et al. (2024) highlight how JP Morgan's investment in innovation has enabled it to integrate artificial intelligence (AI) technologies in its core product line.[1]

Equity investment could be an effective way of collaboration between banks and fintech firms, especially if utilized as a control-oriented innovation strategy.[2] Such strategic initiatives could enable banks to align the services and products of fintech firms with their own through board positions (Hornuf et al., 2021). However, the literature has identified several challenges that prevent banks from effectively exploiting collaboration with fintech firms. These challenges include strategic misalignment (Riikkinen and Pihlajamaa, 2022), regulatory landscape (Hornuf et al., 2021), considering fintech firms as vendors (Meinert, 2017), and agency costs (Stulz, 2019). Therefore, despite the perceived benefits of collaborating with fintech startups, the real effect of this collaboration on bank innovation requires further investigation.

In this paper, we investigate how banks' participation in the equity funding rounds of fintech startups relates to their own innovation outcomes. While recent years have seen growing interest in bank–fintech collaboration (Kwon et al., 2024; Li et al., 2023; Bellardini

[1]Other notable examples include the US Bank which announced in 2021 its ownership stake in two venture capital firms that specialize in fintech startups (U.S. Bank, 2021). The bank has noted in its announcement that these partnerships enable it to obtain necessary innovations without undergoing the lengthy, risky, and challenging process of creating technology from scratch. Additionally, Live Oak Bank has established a venture capital company named Canapi Inc., which aims to invest in and collaborate with fintech startups that provide banks with innovative platforms (Callison, 2019).

[2]Bank-fintech collaboration can take several forms including acquisitions, alliances, incubation, and joint ventures (Drasch et al., 2018). Acquisition can be defined as the purchase of a majority stake in the target firm. An alliance is a contractual agreement between two parties to share resources to achieve common goals. Incubation is the fostering of early-stage startups. A joint venture is a business arrangement in which partners create an independent firm.

et al., 2022; Hornuf et al., 2021; Del Gaudio et al., 2024; Zheng and Mao, 2024), the implications of such partnerships for bank innovation remain underexplored. Zheng and Mao (2024) touch on this issue, but from a different angle, focusing on short-term market reactions to fintech mergers and acquisitions (M&As) involving a limited sample of 14 banks. Their analysis includes public banks, nonbank financial institutions, and tech firms as acquirers, without examining long-term innovation outcomes. To address this gap, our study provides a more targeted and comprehensive examination of the relationship between equity investments in fintech startups and innovation performance within US banks.

Assessing how banks' equity investments in fintech startups are related to their own innovation faces three key hurdles: (i) selecting a credible proxy for bank innovation, (ii) accurately tracking US banks' participation in fintech funding rounds, and (iii) addressing the endogeneity of those investment decisions, which are shaped by banks' pre-existing innovation capabilities.

First, to measure bank innovation, we rely on two well-established proxies: trademark and patent applications (Duygun et al., 2013; González-Pedraz and Mayordomo, 2012; Lerner et al., 2024). Trademarks signal the commercialization phase, marking the market launch and branding of new financial products or services, whereas patents are typically filed at earlier, exploratory stages of the innovation pipeline (Hsu et al., 2022). Employing both indicators, therefore, lets us observe the full innovation cycle from idea generation (patents) to product roll-out (trademarks). It also captures both the creation and subsequent expansion of banks' financial offerings as an output of the increased innovation capabilities.

Second, we trace banks' equity stakes in fintech startups with *Crunchbase*, a widely used database that covers US deal activity back to 2005 (e.g., Li et al., 2023; Hornuf et al., 2021; Butticè et al., 2020; Cumming et al., 2019). For each funding round, Crunchbase reports the date, amount, round type, and cumulative funding, along with detailed firm attributes (name, location, description, revenue range, employee count, website) and the full investor line-up, including lead and partner participants. These data allow us to (i) link individual investments to specific banks, (ii) categorize the fintech's business model, and (iii) infer each deal's strategic purpose.

Third, we address endogeneity in two stages. In the first stage, we pre-process the sample with propensity-score matching (PSM): treated banks (those that invest in fintech equity) are matched 1:1 to non-investing banks on pre-treatment covariates, most importantly, size. This balances observable differences and ensures common support before estimation. In the second stage, we estimate the effect on innovation in the matched panel with a dynamic system–GMM (SYS-GMM) framework, widely employed in bank–fintech research (Wu et al., 2023, 2024; Yao and Song, 2023; Lee et al., 2021). SYS-GMM has several advantages: (i) instruments the lagged dependent variable to control for dynamic feedback, (ii) eliminates unobserved, time-invariant bank effects through differencing, and (iii) maintains efficiency in panels with many banks and moderate time spans. As shown by Blundell et al. (2001), this two-step SYS-GMM estimator improves precision and reduces finite-sample bias, while the preceding PSM step mitigates selection on observables, strengthening the overall causal identification.

Our baseline results provide compelling evidence that participating in fintech equity investment rounds is strongly associated with a higher number of trademark and patent applications by banks. This result holds even when we limit the involvement of banks to the initial investment made in every fintech funding round. Our findings are consistent with the notion that equity investments enable banks to better control fintech startups, overseeing the development of services that align with the bank's strategy and engineering them for easier integration into the bank's existing functions (Hornuf et al., 2021). We confirm the robustness of our baseline results by using alternative measures of bank innovation and estimating the relationship over longer periods of time. We also test for a reverse relationship to assess whether more innovative banks might be more inclined to invest in fintech startups, without any significant results.

This paper fills a knowledge gap by presenting the first empirical evidence on the long-term relationship between investing in fintech startups and bank innovation, thus extending the existing literature on bank-fintech collaboration (Beck et al., 2016; Wu et al., 2024; Zhang et al., 2023; Wu et al., 2023). Our findings are consistent with the notion that investing in fintech equity investment can be considered as a control-oriented innovation strategy for banks, allowing them to benefit from modern financial technology developments (Carlini et al., 2022).

Furthermore, this paper contributes to the literature by providing novel insights into the relationship between banks' equity investments in fin-native startups (i.e., those that primarily provide financial services) and tech-native startups (i.e., those that mainly provide technological services) and their innovation. Our work extends the literature that categorizes fintech firms based on their primary business model (e.g., Bellardini et al., 2022; Li et al., 2023; Del Gaudio et al., 2024; Zheng and Mao, 2024). Our empirical analysis shows a positive and statistically significant association between banks' investments in the equity investment rounds of fin-native fintech firms and the number of trademark and patent applications filed by the bank. This finding underscores the relevance of industry alignment between the two parties, as demonstrated by their awareness of the regulatory environment and consumer demands. Such an understanding of the financial industry's landscape appears to facilitate a smoother integration of technology into banks' product offerings.

In addition, we contribute to the literature on the effect of home bias in investment allocation (Solnik and Zuo, 2017; Levis et al., 2016). Our additional analysis indicates the tendency of US banks to participate more in funding rounds conducted by domestic fintech firms. This pattern is positively associated with higher levels of bank innovation through an increase in the number of trademark and patent applications. Our results suggest a rationale for banks' inclination to prioritize investments in domestic fintech firms, while potentially missing out on several advantages. For example, previous research focusing on bank bias towards investing in domestic fintech firms indicates that a bank's tendency to favor local investments may limit its ability to innovate and result in missed opportunities (Del Gaudio et al., 2024).

The remainder of this paper proceeds as follows. Section 2 outlines the study's theoretical background and introduces its hypothesis. Section 3 discusses the sample selection process, analyzes the bank-fintech investment rounds, previews the variables, and presents the econometric model used for the main analysis. Section 4 presents the results, robustness checks, and additional analysis. Section 5 concludes the study and discusses the implications.

2 Theoretical background and hypothesis development

2.1 Bank innovation

Innovation is the creative application of technologies, processes, or ideas to achieve objectives (Horn, 2015). Previous research has contributed to the development of a theoretical framework for understanding the dynamics of firm innovation and its interaction with acquisition activities (Hitt et al., 1996; Ahuja and Katila, 2001), organizational structure (Koberg et al., 1996), technological strategy (Beneito, 2003), and external cooperation (Freel, 2003), among other factors. At its core, tangible innovation requires a series of internal research and development (R&D) commitments, together with the use of external knowledge sources (Roper et al., 2008).

Although banks have recently increased their involvement in financial technology, either through the acquisition of fintech firms (Kwon et al., 2024; Collevecchio et al., 2023; Zheng and Mao, 2024; Cappa et al., 2022; Kueschnig and Schertler, 2024), or equity investment in fintech firms (Del Gaudio et al., 2024; Li et al., 2023; Bellardini et al., 2022; Carlini et al., 2022), the empirical research conducted to examine the impact of this engagement on banks' innovation capabilities remains sparse. Part of this might be attributed to difficulties in quantifying bank financial innovation, which has posed significant challenges to scholars attempting to measure it, particularly because of the ambiguity surrounding its definition and lack of available data (Frame and White, 2004).

For the purpose of this study, we follow Pi and Yang (2023) and refer to bank innovation as financial innovation. Frame and White (2004) define financial innovation as the combination of several activities that include the introduction of new products, new production processes, and new organizational structures. Researchers in the banking literature have creatively used various metrics to quantify bank innovation. These include bank off-balance sheet activities (Beck et al., 2016; Chortareas et al., 2009; Lozano-Vivas and Pasiouras, 2014; Lee et al., 2020), research and development (R&D) expenses (Beck et al., 2016; Lee et al., 2020), IT expenditure (Kwon et al., 2024; Beccalli, 2007; Shu and Strassmann, 2005; Licht and Moch, 1999), intangible assets (Collevecchio et al., 2023; Ayadi et al., 2021; Cao et al., 2022), trademarks (Duygun et al., 2013; González-Pedraz and Mayordomo, 2012), patents (Zheng and Mao, 2024; Liu and Li, 2024; Zhao et al., 2022; Tan et al., 2023), securitization (Beck et al., 2016; González et al., 2016; Allen and Carletti, 2006), and textual analysis of bank annual reports (Wu et al., 2023; Guo and Zhang, 2023; Zhang et al., 2023). Moreover, Bos et al. (2013) provide an excellent overview of early empirical studies that investigate innovation within the US banking sector.

In this paper, we measure bank financial innovation through trademarks and patents. Even though trademarks and patents are examples of intellectual property programs that may promote innovation by providing innovators with protection against unauthorized copying by competitors in the market (Frame and White, 2004), they serve slightly different purposes. Trademarks are associated with the commercialization of a developed product or service, while patents are typically applied for in the early stages of the innovation process (Hsu et al., 2022). We argue that the combination of these two indicators provides us with the unique advantage of capturing bank financial innovation. This includes bank product innovation through the expansion of bank financial products, as captured by bank trademarks, as well as the initial development of bank innovative service/product, as captured by bank patents.

A trademark is any word, phrase, symbol, design, or combination thereof that identifies goods or services. It's how customers recognize you in the marketplace and distinguish you from your competitors (United States Patent and Trademark Office, 2024b). In the US banking industry, Goldman Sachs's digital consumer loan platform, Marcus, is an example of a registered trademark associated with their brand. JP Morgan has recently launched

Partior, a new product that provides a blockchain-based wholesale payment network. The bank has also officially registered Partior as a trademark. In related literature, Duygun et al. (2013) and González-Pedraz and Mayordomo (2012) support the notion that trademarks are linked to bank innovation as they represent the commercial aspect of innovation. In light of this, we contend that bank trademarks can be a reliable indicator of bank innovation in this paper, particularly from the perspective of bank product expansion.

A patent is a legally granted exclusive right that allows the holder to prevent others from producing, using, marketing, or selling an innovation (United States Patent and Trademark Office, 2024a). Wells Fargo's recent filing for a smart contract patent titled 'Smart contract blockchain abstraction API' is an example of a patent.[3] Our use of patents as a proxy of bank financial innovation is primarily motivated by the literature. In particular, Lerner et al. (2024) provide compelling evidence through three investigations, each designed to test whether patenting may serve as a reliable indicator of financial innovation. The first test explores the value significance of financial patents, the second test examines the correlation between major financial innovations and patents, and the third test measures the consistency of patenting with the investments in new technologies. Together, these tests support the validity of patents as a measure of bank financial innovation.

2.2 Bank-fintech collaboration

According to the Schumpeterian theory of innovation, bank funding is essential for innovative entrepreneurs, enabling them to realize their innovations (Akdere and Benli, 2018).[4] In light of this, banks have the capacity not only to provide financing to financial entrepreneurs but also to build partnerships. Although the existing literature thoroughly examines the influence of fintech development on bank performance (Haddad and Hornuf, 2023; Hodula, 2024; Zhao et al., 2022; Phan et al., 2020; Scott et al., 2017), bank risk-taking (Banna et al., 2021; Wang et al., 2021a; Cheng and Qu, 2020), bank efficiency (Lee et al., 2023,

[3]Smart contracts are blockchain-based contractual agreements that eliminate the need for a trusted intermediary (Thakor, 2020).

[4]Bircan and De Haas (2020) provide further evidence that bank funding increases a firm's propensity to apply for patents or trademarks in emerging markets, indicating greater innovative capability.

2021; Wang et al., 2021b), financial inclusion (Demir et al., 2022; Senyo et al., 2022), and economic growth (Bu et al., 2023; Laeven et al., 2015). A significant knowledge gap exists in our understanding of the effects of collaboration between banking institutions and financial technology firms (Choudhary and Thenmozhi, 2024; Chernoff and Jagtiani, 2023).

Despite the lack of comprehensive documentation on the bank-fintech relationship, a limited number of papers have shed light on the two parties' motives to collaborate. For example, Hornuf et al. (2021) find that banks may modernize their product offerings and gain a competitive edge by forming alliances with fintech firms, which allow them to acquire exclusive rights to use specific applications. However, fintech firms pursue collaboration with banks in order to gain easier market access, enhance profitability, and develop new products (Bömer and Maxin, 2018).

The market reaction to bank-fintech collaboration has suggested multiple views. On the one hand, Kueschnig and Schertler (2024) argue that banks have a higher abnormal return following their first bank-fintech deal, as it may signal the bank's commitment to financial technology. On the other hand, Zheng and Mao (2024) find evidence of a negative reaction, possibly driven by the bank's overestimation of the benefits of collaboration and overlooking the associated costs involved with integration. Similarly, Carlini et al. (2022) document a negative effect and attribute it to market participants perceiving bank-fintech investments as risky and time-consuming in order to turn the investments into profit. Another group of papers has found that the market's reaction to bank-fintech M&As depends on specific characteristics such as the type of acquisition or services provided by the fintech firm (Collevecchio et al., 2023; Cappa et al., 2022).

A few other studies have examined the determinants of bank–fintech collaboration. Del Gaudio et al. (2024) analyze the composition of banks' boards of directors and find that banks whose boards are characterized by strong network connections, greater female representation, and younger directors are more inclined to invest in fintech firms' funding rounds. Moreover, Bellardini et al. (2022) show that larger amounts are invested in bank–fintech collaborations through equity investments when the fintech firm specializes in financial services (fin-native), is older, the deal includes additional investors, and the bank is larger in size. Furthermore, Hornuf et al. (2021) find that fintech firms seeking financial assistance may prefer to partner with larger banks, as these banks have a stronger interest in investing in financial innovation. In contrast, fintech firms pursuing growth are more likely to collaborate with smaller banks that prioritize product-based cooperation. Additionally, they show that banks that adopt a clear digital strategy and/or appoint a chief digital officer are more inclined to establish partnerships with fintech firms.

To sum up, banks have shown growing interest in fintech innovation in recent years, as evidenced by their involvement in activities such as acquiring fintech firms or participating in fintech startups' funding rounds. However, little is known about the impact of bank–fintech collaboration on bank innovation. To fill this important knowledge gap, we examine US banks' participation in fintech firms' funding rounds and assess the relationship between this participation and bank financial innovation, measured by the number of trademark and patent applications filed by banks.

2.3 Hypothesis development

This paper analyzes the impact of bank-fintech collaboration, specifically through the equity investment channel, on banks' innovation capabilities. Two perspectives are discussed in this regard. On the one hand, Carlini et al. (2022) argue that bank-fintech equity investment can be viewed as a control-oriented innovation strategy adopted by banks to engage with emerging technologies. They further note that the closest connection between the two parties is formed through equity investment. Such investment may grant banks unique advantages. For example, through equity stakes in fintech firms, banks may obtain board representation, enabling them to align the fintech firm's services with their own (Hornuf et al., 2021). Consequently, many banks may find collaboration with fintech firms to be a more effective way to enhance their innovation capabilities than developing fintech innovation internally, which can be both costly and risky (Li et al., 2023).

On the other hand, several complications hinder the bank from fully capitalizing on the advantages of collaborating with a fintech firm. Strategic misalignment between the two parties may limit the bank's pursuit of an effective technological advancement (Riikkinen and Pihlajamaa, 2022). Furthermore, the financial industry has come under great regulatory scrutiny after the 2008 global financial crisis (GFC) to ensure the stability and safeguarding of participants in the financial sector. Regulatory conditions not only dictate the scope of bank-fintech collaboration, but also the type of products affected by such an alliance (Hornuf et al., 2021). In addition, viewing fintech firms as mere service vendors to the bank undermines the partnership that should be based on recognizing the fintech firm as a business partner (Meinert, 2017). In a recent study, Zheng and Mao (2024) find limited evidence supporting the bank's long-term innovation performance, as measured by the number and quality of bank patents filed, following the announcement of the acquisition of fintech firms. They document that banks may overestimate the advantages of such deals, neglecting the associated costs of integrating advanced technology into their operations. According to Stulz (2019), agency costs are another contributing factor that hinders bank innovation. The process of introducing new products that could compete with existing ones may face internal resistance from bank executives whose incentives are based on the success of existing products. Therefore, minimizing the desired innovation benefits of collaborating with fintech firms. In light of the aforementioned discussions, we propose the following hypothesis.

H1*: Bank-fintech equity investment significantly enhances bank innovation.*

We further explore how the impact of bank equity investment in fintech startups varies across domestic and international partnerships, essentially exploring the impact of home and local bias in bank-fintech investment on bank innovation. Home bias in the field of financial economics is the tendency of investors to allocate a larger share of their portfolio to assets in their home country (French and Poterba, 1991). A stronger form of this bias is known as local bias, where investors show a preference for investing in firms that are geographically close to them, such as within their state or city, also known as home bias at home (Coval and Moskowitz, 1999). Extant literature has extensively explored the phenomenon of home bias and provided several reasons for its presence. These include information asymmetry (Van Nieuwerburgh and Veldkamp, 2009), the availability of home-based alternatives (Errunza et al., 1999), cultural and institutional similarities (Levis et al., 2016), and investors' optimism towards domestic assets (Solnik and Zuo, 2017). Our paper adds to this strand of literature through the unique perspective of US bank equity investment in innovative financial technology startups.

The evidence on the potential benefits of cooperating with domestic or cross-border firms is mixed in the literature. For example, Gaar et al. (2022) highlight that investing in domestic or local firms has the potential to yield greater returns by better exploiting superior knowledge and reducing information asymmetries compared with investing in cross-border firms. However, Del Gaudio et al. (2024) provide empirical evidence supporting the argument that banks' innovative potential can be significantly constrained by their tendency to invest in and collaborate with fintech firms that are located in close proximity to them. In light of the aforementioned discussion, we propose the following hypotheses:

H2a*: Domestic bank-fintech partnerships are positively associated with bank innovation.*

H2b*: Cross-border bank-fintech partnerships are positively associated with bank innovation.*

H2c*: Same-state bank-fintech partnerships are positively associated with bank innovation.*

H2d*: Different-state bank-fintech partnerships are positively associated with bank innovation.*

Moreover, we investigate the relationship between the broad categories of fintech firms and bank innovation. We contribute to a growing strand of literature that broadly categorizes fintech firms into two groups based on their primary business line: fin-native and tech-native (Bellardini et al., 2022; Li et al., 2023; Del Gaudio et al., 2024; Zheng and Mao, 2024). The fin-native fintech firms primarily focus on providing financial services as their core function. Examples of such firms are those that specialize in providing services such as payment, lending, investment, personal finance, insurance, and digital banking. The tech-native group includes fintech startups that mainly provide technological services such as blockchain, software and services, data analytics, and regtech.

Existing evidence suggests that banks tend to acquire or invest in fintech firms that are closely related to their business strengths. For example, Bellardini et al. (2022) argue that bank investments are enhanced when channeled toward fin-native firms rather than tech-native ones. The rationale is that collaborating with firms that share a closely related business line, such as fin-native firms, allows banks to mitigate information asymmetries. Accordingly, they further argue that tech-native fintech firms are perceived by banks as a riskier option. Additionally, Li et al. (2023) provide empirical evidence that banks significantly outperform independent venture capitalists when selecting to partner with fintech firms that operate in the same business line (fin-native), possibly due to banks' unique industry expertise. In light of the aforementioned discussion, we propose the following hypotheses:

***H3a**: Fin-native bank-fintech partnerships are positively associated with bank innovation.*

***H3b**: Tech-native bank-fintech partnerships are positively associated with bank innovation.*

3 Data and methodology

3.1 Sample selection

To construct our sample, the *Crunchbase* database (www.crunchbase.com) is used to retrieve data on US banks' investments in fintech financing rounds from 2005 to 2023. We opt to start our investigation from 2005 since Prosper, one of the top US fintech firms, was founded in this year, and the fintech industry boomed shortly afterward with the introduction of GreenSky. Crunchbase is an online database that provides updated data on companies, investment rounds, and M&A deals. It is often used in related literature (e.g., Li et al., 2023; Hornuf et al., 2021; Butticè et al., 2020; Cumming et al., 2019), and it offers a comprehensive view of fintech firms' funding rounds. This includes deal characteristics such as the funding date, funding amount, cumulative funding amount, funding type, and funding status. Additionally, it provides relevant information about the fintech firm, including its name, location, business description, revenue range, number of employees, and website. Furthermore, it offers insights into the investors involved, including their names, the names of lead investors, and the number of partner investors. A drawback of using the Crunchbase database is that it does not provide details on the type of equity ownership in bank-fintech investments, whether it is a minority stake, majority control, or a full acquisition of target firms.

To identify US banks in the Crunchbase database, we limit the location of investors to be in 'United States'. We include banks by adding their two main industries in Crunchbase; these are: 'Financial Services' and 'Banking'. We also follow Li et al. (2023) and include the investment arm or venture capital firm that belongs to the bank and has the specialty to undertake investment in funding rounds of startups on behalf of the bank. Examples of such companies include Norwest Venture Partners (Wells Fargo), One Equity Partners (JP Morgan), Citi Impact Fund (Citibank), and American Express Ventures (American Express). As such, to identify these firms, we include the term 'Venture Capital' as one of the main firm industries in Crunchbase.

Our identification process of fintech firms in the Crunchbase database is two-fold. First, we include a fintech firm if it integrates technology into its financial product offerings. To do this, we follow Li et al. (2023) and include firms that work in the 'Financial Services' industry as categorized by Crunchbase, which includes firms in sub-industries such as 'FinTech', 'Lending', and 'Payments'. It also includes firms in 'InsurTech', 'Asset Management', 'Mobile Payments', 'Trading Platform', 'Accounting', 'Banking', 'Cryptocurrency', and 'Blockchain' sub-industries. Second, we include possible firms that were not captured in our first step by adding firms in technological industries that use at least one of these keywords in their description: 'financial', 'banking', 'fintech'. These industries are: 'Software', 'Data and Analytics', 'Information Technology', 'Internet Services', and 'Privacy and Security'.

To assess the level of commitment that banks have towards financial innovation, we limit our sample to deals where banks invest in fintech firms in exchange for equity. As such, we exclude deals that include these investment types in the Crunchbase database: 'Debt Financing', 'Grant', 'Non-equity Assistance', 'Product Crowdfunding', and 'Post-IPO Debt'. The final bank-fintech equity investment sample includes 81 US banks that invested in 512 fintech ventures through the participation of 772 fundraising rounds in the period under study. We supplement this sample with bank-level financial data retrieved from the Federal Financial Institutions Examination Council's (FFIEC) Reports of Condition and Income (Call Reports).

Furthermore, we employ propensity score matching (PSM) to address potential sample selection bias and to enhance the generalizability of our main findings. Specifically, we create a sample of non-investing banks that are similar in size, as measured by the natural logarithm of bank total assets (Del Gaudio et al., 2024). We choose to match on bank size as it incorporates a range of characteristics that affect the bank's propensity to innovate. As innovation may be a result of bank research and development (R&D) initiatives, larger institutions leverage economies of scale inherent in such activities to innovate (Frame and White, 2004). We argue that financial innovation is a complex phenomenon that requires the availability of adequate financial resources to mitigate the costs associated with innovation, necessitates a highly skilled human capital that is capable of driving innovation, and requires the availability of advanced technological infrastructure. The argument is supported by Pi and Yang (2023)'s findings in the Chinese banking market, which show that larger banks are more inclined to conduct innovative strategies, supported by their higher human, material, and financial resources. Therefore, large banks are best suited to innovate due to the availability of necessary tools that distinguish them from smaller banks. This is further supported by the statistically significant difference in mean value between investing banks and non-investing banks, as shown in Table 1.

[Table 1 here]

To implement the PSM technique, we follow Kwon et al. (2024) and Del Gaudio et al. (2024) in applying a one-to-one nearest neighbor matching with a caliper of 0.01 to ensure that the most similar banks are paired together. Following the matching process, we are able to create a control group that closely matches the treatment group in terms of bank size. As indicated in Table 1, no statistically significant difference in mean value between the two groups is observed, which enables us to capture the impact of bank-fintech investment behaviour on bank innovation more effectively. The final regression sample includes 9,734 bank-level observations.

Although our sample size is relatively small, it is comparable to those used in the bank–fintech literature. For example, Carlini et al. (2022) examine bank–fintech collaboration over the period 2013–2018, using a sample of 80 banks that invested in 334 fintech firms across 581 investment rounds in North America and the EU. Bellardini et al. (2022) analyze a global sample of 236 banks that invested in 623 fintech firms through 803 investment rounds between 2008 and 2018. Similarly, Del Gaudio et al. (2024) use data on 140 banks across the US, EU, and UK during the period 2008–2018. Finally, Li et al. (2023) investigate 117 banks and 840 fintech firms in the US market over the period 2000–2018.

3.2 Preliminary observations

Our objective is to investigate the impact of bank equity involvement in fintech financing rounds on bank innovation. To achieve this, we first analyze the fintech investment rounds in which at least one US bank participated as an equity investor. Initially, we examine the total funds received by fintech companies throughout their fundraising campaigns. Figure 1 illustrates the growth of investments in fintech firms during funding rounds in the sample period (2005Q1-2023Q4). The cumulative amount of investments raised by fintech firms during funding rounds involving US banks reaches $34.3 billion over the entire study period.

[Figure 1 here]

The graph can be divided into three periods based on investment activity: 2005Q1–2011Q4, 2012Q1–2019Q4, and 2020Q1–2023Q4. From 2005Q1 to 2011Q4, equity financing was small and infrequent, totaling $0.6 billion. This likely reflects the fintech industry's early unproven stage and the effects of the 2008 global financial crisis (GFC), which made banks risk-averse and constrained by tighter regulations. Haddad and Hornuf (2019) highlight the potential of fintech ventures to take advantage of the ongoing distrust towards financially stressed incumbents. However, from 2012Q1 to 2019Q4, investment rose sharply, reaching $12.2 billion. US banks participated regularly, driven by rising consumer use of digital platforms and the need to meet evolving expectations. Cornelli et al. (2023) note that during this period, several innovative intermediaries have disrupted the financial landscape through the lending channel, offering alternative credit solutions. Interestingly, although fintech investments dipped during the early COVID-19 pandemic due to uncertainty and disruptions, Fu and Mishra (2022) find a sharp rise in finance-related mobile app use, particularly in the areas of payment, lending, and investment. This rise in digital demand pushed banks to embrace rapid financial digitalization. Consequently, equity investment rounds involving US banks totaled $21.5 billion from 2020Q1 to 2023Q4, surpassing pre-pandemic averages.

We further examine the stages at which fintech firms received funding. Figure 2 shows the funding types across the 772 rounds studied. According to Crunchbase, these fall into two main categories: early-stage and late-stage funding. Early-stage funding includes Pre-seed, Seed, Angel, Series A, and Series B rounds. In our sample, 373 rounds (48%) were early-stage, suggesting banks often invest in riskier startups still establishing their business models and market presence. Hornuf et al. (2021) find that banks tend to back smaller fintech firms, possibly to influence their strategic direction in line with bank interests. Additionally, late-stage funding includes Series C to G, private equity, and post-IPO rounds, representing 229 rounds (30%). Firms at this stage have proven their products and seek to expand market share. The remaining 170 rounds (22%) were either not applicable to the categorization or unidentified due to a lack of data availability. These include Secondary Market, Post-IPO Secondary, Convertible Note, Corporate Round, and unknown funding rounds.

[Figure 2 here]

3.3 Variables

We proxy bank innovation using two variables: the number of trademark and patent applications filed to the United States Patent and Trademark Office (USPTO). Empirically, we estimate bank trademarks as the natural logarithm of one plus the number of trademark applications filed by the bank, while patents are estimated as the natural logarithm of one plus the number of patent applications filed by the bank.[5]

We use the Lens (www.lens.org) and Onscope (www.onscope.com) databases to collect data on banks' trademark and patent applications. In this study, the two databases complement each other: Lens is used to capture bank patent applications, while Onscope is primarily used to retrieve information on bank trademark activity. Choosing Lens and Onscope as our data sources provides several advantages. By combining the two datasets, we are able to obtain more comprehensive insights into bank innovation from multiple perspectives. Furthermore, these databases allow us to track the trademark and patent application activity of U.S. banks over a 19-year period, from January 1, 2005, to December 31, 2023. A limitation of these databases is that the data had to be collected manually for individual banks, as bulk industry-level data were not available at the time of collection.[6] Nevertheless, both databases have been used in prior academic studies, demonstrating their reliability and relevance (de Boyrie and Pavlova, 2025; Yalcin and Daim, 2022).

In addition, we include some control variables that contribute to explaining bank innovation. Table A.1 provides definitions of all variables used in this study. First, we measure bank profitability using return on equity (ROE), calculated as net income divided by total equity. Innovation involves uncertainty, requiring available funds and profitability to absorb potential losses. Thus, we expect a positive correlation between profit and innovation. We also consider bank capitalization, measured by total equity over total assets, expecting a positive effect since well-capitalized banks can better absorb losses and support innovation,

[5]We use the natural logarithm of the number of patents or trademarks plus one to account for the presence of zero values for some banks in different temporal periods.

[6]We provide further validation of the main results using an alternative measure of bank innovation in Appendix B.1.

enhancing their ability to create intellectual property. We include the ratio of liquid assets to total assets, expecting a positive link with innovation, as banks with more liquid assets can finance new initiatives. We also add non-performing loans (NPLs), anticipating a negative impact as banks with high NPL levels may avoid risky, costly innovation. Cheng and Qu (2020) report a negative link between banks' NPLs and their fintech development. Finally, we control for the nominal lending rate, expecting a positive association via the profitability channel, as found by Alessandri and Nelson (2015).

We present in Table 2 the correlation matrix of independent variables. Overall, the combination of independent variables does not appear to cause multicollinearity. Most importantly, trademarks and patents have a positive correlation value of 0.487, suggesting that these two variables quantify distinct but related aspects of innovation, consistent with the findings in the related literature. For example, Hsu et al. (2022) argue that trademarks signal the commercialization of products, whereas patents are typically filed during the exploratory stage of innovation. This further supports our earlier argument that using both trademarks and patents as measures of bank innovation provides us with a unique ability to capture the innovation cycle from idea generation (patents) to product roll-out (trademarks).

[Table 2 here]

Table 3 presents the summary statistics of variables used in the baseline regression analysis categorized in three groups: (1) All banks, (2) Investing banks (banks that have invested in the equity shares of at least one fintech firm), and (3) Non-investing banks (banks that did not participate in any equity funding round conducted by a fintech firm).

[Table 3 here]

We note some interesting observations. Investing banks filed for significantly more trademarks (2,409) and patents (32,386) than non-investing banks (385 and 138, respectively), possibly suggesting that fintech equity involvement enhances innovation. This highlights the economic significance of the bank-fintech partnerships, which is also in line with related literature suggesting that banks may modernize their product offerings by forming alliances with fintech firms (Hornuf et al., 2021). Additionally, investing banks show higher profitability, with an ROE of 5.53% versus 5.27% for non-investing banks, implying that profit may support innovation and equity investments. However, investing banks have lower capitalization (11.06%) compared to non-investing banks (11.98%), indicating the latter may emphasize capital preservation. Investing banks also hold more liquid assets (11.24%) than their counterparts (9.35%), and report a lower NPL ratio (1.13% vs. 1.28%).

3.4 Econometric model

To empirically investigate the effect of bank-fintech investment on bank innovation, we use the system generalized method of moments (SYS-GMM) to estimate the parameters of our baseline model. The SYS-GMM technique, an extension of the regular GMM method, has been developed to improve its performance when dealing with dynamic panel data (Blundell et al., 2001). This method was initially proposed by Arellano and Bond (1991) and consists of two equations, one for first differences and one for levels, to address certain biases, such as omitted variables bias. It has been extensively used in the literature of bank-fintech (Wu et al., 2024, 2023; Yao and Song, 2023; Lee et al., 2021).

Choosing the system GMM as our model estimator is helpful in many ways to address econometric issues. Since bank innovation levels might be influenced by previous periods, system GMM allows for the design of dynamic panel models by including bank innovation as a lagged explanatory variable. Furthermore, it is capable of effectively dealing with the problem of endogeneity, which refers to the correlation between independent variables and the error term. It also handles the presence of unobserved bank-specific effects, as well as variations between banks. However, we acknowledge that it can not fully eliminate unobservable effects. Another advantage of using the system GMM estimator is that it significantly increases the precision while reducing finite sample bias as documented by Blundell et al. (2001). To ensure the consistency of system GMM estimations, we report two post-estimation tests in all regression tables. First, we use the Hansen J statistics to verify our selection of instruments. This test evaluates the suitability of our endogenous and instrumental variables, determining whether they appear exogenous. Second, we examine the presence of first-order AR(1) and second-order AR(2) autocorrelation.

To examine the impact of bank equity investment in fintech firms on bank innovation, the following model specification is used:

$$\begin{aligned} Bank\_Innovation_{i,t} = \alpha_i + \beta_1 Bank\_Innovation_{i,t-1} + \beta_2 Fintech\_Investment_{i,t-1} \\ + \theta X_{i,t-1} + \gamma_i + \epsilon_{i,t} \end{aligned} \tag{1}$$

where $Bank\_Innovation_{i,t}$ is the bank-level measure of innovation for bank i in time t. We measure bank innovation using two indicators: (1) trademark applications, and (2) patent applications. $Fintech\_Investment_{i,t-1}$ is our main explanatory variable, which represents the investment of bank i in fintech firms' funding rounds in time t. Two indicators are used to measure bank-fintech equity investment: (1) multiple investments, and (2) initial investment. $X_{i,t-1}$ includes a set of bank-level and macroeconomic characteristics that might influence the innovation capabilities of banks. These are: bank size (natural logarithm of total assets), profitability (net income/total equity), capitalization (total equity/total assets), bank liquidity as measured by the sum of cash and short-term investment over total assets, bank non-performing loans over total loans, and the bank's nominal lending rate. γ_i is the time-specific fixed effects. $\epsilon_{i,t}$ is the error term.

4 Results and discussion

4.1 Bank-fintech equity investment and bank innovation

Before presenting the results, we distinguish between two types of bank-fintech investment strategies: a single occurrence of equity investment in a unique fintech firm financing round, and multiple investments made in several equity fundraising rounds for the same firm by the same US bank. By using this approach, we follow Li et al. (2023) and mitigate some concerns relating to the possible inaccuracies in reporting of funding rounds (Aragon et al., 2023; Lerner, 1995), or giving more weight to banks that have invested in subsequent fintech equity funding rounds as some investors may prefer to split their investment across successive funding rounds to monitor the development of invested firm (Aragon et al., 2023; Gompers, 1995). Our objective is to examine how banks' initial and multiple equity investments in fintech firms are related to their innovation capabilities.

Table 4 shows the paper's main findings. When banks participate in multiple fintech equity investment rounds, it has a positive and statistically significant association with the number of trademark applications submitted directly by the bank at a 1% significance level. Similarly, it has a positive association with the number of patent applications filed directly by the bank at a 1% significance level. By restricting the bank's equity involvement in fintech startups only to the first investment, or first 'hand-shake' (Li et al., 2023), we still observe a similar and significantly positive association with the number of the parent bank's trademark and patent applications at the 1% level. Our results offer a different perspective from the findings of Zheng and Mao (2024), who find that banks may overestimate the associated benefits. We show that banks that invested in fintech firms' equity funding rounds (indicating a greater level of involvement in financial technology) between 2005Q1 and 2023Q4 are associated with higher bank innovation capabilities, as shown by a higher number of legally protected intellectual rights in the form of bank trademarks and patents.

Interestingly, our findings reveal that even when considering only the initial equity investment by banks, it continues to have a positive association with bank innovation, emphasizing the significance of bank-fintech alliances. We propose that new technological developments brought about by financial technology companies may contribute to enhancing the innovation capabilities of banks via the equity investment channel. Hornuf et al. (2021) suggest that through equity investment, banks may better control fintech startups, overseeing the development of services that align with the bank's strategy and engineering them for easier integration into the bank's existing functions. Our findings are consistent with this view and support our proposed hypothesis (H1) that bank-fintech equity investment collaboration enhances bank innovation.

Regarding the control variables, we find an insignificant negative effect of bank profitability (ROE). This result is partly consistent with the findings of Fukuyama and Tan (2022), who find that innovation inefficiency (measured as intangible assets) is not aligned with profitability efficiency, suggesting that profitability may not necessarily predict innovation output within banks. Moreover, we find that banks that engage in innovative experiments, which result in more trademark and patent applications, have easier access to cash, as shown by the positive and statistically significant coefficients of bank liquidity. Although not statistically significant, we find that banks' higher levels of non-performing loans (credit risk) are associated with lower innovative output, which is supported by Kwon et al. (2024), who find that NPLs hinder banks' ability to be involved in fintech acquisitions. Overall, the findings of the control variables are broadly consistent with related literature.

[Table 4 here]

Furthermore, to explore the economic significance of our findings, we calculate the marginal effects of bank-fintech equity investments (multiple and initial occurrences) on bank innovation and plot the results in Figure 3.[7] The results suggest that a one standard deviation increase in bank-fintech investment is associated with around a 5-6% increase in trademark applications and a 13-14% increase in patent applications filed by the bank. This underscores the importance of the bank-fintech relationship, extending beyond the statistical significance to corroborate existing evidence that this partnership may stimulate innovation within banks operating in an increasingly competitive financial sector (Hornuf et al., 2021). Moreover, these results are in line with surveys showing that more than 78% of senior directors at US banks are explicitly expressing their intention to increase their investments in fintech firms in 2025 and 2026, according to a recent industry report (York, 2025). These results also align with the descriptive evidence presented in Table 3, which shows that banks that invest in fintech firms have, on average, significantly more trademark and patent applications than non-investing banks.

[7] We follow related literature (e.g., Cole and Altman 2017) and compute the marginal effects of fintech investment (both multiple and initial ones) on bank trademarks and patents. Specifically, we multiply the estimated log-log regression coefficient by a one standard deviation of the fintech investment variable and transform it to a percentage change. This allows us to get the percentage change of trademark and patent applications following a one standard deviation increase in fintech equity investment.

[Figure 3 here]

4.2 Robustness checks

4.2.1 Falsification test

To provide validity to our main findings, we conduct a falsification test. Specifically, we test for the alternative explanation that banks with higher innovative capabilities, as indicated by a larger number of trademark and patent applications, are inherently more motivated to participate in fintech equity investment rounds. To do this test, we use Equation 1 and swap the dependent variable $Bank\_Innovation$ with the explanatory variable $Fintech\_Investment$. Table 5 shows a statistically insignificant coefficient for bank trademark and patent filings, suggesting that bank innovation is not affecting the investment in fintech firms.

[Table 5 here]

4.2.2 Longer time horizon

Our next test is to check the relationship over longer lagged periods. We do this by including the second and third lag of $Fintech\_Investment$. This analysis aims to examine whether current bank innovation is affected by previous fintech investments. Table 6 shows the empirical findings. Similar to the main analysis, the first lag shows a positive and statistically significant association between bank-fintech investment (both multiple and initial ones) and bank innovation. Furthermore, the second and third lags of bank-fintech investments also show a positive and statistically significant association. These results suggest that the positive relationship between bank-fintech investment and bank innovation, as measured by bank trademarks and patents, can be observed in the short-term and long-term. This is consistent with the theoretical findings of Fang and Wen (2024), who highlight the critical elements that drive successful bank-fintech collaborations, such as benefits distribution, cost control, and collaborative synergy. They find that this alignment enhances the long-term effectiveness of innovation strategies within banks.

[Table 6 here]

4.2.3 Placebo test

We further perform a placebo test to confirm that the positive association found in the main results between bank-fintech equity investment and bank innovation is not driven by unobserved or latent factors. To this end, we repeat our main analysis after constructing two new variables, $Placebo\_Multiple\_Investment$ and $Placebo\_Initial\_Investment$, and randomly assigning them dates that have no bank-fintech equity investments. This test is fully consistent with established approaches in the bank–fintech literature (e.g., Del Sarto et al., 2025; Ferilli et al., 2024; Balyuk, 2023), thereby offering robust additional validation for our baseline results. Table 7 shows the empirical findings. No significant association is observed for the placebo fintech investment variables, suggesting that it is unlikely that bank innovation in our model is influenced by unobserved factors. Overall, the placebo test confirms that the positive relationship found in the main results is indeed related to actual bank equity investments in fintech firms, rather than unobserved and latent factors.

[Table 7 here]

4.2.4 Additional robustness checks

We also conduct additional robustness checks using intangible assets as an alternative proxy for bank innovation, controlling for banks' technological development, and accounting for equity funding rounds. The results of these tests, reported in Appendix B, are consistent with our baseline findings.

4.3 Additional analyses

4.3.1 Home bias in bank-fintech investment

We further conduct some additional analysis to provide insights into the home bias in bank-fintech investment. Table 8 shows that in our sample, out of the 772 investment rounds, 556 rounds (or 72%) were bank investment in domestic US fintech firms, while 216 rounds were cross-border (or 28%). Given that our sample of US banks seems to exhibit home bias in their investment behavior, we aim to investigate the association between investing in domestic/international fintech companies and bank financial innovation. For this reason, we use model Equation 1 and introduce two location-based dummy variables. Specifically, we rely on the Crunchbase database's 'Organization Location' and construct a dummy variable, *Domestic*, which takes the value of 1 if the fintech firm is located in the US, and 0 otherwise. Also, we construct another dummy variable, $Cross\_Border$, that takes 1 if the fintech firm is located in a foreign country outside the US, 0 otherwise.

[Table 8 here]

The results of estimating Equation 1 after including dummy variables for domestic and cross-border fintech firms are shown in Table 9. The findings indicate that investing in domestic fintech ventures is correlated with an increase in bank trademark applications, as seen in column (1), with a positive and statistically significant relationship at a 5% confidence level. A similar positive and statistically significant (at 5% level) relationship is shown if we use the number of patent applications as a measure of bank innovation, as shown in column (3). For cross-border firms, no statistically significant coefficients are found in columns (2) and (4). Our initial sample analysis found a tendency for US banks to invest in domestic fintech startups, and our empirical analysis suggests that such propensity may be warranted, as reflected in increased levels of bank financial innovation, thereby confirming hypothesis *H2a*.

[Table 9 here]

We further investigate the underlying factors driving US banks' preference for investing in domestic fintech firms. Thus, we introduce two new dummy variables to capture geographical proximity: $Different\_State$ and $Same\_State$. These variables take the value of 1 if the investing bank and the fintech firm are located in different US states or the same state, respectively, and 0 otherwise. Table 10 presents the findings with the inclusion of these proximity measures.

The findings reveal that US banks' equity investments in fintech firms headquartered in the same state are associated with significantly greater innovation outcomes as measured by trademark and patent applications, compared to investing in firms outside the state. Specifically, same-state investments exhibit a positive and statistically significant relationship at the 1% level. In contrast, banks' investments in fintech firms located in different states within the US show a more limited association, being significant (at 1%) only for trademark applications. Overall, this result suggests that geographical proximity is positively associated with the innovation advantages banks get from their domestic fintech equity investments, supporting hypothesis *H2c* and partially hypothesis *H2d*. This proximity advantage could provide a possible explanation for US banks' stronger inclination toward domestic investments over cross-border ones, as localized partnerships appear to be more conducive to fostering innovation within banks.

[Table 10 here]

A policy intervention is recommended to promote a healthy environment for domestic bank-fintech collaboration. Existing literature suggests that such bank-fintech collaboration helps banks develop innovative products that support their competitive position in a rapidly digitalized market, and meet the growing demands of consumers (Hornuf et al., 2021). Although international collaboration may pose challenges in integration, its diverse nature enables firms to introduce more novel products to the domestic market compared to those launched through domestic alliances (Rodríguez et al., 2022). As such, bank executives are advised to mitigate their home bias investment behavior and explore international innovation collaborations to avoid missing out on opportunities (Del Gaudio et al., 2024).

4.3.2 Which fintech firms drive bank innovation?

The second additional analysis extends the focus of this paper by investigating which category of fintech firms is most closely associated with bank innovation. We employ a qualitative content analysis (QCA) approach to classify each fintech company in the sample according to its specific sub-industry, based on the services it provides. For a detailed discussion of this approach and the characteristics of the identified fintech sub-industries, see Appendix C. Table 8 shows that fin-native firms conducted 480 investment rounds, accounting for 62% of the total rounds, while tech-native firms conducted 292 rounds, accounting for 38%. To perform the analysis, we use the model specified in Equation 1 and include two dummy variables, Fin_native and $Tech\_native$, representing the broader orientation of a fintech firm.

[Table 11 here]

The regression results are shown in Table 11. The results presented in columns (1) and (3) show that investment in fin-native firms is associated with a positive and statistically significant (at 5% level) increase in the number of bank trademark and patent applications. While columns (2) and (4) indicate that investment in tech-native firms has no statistically significant association with bank innovation. A possible explanation for this result is that fin-native firms have a shared understanding with banks on the regulatory environment and consumer demands in the financial industry, which might not be as common among tech-native fintech firms. Such understanding can facilitate the smooth integration of new technologies into the bank's product suite, which ultimately increases its number of trademark and patent applications. Del Gaudio et al. (2024) highlight the significant role of industry alignment in influencing banks' decisions to participate in equity funding rounds of fintech firms. They find that the effect of home bias is more pronounced when banks invest in fin-native fintech firms. Similarly, Bellardini et al. (2022) argue that banks perceive fin-native firms as a safer option compared with tech-native ones.

5 Conclusion

5.1 Academic contributions

Although prior work shows that partnering with fintech firms can enhance bank performance (Kwon et al., 2024; Li et al., 2023; Bellardini et al., 2022; Hornuf et al., 2021; Del Gaudio et al., 2024), the consequences for banks' own innovation remain unclear. We bridge this gap by analyzing the relationship between banks' equity stakes in fintech funding rounds and their subsequent bank innovation, measured by trademark and patent applications. Using a panel dataset of US banks over the period 2005–2023, we find that larger cumulative fintech investments are strongly associated with more patents and trademarks. The relationship is particularly pronounced when the target fintech firm is (i) domestic and (ii) fin-native (payments, lending, core banking infrastructure) rather than tech-native (reg-tech, data analytics), suggesting tighter knowledge complementarities and smoother integration into existing systems.

These results are consistent with the view that equity positions give banks privileged access to emerging technologies and the ability to steer product development toward applications that fit their legacy infrastructure (Hornuf et al., 2021). To our knowledge, this is among the first studies to document a potential innovation channel of bank–fintech equity collaboration. Overall, our findings contribute to ongoing debates about open banking, venture participation, and regulatory sandboxing, highlighting equity investment as a potential channel connecting traditional financial services with modern innovation.

5.2 Policy recommendations

The findings of this paper have implications for policymakers, bank executives, and entrepreneurs. In terms of policymaking, our evidence indicates that equity partnerships with fintech firms are related to higher banks' innovation capacity. Regulators can therefore foster productivity and competition by lowering the frictions to such deals. In the United States, the Office of the Comptroller of the Currency (OCC) created a unit called the Office of Financial Technology (OFT) in March 2023 to supervise and experiment with bank-fintech partnerships (Office of the Comptroller of the Currency, 2023). Scaling up "innovation experiments" run by the OFT or expanding regulatory sandboxes would let banks test new technologies in a controlled environment while keeping prudential risks in check. Regarding bank executives, an effective route for incumbents to capture the next wave of financial-technology advances is direct equity participation in fintech funding rounds. Beyond co-designing niche products, banks should use these stakes to embed external capabilities (APIs, data analytics, AI credit scoring) into their legacy systems and nurture an internal culture of continuous innovation (Fu and Mishra, 2022). Finally, for fintech entrepreneurs, collaboration with well-capitalized incumbents can offset the sharp funding slowdown the sector has faced, where global fintech investment fell from $78.6 billion in 2022 to $39.2 billion in 2023, a 50 % year-on-year drop (CB Insights, 2024). Industry surveys rank tighter macro-funding conditions as the dominant constraint (CCAF, 2024). Partnering with banks not only supplies capital but also opens distribution channels and regulatory expertise, increasing the odds of scaling sustainably. In short, a well-designed ecosystem that facilitates bank–fintech equity collaboration can simultaneously advance regulatory goals, enhance incumbents' innovation pipelines, and provide vital lifelines for fintech startups.

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 statement

The authors do not have permission to share data.

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Figures and Tables

Figure 1: Fintech equity fundraising in rounds involving US banks (in USD) (2005Q1-2023Q4)

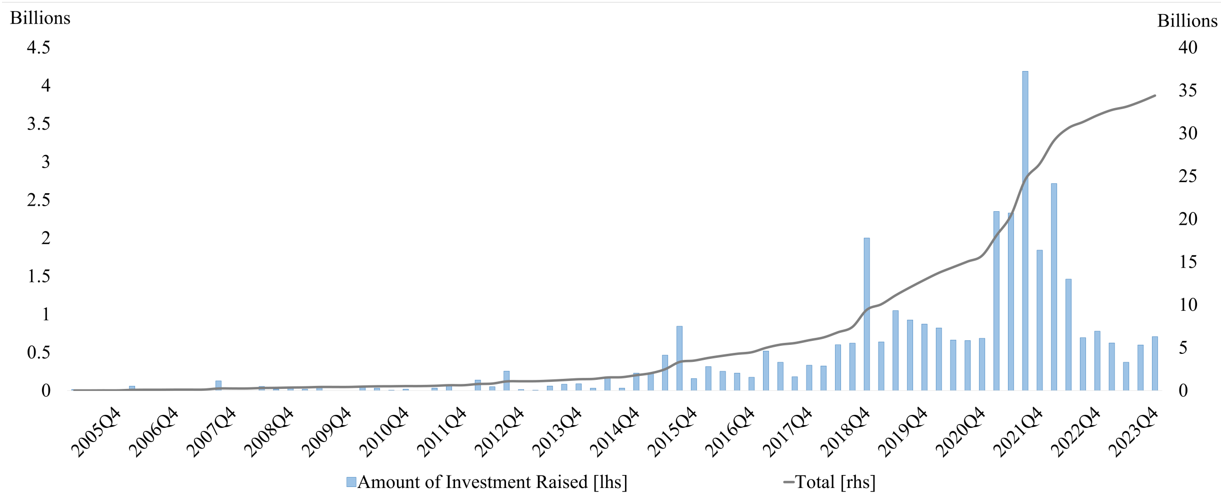


Figure 2: Fintech firms funding types (2005Q1-2023Q4)

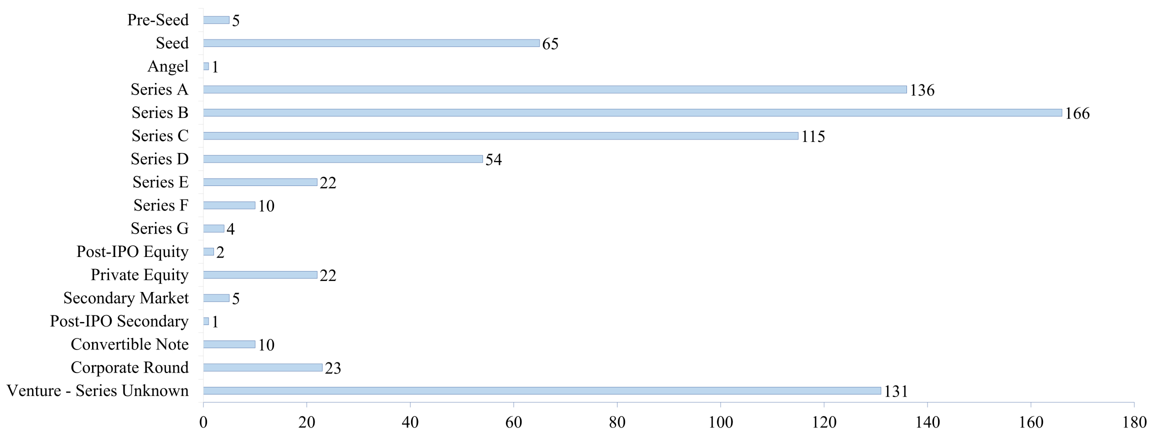


Figure 3: Marginal effects of bank-fintech equity investments

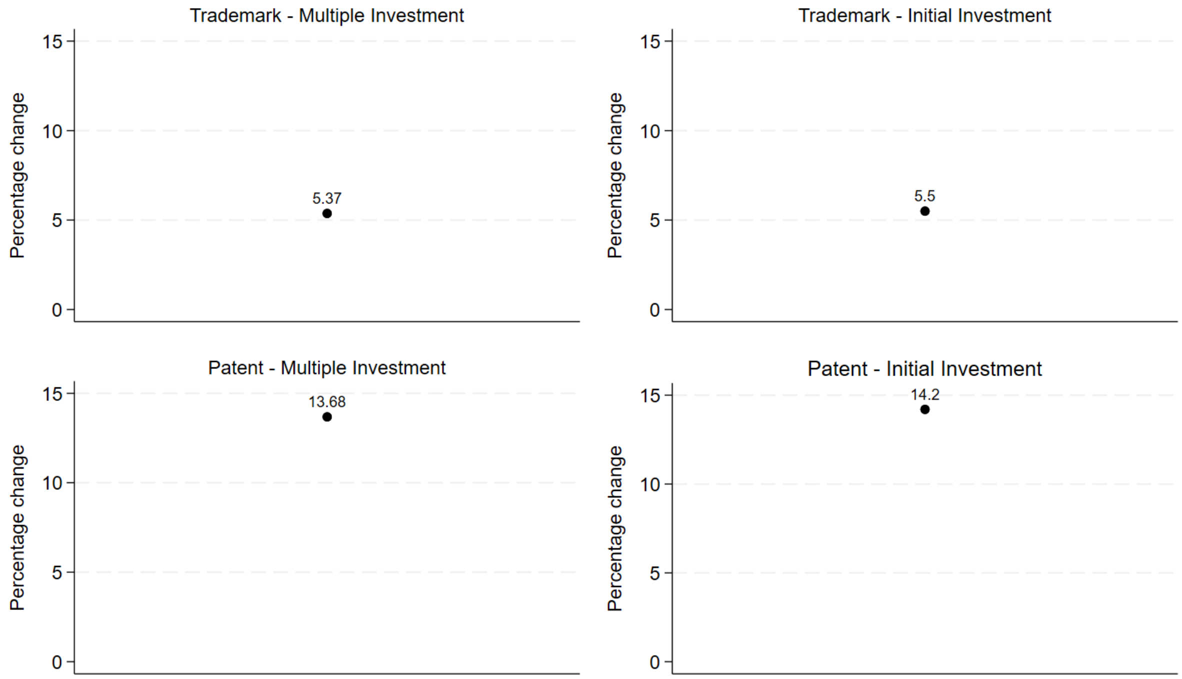


Table 1: Propensity score matching

	Before Matching				After Matching			
	Investing banks	Non-investing banks	MD (Abs)	p-value	Investing banks	Non-investing banks	MD (Abs)	p-value
Size (ln)	15.423	12.111	-3.312	0.000	15.423	15.424	0.001	0.999

Note: This table shows the propensity score matching results. Investing banks are banks that have invested in a fintech funding round at least once in the period 2005Q1 to 2023Q4. Non-investing banks are banks that did not partake in any fintech investment rounds. *Size*, estimated as the bank's total assets in logarithmic form, was used as a matching variable. Mean values are shown, along with the statistical significance difference (p-value).

Table 2: Pairwise correlation matrix of independent variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	*Trademarks* (ln)	1.000								
(2)	*Patents* (ln)	0.487	1.000							
(3)	*Multiple_Investment* (ln)	0.331	0.412	1.000						
(4)	*Initial_Investment* (ln)	0.306	0.378	0.942	1.000					
(5)	*ROE* (%)	0.066	0.093	0.069	0.055	1.000				
(6)	*Capitalization* (%)	-0.009	0.015	-0.050	-0.045	-0.129	1.000			
(7)	*Liquidity* (%)	0.126	0.228	0.220	0.196	-0.004	0.075	1.000		
(8)	*NPLs* (%)	-0.052	-0.033	-0.063	-0.062	-0.307	-0.003	0.027	1.000	
(9)	*Interest_Rate* (%)	0.023	0.004	0.008	0.007	0.157	-0.061	-0.035	-0.261	1.000

Table 3: Summary Statistics

	All banks		Investing banks		Non-investing banks		Mean Difference (MD)
	Mean	SD	Mean	SD	Mean	SD	Abs
Trademarks (ln)	0.12	0.37	0.18	0.44	0.04	0.22	-0.14***
Patent (ln)	0.22	0.77	0.37	0.97	0.01	0.14	-0.36***
Multiple_Investment (ln)	0.04	0.21	0.08	0.27	0	0	-0.08***
Initial_Investment (ln)	0.03	0.17	0.06	0.23	0	0	-0.06***
ROE (%)	5.42	7.05	5.53	7.09	5.27	7.01	-0.26*
Capitalization (%)	11.44	3.82	11.06	3.45	11.98	4.22	0.92***
Liquidity (%)	10.45	10.52	11.24	10.55	9.35	10.39	-1.89***
NPLs (%)	1.19	1.73	1.13	1.54	1.28	1.95	0.15***
Interest_Rate (%)	4.62	1.80	-	-	-	-	-

Note: This table presents the summary statistics of regression variables in the period under study (2005Q1-2023Q4) for three groups of banks; the first group contains all banks in the regression estimation sample (All banks), the second group contains banks who invested in the equity shares of at least one fintech firm (Investing banks), and the third group contains statistics for banks that did not participate in any equity funding round conducted by a fintech firm (Non-investing banks). Mean and standard deviation (SD) values are calculated as the average cross-sectional mean and SD of the individual time-series bank values. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the findings. Table A.1 shows the definition of all variables. MD in the last column refers to the mean difference between acquiring banks and non-acquiring banks in absolute (Abs) values and its statistical significance which is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Table 4: Impact of bank-fintech equity investment on bank innovation

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	-0.014	-0.017		
	(0.027)	(0.028)		
$Patents_{t-1}$ (ln)			0.198***	0.179***
			(0.058)	(0.058)
$Multiple\_Investment_{t-1}$ (ln)	0.240***		0.590***	
	(0.078)		(0.144)	
$Initial\_Investment_{t-1}$ (ln)		0.298***		0.739***
		(0.104)		(0.199)
ROE_{t-1} (%)	-0.017	-0.017	-0.022	-0.024
	(0.013)	(0.013)	(0.014)	(0.015)
$Capitalization_{t-1}$ (%)	-0.003	-0.002	0.007	0.008
	(0.006)	(0.007)	(0.013)	(0.013)
$Liquidity_{t-1}$ (%)	0.004*	0.004*	0.008**	0.009**
	(0.002)	(0.002)	(0.004)	(0.004)
$NPLs_{t-1}$ (%)	-0.297	-0.303	-0.366	-0.413
	(0.211)	(0.211)	(0.307)	(0.329)
$Interest\_Rate_{t-1}$ (%)	0.385	0.377	-0.130	-0.164
	(0.245)	(0.249)	(0.500)	(0.487)
Number of Observations	9,491	9,491	9,491	9,491
Number of Groups	161	161	161	161
Number of Instruments	30	30	30	30
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.586	0.613	0.533	0.803
Hansen Test	0.269	0.267	0.075	0.087

Note: This table shows the two-step system GMM regression results for Equation 1 during the period 2005Q1-2023Q4. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 5: Falsification test

	Dependent: Multiple Investment (ln)		Dependent: Initial Investment (ln)	
	(1)	(2)	(3)	(4)
$Multiple\_Investment_{t-1}$ (ln)	0.004	0.022		
	(0.117)	(0.036)		
$Initial\_Investment_{t-1}$ (ln)			0.037	0.053
			(0.045)	(0.036)
$Trademarks_{t-1}$ (ln)	0.789		0.175	
	(1.246)		(0.321)	
$Patents_{t-1}$ (ln)		0.056		0.044
		(0.060)		(0.073)
ROE_{t-1} (%)	-0.001	0.002	0.001	0.001
	(0.008)	(0.001)	(0.001)	(0.001)
$Capitalization_{t-1}$ (%)	0.000	-0.002	-0.001	-0.002
	(0.008)	(0.002)	(0.003)	(0.003)
$Liquidity_{t-1}$ (%)	-0.000	0.001	0.001	0.001
	(0.004)	(0.001)	(0.001)	(0.001)
$NPLs_{t-1}$ (%)	0.122	-0.019	0.001	-0.007
	(0.341)	(0.052)	(0.079)	(0.061)
$Interest\_Rate_{t-1}$ (%)	-0.082	-0.026	-0.049*	-0.042**
	(0.089)	(0.017)	(0.029)	(0.016)
Number of Observations	9,491	9,491	9,491	9,491
Number of Groups	161	161	161	161
Number of Instruments	30	30	30	30
AR(1)	0.355	0.001	0.000	0.000
AR(2)	0.246	0.168	0.120	0.115
Hansen Test	0.574	0.155	0.407	0.397

Note: This table shows the two-step system GMM regression results during the period 2005Q1-2023Q4. Columns (1) and (2) were estimated using the natural logarithm of one plus the total number of bank investments in fintech firms' funding rounds as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of initial bank investment in fintech firms' funding rounds as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Table 6: Longer lagged periods: impact of bank-fintech equity investment on bank innovation

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	-0.005	-0.007		
	(0.022)	(0.022)		
$Patents_{t-1}$ (ln)			0.144*	0.128
			(0.086)	(0.087)
$Multiple\_Investment_{t-1}$ (ln)	0.198***		0.481***	
	(0.063)		(0.146)	
$Multiple\_Investment_{t-2}$ (ln)	0.220***		0.548**	
	(0.055)		(0.249)	
$Multiple\_Investment_{t-3}$ (ln)	0.204***		0.423***	
	(0.049)		(0.131)	
$Initial\_Investment_{t-1}$ (ln)		0.202***		0.568***
		(0.064)		(0.206)
$Initial\_Investment_{t-2}$ (ln)		0.251***		0.719**
		(0.063)		(0.314)
$Initial\_Investment_{t-3}$ (ln)		0.240***		0.535***
		(0.060)		(0.145)
ROE_{t-1} (%)	-0.006	-0.006	0.030	0.034
	(0.007)	(0.008)	(0.064)	(0.066)
$Capitalization_{t-1}$ (%)	-0.011	-0.012	-0.001	-0.003
	(0.009)	(0.009)	(0.02)	(0.021)
$Liquidity_{t-1}$ (%)	0.002	0.003	0.004	0.005
	(0.002)	(0.002)	(0.006)	(0.006)
$NPLs_{t-1}$ (%)	0.107	0.117	0.539	0.654
	(0.168)	(0.175)	(1.348)	(1.527)
$Interest\_Rate_{t-1}$ (%)	0.401**	0.428***	-0.753	-0.701
	(0.162)	(0.164)	(0.801)	(0.714)
Number of Observations	9,172	9,172	9,172	9,172
Number of Groups	160	160	160	160
Number of Instruments	30	30	30	30
AR(1)	0.000	0.000	0.172	0.170
AR(2)	0.929	0.938	0.668	0.637
Hansen Test	0.477	0.506	0.110	0.150

Note: This table shows the two-step system GMM regression results for Equation 1 during the period 2005Q1-2023Q4. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality, while the main explanatory variables were lagged by two and three periods. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Table 7: Placebo test: impact of bank-fintech equity investment on bank innovation

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	-0.027	-0.017		
	(0.041)	(0.062)		
$Patents_{t-1}$ (ln)			0.218*	0.276*
			(0.124)	(0.145)
$Placebo\_Multiple\_Investment_{t-1}$ (ln)	3.008		5.170	
	(2.063)		(10.22)	
$Placebo\_Initial\_Investment_{t-1}$ (ln)		3.794		5.024
		(2.665)		(8.741)
ROE_{t-1} (%)	0.019	0.022	-0.001	0.002
	(0.028)	(0.029)	(0.101)	(0.112)
$Capitalization_{t-1}$ (%)	-0.005	-0.001	-0.005	-0.002
	(0.008)	(0.014)	(0.021)	(0.028)
$Liquidity_{t-1}$ (%)	-0.003	-0.005	-0.001	0.003
	(0.006)	(0.007)	(0.03)	(0.021)
$NPLs_{t-1}$ (%)	0.059	-0.128	-0.266	
	(0.308)	(0.413)	(1.560)	(1.477)
$Interest\_Rate_{t-1}$ (%)	0.109	0.129	0.0710	0.0901
	(0.127)	(0.139)	(0.503)	(0.498)
Number of Observations	9,491	9,491	9,491	9,491
Number of Groups	160	160	160	160
Number of Instruments	30	30	30	30
AR(1)	0.052	0.070	0.563	0.498
AR(2)	0.803	0.953	0.760	0.853
Hansen Test	0.570	0.908	0.715	0.605

Note: This table shows the two-step system GMM regression results for Equation 1 during the period 2005Q1-2023Q4. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality, while the main explanatory variables were lagged by two and three periods. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Table 8: Analysis of fintech firms investment rounds

	Fin-native	Tech-native	**Total**
Domestic	336	220	**556**
Cross-border	144	72	**216**
Total	**480**	**292**	**772**

Note: This table provides a detailed analysis of fintech firms' investment rounds that are included in our sample, categorized by geographic location (domestic US or cross-border) and main service provided (fin-native or tech-native). The data is sourced from Crunchbase.

Table 9: Impact of domestic and cross-border bank-fintech equity investment on bank innovation

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	-0.002	-0.022		
	(0.023)	(0.092)		
$Patents_{t-1}$ (ln)			0.168**	0.241*
			(0.074)	(0.137)
Domestic (dummy)	1.742**		3.592**	
	(0.871)		(1.711)	
$Cross\_Border$ (dummy)		0.958		4.791
		(4.015)		(7.318)
$Multiple\_Investment_{t-1}$ (ln)	0.211**	0.075	0.520***	-0.038
	(0.089)	(0.164)	(0.175)	(0.427)
ROE_{t-1} (%)	-0.003	-0.010	0.013	-0.009
	(0.005)	(0.011)	(0.010)	(0.015)
$Capitalization_{t-1}$ (%)	0.002	-0.003	0.015	-0.001
	(0.004)	(0.008)	(0.011)	(0.016)
$Liquidity_{t-1}$ (%)	-0.001	0.007	-0.008	0.004
	(0.007)	(0.019)	(0.016)	(0.030)
$NPLs_{t-1}$ (%)	-0.052	-0.265	0.268	-0.270
	(0.176)	(0.321)	(0.388)	(0.497)
$Interest\_Rate_{t-1}$ (%)	0.289	0.504*	-0.891	0.381
	(0.179)	(0.280)	(0.545)	(0.433)
Number of Observations	9,492	9,492	9,492	9,492
Number of Groups	161	161	161	161
Number of Instruments	31	31	31	31
AR(1)	0.002	0.000	0.036	0.333
AR(2)	0.874	0.617	0.023	0.740
Hansen Test	0.922	0.431	0.304	0.663

Note: This table shows the two-step system GMM regression results for Equation 1 with the inclusion of two dummy variables *Domestic* and $Cross\_Border$. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Table 10: Impact of bank-fintech equity investment on bank innovation using geographical proximity measures

	Dependent: Trademarks (ln)	Dependent: Patents (ln)
	(1)	(2)
$Trademarks_{t-1}$ (ln)	0.015	
	(0.0328)	
$Patents_{t-1}$ (ln)		0.152
		(0.113)
$Different\_State$ (dummy)	0.286***	0.487
	(0.083)	(0.353)
$Same\_State$ (dummy)	0.258***	0.564***
	(0.072)	(0.214)
$Multiple\_Investment_{t-1}$ (ln)	0.269**	0.764**
	(0.108)	(0.345)
ROE_{t-1} (%)	0.006	0.064
	(0.027)	(0.135)
$Capitalization_{t-1}$ (%)	-0.008	-0.008
	(0.008)	(0.0251)
$Liquidity_{t-1}$ (%)	0.002	0.004
	(0.002)	(0.008)
$NPLs_{t-1}$ (%)	0.329	1.382
	(0.645)	(3.390)
$Interest\_Rate_{t-1}$ (%)	0.284	-0.818
	(0.187)	(0.603)
Number of Observations	9,492	9,492
Number of Groups	161	161
Number of Instruments	31	31
AR(1)	0.002	0.350
AR(2)	0.891	0.531
Hansen Test	0.101	0.014

Note: This table shows the two-step system GMM regression results for Equation 1 with the inclusion of two dummy variables $Same\_state$ and $Different\_state$. Column (1) was estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Column (2) was estimated using the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Table 11: Impact of fin-native and tech-native bank-fintech equity investment on bank innovation

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	-0.016	-0.005		
	(0.038)	(0.047)		
$Patents_{t-1}$ (ln)			0.137**	0.186***
			(0.068)	(0.068)
Fin_native (dummy)	1.670**		4.638**	
	(0.757)		(2.053)	
$Tech\_native$ (dummy)		0.455		2.578
		(1.584)		(3.054)
$Multiple\_Investment_{t-1}$ (ln)	0.247**	0.228***	0.687***	0.550***
	(0.103)	(0.066)	(0.237)	(0.165)
ROE_{t-1} (%)	-0.001	-0.003	0.001	-0.002
	(0.002)	(0.003)	(0.003)	(0.003)
$Capitalization_{t-1}$ (%)	0.002	-0.001	0.007	-0.002
	(0.003)	(0.003)	(0.007)	(0.007)
$Liquidity_{t-1}$ (%)	-0.000	0.007	-0.002	0.014
	(0.003)	(0.004)	(0.010)	(0.012)
$NPLs_{t-1}$ (%)	-0.003	-0.060	0.066	-0.156
	(0.064)	(0.066)	(0.085)	(0.142)
$Interest\_Rate_{t-1}$ (%)	0.289	0.372*	0.167	-0.713
	(0.180)	(0.211)	(0.581)	(0.513)
Number of Observations	9,492	9,492	9,492	9,492
Number of Groups	161	161	161	161
Number of Instruments	31	31	31	31
AR(1)	0.000	0.000	0.020	0.206
AR(2)	0.653	0.929	0.837	0.252
Hansen Test	0.983	0.524	0.741	0.125

Note: This table shows the two-step system GMM regression results for Equation 1 with the inclusion of two dummy variables Fin_native and $Tech\_native$. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Appendix A Variable Definitions

Table A.1: Variable definitions

Variable	Definition
Trademarks (ln)	The natural logarithm of one plus the number of trademark applications filed by the bank.
Patents (ln)	The natural logarithm of one plus the number of patent applications filed by the bank.
Multiple_Investment (ln)	The natural logarithm of one plus the total number of bank investments in fintech firms' funding rounds.
Initial_Investment (ln)	The natural logarithm of one plus the number of initial bank investment in fintech firms' funding rounds.
Size (ln)	The natural logarithm form of bank total assets.
ROE (%)	The ratio of net income / total equity.
Capitalization (%)	The ratio of total equity / total assets.
Liquidity (%)	The ratio of cash and short-term investment / total assets.
NPLs (%)	The ratio of total loans on non-accrual status / total loans.
Interest_Rate (%)	The quarterly bank nominal lending rate.
Intangible_Assets (ln)	The natural logarithm of one plus the total amount of bank intangible assets.
Domestic (dummy)	A dummy variable that takes the value of 1 if the headquarters of the fintech firm is located in the United States, and 0 otherwise.
Cross_Border (dummy)	A dummy variable that takes the value of 1 if the headquarters of the fintech firm is located outside the United States, and 0 otherwise.
Same_State (dummy)	A dummy variable that takes the value of 1 if the headquarters of the fintech firm is located in the same US state as the acquiring bank, and 0 otherwise.
Different_State (dummy)	A dummy variable that takes the value of 1 if the headquarters of the fintech firm is located in a different US state than the acquiring bank, and 0 otherwise.
Fin_native (dummy)	A dummy variable that takes the value of 1 if the primary business line of the fintech firm is one of the following sub-industries: payment, lending, investment, personal finance, insurance, and digital credit. It takes 0 otherwise.
Tech_native (dummy)	A dummy variable that takes the value of 1 if the primary business line of the fintech firm is one of the following sub-industries: blockchain, software and services, data analytics, and regtech. It takes 0 otherwise.

Appendix B Additional robustness checks

Appendix B.1 Alternative measure of bank innovation

To provide further validity to our main findings, an alternative measure of bank innovation is utilized. We follow extant literature (Collevecchio et al., 2023; Ayadi et al., 2021; Cao et al., 2022) and use bank intangible assets to quantify the innovation capabilities within banks. We argue that intangible assets is a relevant indicator that is worth investigating. Primarily due to its relevance to bank intellectual properties, which include trademarks and patents within its calculations according to the generally accepted accounting principles (GAAP) that is mandated when banks present their financial statements (Federal Deposit Insurance Corporation, 2024). In this subsection, we replicate the main analysis outlined in Equation 1 and include the natural logarithm of one plus the total amount of bank intangible assets as a dependent variable.

Table B.1 presents the regression results of the alternative measure analysis. We still observe a significantly positive relationship between the total number of bank investments in the funding rounds of fintech startups and the level of bank innovation, as measured by bank intangible assets. The initial bank investment in fintech funding rounds continues to have a significantly positive association. Overall, our alternative measure analysis has resulted in broadly similar findings to those found in the main analysis. This provides additional reliability to our main results.

Appendix B.2 Controlling for technological development

We provide further validity checks to our main results by controlling for banks' technological development that may impact their innovation levels. Specifically, following related literature (Sefried and Riepe 2023; Sedunov 2017), we construct the variable $IT\_Expenditure$, measured as the ratio of data processing costs to non-interest expenses. The inclusion of this variable in our model provides us the ability to quantify banks' in-house technological advancement, and address a concern that bank-fintech investment could be influenced by the level of technological development within banks. The results are presented in Table

Table B.1: Impact of bank-fintech equity investment on bank innovation using alternative measure

	Dependent: Intangible Assets (ln)	
	(1)	(2)
$Intangible\_Assets_{t-1}$ (ln)	0.994***	0.994***
	(0.008)	(0.008)
$Multiple\_Investment_{t-1}$ (ln)	0.081**	
	(0.035)	
$Initial\_Investment_{t-1}$ (ln)		0.101**
		(0.043)
ROE_{t-1} (%)	0.003	0.003
	(0.006)	(0.006)
$Capitalization_{t-1}$ (%)	-0.003	-0.003
	(0.005)	(0.005)
$Liquidity_{t-1}$ (%)	0.000	0.000
	(0.001)	(0.001)
$NPLs_{t-1}$ (%)	-0.105	-0.106
	(0.107)	(0.108)
$Interest\_Rate_{t-1}$ (%)	-0.018	-0.019
	(0.049)	(0.049)
Number of Observations	9,492	9,492
Number of Groups	161	161
Number of Instruments	30	30
AR(1)	0.000	0.000
AR(2)	0.299	0.304
Hansen Test	0.420	0.424

Note: This table shows the two-step system GMM regression results for Equation 1 during the period 2005Q1-2023Q4. The dependent variable used in this table is the natural logarithm of one plus the total amount of bank intangible assets. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

B.2. We find no evidence suggesting that the IT expenditure activity is related to banks' trademark and patent applications, as we observe a statistically insignificant coefficients of IT expenditure across all specifications. Most importantly, we find that the coefficients of fintech investment (both multiple and initial) are still statistically significant following the inclusion of IT expenditure as a control variable. Overall, the results suggest that IT expenditure can not explain the variations in innovation capabilities within banks, and that the main results are not driven by omitted in-house technological development.

Table B.2: Impact of bank-fintech equity investment on bank innovation - Controlling for banks' IT expenditure

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	-0.02	-0.024		
	(0.025)	(0.026)		
$Patents_{t-1}$ (ln)			0.194***	0.178***
			(0.061)	(0.059)
$Multiple\_Investment_{t-1}$ (ln)	0.261***		0.571***	
	(0.076)		(0.147)	
$Initial\_Investment_{t-1}$ (ln)		0.327***		0.713***
		(0.102)		(0.204)
$IT\_Expenditure_{t-1}$ (%)	0.002	0.001	-0.002	-0.002
	(0.009)	(0.009)	(0.012)	(0.012)
ROE_{t-1} (%)	-0.025**	-0.025**	-0.017	-0.0197
	(0.012)	(0.012)	(0.02)	(0.021)
$Capitalization_{t-1}$ (%)	-0.002	-0.002	0.001	0.001
	(0.006)	(0.006)	(0.008)	(0.008)
$Liquidity_{t-1}$ (%)	0.005*	0.005**	0.007	0.007
	(0.002)	(0.002)	(0.005)	(0.005)
$NPLs_{t-1}$ (%)	-0.362	-0.366	-0.246	-0.274
	(0.246)	(0.246)	(0.385)	(0.409)
$Interest\_Rate_{t-1}$ (%)	0.481**	0.479**	-0.092	-0.097
	(0.240)	(0.242)	(0.531)	(0.516)
Number of Observations	9,491	9,491	9,491	9,491
Number of Groups	161	161	161	161
Number of Instruments	30	30	30	30
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.243	0.248	0.255	0.423
Hansen Test	0.472	0.485	0.029	0.033

Note: This table shows the two-step system GMM regression results for Equation 1 during the period 2005Q1-2023Q4. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Appendix B.3 Controlling for funding rounds

Finally, we provide an additional robustness check to address the potential confounding effects of investment stage, which could influence the relationship between investing in domestic vs cross-border and fin-native vs tech-native subgroups on one side, and bank innovation on the other side. For example, it might be argued that early-stage domestic investments may coincide with smaller deal sizes and higher proximity advantages. To empirically address this issue, we control for equity funding stage in our subgroup analyses by including an equity funding stage dummy variable that equals 1 if the funding round was early (i.e., Pre-seed, Seed, Angel, Series A, and Series B rounds), and 0 otherwise. Tables B.3 and B.4 present the results of this test, which remain statistically and economically consistent with our baseline results.

Table B.3: Impact of domestic and cross-border bank-fintech equity investment on bank innovation - Controlling for equity funding stage

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	0.004	0.001		
	(0.028)	(0.091)		
$Patents_{t-1}$ (ln)			0.131	0.143
			(0.083)	(0.166)
Domestic (dummy)	1.500**		2.882**	
	(0.720)		(1.180)	
$Cross\_Border$ (dummy)		0.014		4.499
		(4.195)		(9.441)
$Multiple\_Investment_{t-1}$ (ln)	0.302*	0.215	1.211**	0.482
	(0.169)	(0.263)	(0.483)	(1.283)
$Early\_Stage$ (dummy)	-0.086	0.061	-0.477***	0.009
	(0.098)	(0.126)	(0.176)	(0.441)
ROE_{t-1} (%)	0.005	0.006	0.089	0.045
	(0.023)	(0.031)	(0.081)	(0.101)
$Capitalization_{t-1}$ (%)	0.006	0.004	0.051	0.021
	(0.012)	(0.014)	(0.0433)	(0.043)
$Liquidity_{t-1}$ (%)	-0.003	0.004	-0.033	-0.013
	(0.012)	(0.024)	(0.039)	(0.043)
$NPLs_{t-1}$ (%)	0.205	0.228	2.368	1.257
	(0.636)	(0.907)	(2.257)	(2.800)
$Interest\_Rate_{t-1}$ (%)	0.268	0.450	-0.787*	0.115
	(0.192)	(0.279)	(0.449)	(0.805)
Number of Observations	9,492	9,492	9,492	9,492
Number of Groups	161	161	161	161
Number of Instruments	31	31	31	31
AR(1)	0.001	0.000	0.009	0.499
AR(2)	0.704	0.880	0.136	0.555
Hansen Test	0.913	0.372	0.877	0.620

Note: This table shows the two-step system GMM regression results for Equation 1 with the inclusion of two dummy variables *Domestic* and *Cross_Border*. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Table B.4: Impact of fin-native and tech-native bank-fintech equity investment on bank innovation - Controlling for equity funding stage

	Dependent: Trademarks (ln)		Dependent: Patents (ln)	
	(1)	(2)	(3)	(4)
$Trademarks_{t-1}$ (ln)	-0.010	-0.002		
	(0.041)	(0.045)		
$Patents_{t-1}$ (ln)			0.119	0.141*
			(0.084)	(0.083)
Fin_native (dummy)	1.650**		4.117*	
	(0.766)		(2.202)	
$Tech\_native$ (dummy)		0.114		3.536
		(1.166)		(4.155)
$Multiple\_Investment_{t-1}$ (ln)	0.283*	0.318***	0.786**	0.886*
	(0.151)	(0.119)	(0.358)	(0.453)
$Early\_Stage$ (dummy)	-0.021	-0.056	0.074	0.159
	(0.072)	(0.105)	(0.184)	(0.377)
ROE_{t-1} (%)	0.004	0.01	0.041	0.075
	(0.022)	(0.0171)	(0.075)	(0.100)
$Capitalization_{t-1}$ (%)	0.004	0.004	0.027	0.032
	(0.01)	(0.006)	(0.038)	(0.046)
$Liquidity_{t-1}$ (%)	-0.001	0.002	-0.011	-0.026
	(0.011)	(0.008)	(0.032)	(0.067)
$NPLs_{t-1}$ (%)	0.151	0.327	1.037	2.083
	(0.619)	(0.476)	(1.988)	(3.017)
$Interest\_Rate_{t-1}$ (%)	0.255	0.325	-0.408	-0.558
	(0.205)	(0.201)	(0.763)	(0.410)
Number of Observations	9,492	9,492	9,492	9,492
Number of Groups	161	161	161	161
Number of Instruments	31	31	31	31
AR(1)	0.000	0.039	0.000	0.322
AR(2)	0.910	0.828	0.483	0.432
Hansen Test	0.981	0.438	0.937	0.609

Note: This table shows the two-step system GMM regression results for Equation 1 with the inclusion of two dummy variables Fin_native and $Tech\_native$. Columns (1) and (2) were estimated using the natural logarithm of one plus the number of trademarks filed by a bank as a dependent variable. Columns (3) and (4) represent the results with the natural logarithm form of one plus the number of bank patent applications as the dependent variable. Table A.1 shows the definition of all variables. Time fixed effects were included to account for unobserved time-varying factors. All variables have been winsorized at the 1% and 99% levels to avoid outliers from skewing the paper's findings. All variables were lagged by one period to mitigate potential concerns about endogeneity and reverse causality. We also test for the presence of first and second order serial correlation through AR(1) and AR(2), and we use the Hansen test to check the validity of the instruments used. The statistical significance is denoted by the following symbols: * p<0.1, ** p<0.05, *** p<0.01.

Appendix C Classifying bank-fintech equity investment rounds

We use the qualitative content analysis (QCA) approach to classify each fintech company in the sample according to the specific sub-industry it belongs to, based on the services it offers. Fintech is an interdisciplinary field where firms may use their innovative capabilities to provide a wide variety of products across multiple sub-industries. Bellardini et al. (2022) investigate a global sample of fintech funding rounds between 2008 and 2018. They find that their sample of fintech firms can be classified in the following industries: open banking, deposit and lending, investment management, capital raising, market provisioning, digital wallets and payments, insurtech, blockchain, artificial intelligence, cryptocurrency, and software and services. Similarly, Li et al. (2023) find 11 sub-industries of fintech firms, these are: online banking, payment, lending, investment, capital raising, trading platforms, personal finance, insurtech, blockchain, cybersecurity, and enterprise software and services.

In this paper, we follow Collevecchio et al. (2023)'s approach and assign the fintech company to the sub-industry that is most frequently highlighted in its business description in Crunchbase. In our sample, we have identified 10 sub-industries: PayTech, Software and services, Investment Services, Digital Lending, Data Analytics, Personal Finance, InsurTech, Blockchain, RegTech, and Neobank. We follow Bellardini et al. (2022) and broadly categorize our sample of fintech firms by their sub-industry into two groups: fin-native and tech-native. First, fin-native firms are those that mainly provide financial services, including firms in these sub-industries: payment, lending, investment, personal finance, insurance, and digital banking. Second, tech-native firms are those that primarily provide technological services, including firms in the sub-industries of blockchain, software and services, data analytics, and regtech. Table C.1 lists the characteristics of identified fintech firms' sub-industries in our sample.

Table C.1: Sub-industries of fintech firms

Sub-Industry	**Characteristics**
PayTech	An abbreviation for 'payment technology,' it refers to providing innovative payment solutions including digital wallets and mobile and contactless payments.
Software and Services	Specializing in software services such as financial APIs, SaaS, and BaaS models.
Investment Services	The use of technology to provide cutting-edge investing services. These include robo-advisors, foreign exchange trading, and digital wealth management.
Digital Lending	A type of credit that is issued using online methods. For example, P2P lending, cloud-based credit, and POS financing.
Data Analytics	Firms that use cutting-edge data analysis techniques to offer innovative financial products. It includes credit scoring and capital market analytics services.
Personal Finance	It refers to the management of all financial aspects related to individuals. This includes tools for financial planning, expense management, and debt control.
InsurTech	Short for 'insurance technology', which refers to firms that provide digital insurance solutions such as income protection plans and virtual evaluation and claim services.
Blockchain	The use of distributed ledger technology to offer decentralized financial products and services. Decentralized crypto-trading, cryptocurrency, and tokenization of financial assets are examples of blockchain services.

Continued on next page

Table C.1 – *Continued from previous page*

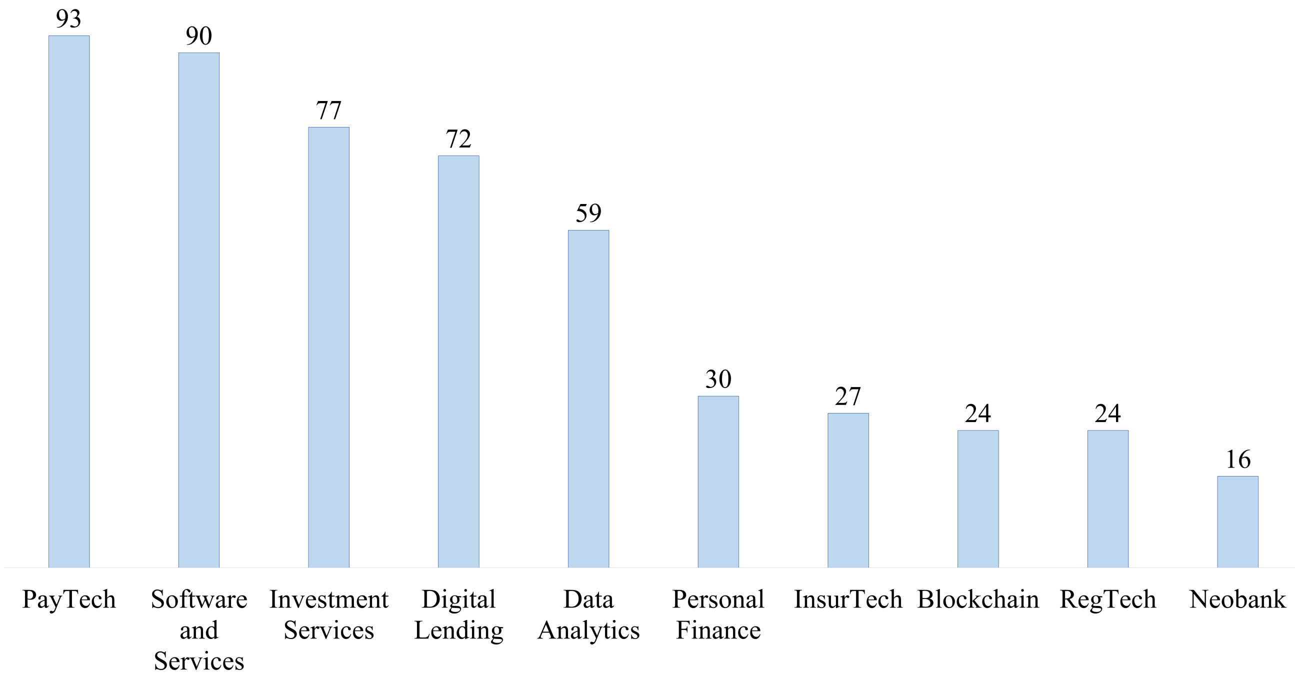
Sub-Industry	**Characteristics**
RegTech	The abbreviation for ‘regulation technology’, which refers to the use of technology to facilitate compliance requirements. It includes financial crime, fraud detection, and AML services.
Neobank	Digital-only banks that provide exclusively online financial services and products to consumers.

Figure C.1 outlines the number of fintech firms categorized into the identified sub-industries in our sample. With 93 firms specializing in providing innovative payment technology (PayTech) services, this sub-industry has the highest number of firms that secured equity investment during the sample period. With a market size of $240 trillion, the potential growth for PayTechs is unlimited with the increasing demands from consumers and merchants (Gancz et al., 2022). Firms under this category have a wide range of niche innovations, including mobile payments, digital wallets, and contactless payments. Through equity investments, banks are forming alliances with innovative paytech ventures in order to maintain their competitiveness and relevance in a rapidly evolving payment industry.

The second-highest number of investments was made in fintech startups specializing in software services, with a total of 90 firms. It involves companies that provide financial and banking application programming interfaces (APIs) which enable the use of third-party features. Additionally, it covers software-as-a-service (SaaS) and banking-as-a-service (BaaS) models, which enable the use of software and banking services to a third party via APIs, such as utilizing robo-advisors or opening savings accounts. It also includes companies that offer cloud accounting and credit card software.

Investment services firms account for 77 of the total fintech firms in the sample. These firms have introduced innovative digital investment tools such as digital wealth management solutions. Moreover, digital lending comes next with 72 firms that use cutting-edge technology in the domain of loans. Services include peer-to-peer (P2P) lending, credit software

Figure C.1: Sub-industries of fintech firms (2005Q1-2023Q4)



based on cloud technology, and financing solutions available through point of sale (POS).

The data analytics sub-industry consists of 59 firms that leverage their innovative data analysis approaches to provide unique financial solutions. It includes risk management companies that specialize in using innovation to deliver services such as credit score and worthiness services. In addition, this sub-industry includes capital market analytics, which involve the use of financial charts and visualization services. Furthermore, there are a total of 30 companies that fall under the Personal Finance category. These companies provide customers with tools and services to facilitate the management of their finances. For example, companies that manage expenses, debt, and financial planning are included. In addition to cutting-edge retirement plans and income intelligence services.

InsurTech is the term used to describe the use of technology in the insurance sector. 27 firms are under this category, and it covers several innovative solutions to provide unique insurance services. Companies within this sub-industry provide online platforms that allow consumers to apply for income protection plans, as well as virtual evaluation and claim services. The following category consists of blockchain firms that use distributed ledger technology to provide decentralized solutions (Goldstein et al., 2019). DeFi (Decentralized Finance), decentralized crypto-trading, cryptocurrency, and tokenized issuance of financial securities are among the services offered by 24 blockchain firms.

Next, regulatory technology, or RegTech, is the application of technology to facilitate compliance requirements. In our sample, 24 firms are labeled as RegTech firms that provide financial crime and fraud detection tools, anti-money laundering (AML), and client verification services. Finally, 16 companies are classified as neobanks, which are digital-only banks with no physical presence. They provide customers with a broad range of financial solutions via digital platforms.