

Chapter 3 at a Glance

- Fintech—technological innovation in financial activities—can reduce costs and frictions, increase efficiency and competition, and broaden access to financial services.
- This chapter focuses on vulnerabilities and financial stability implications of the rapid growth of fintech firms (“fintechs”), accelerated by the COVID-19 pandemic. Their fast growth into risky business segments, combined with sometimes inadequate regulation and/or supervision, gives rise to systemic risks and potential financial stability implications.
- Digital banks (“neobanks”) are growing in systemic importance in their local markets. A case study on neobanks unveils several vulnerabilities: (1) higher risk-taking in retail loan originations without appropriate provisioning and underpricing of credit risk; (2) higher risk-taking in the securities portfolio; and (3) an inadequate liquidity management framework.
- Fintech firms not only take on risks themselves but also exert pressure on incumbents. The case study of the US mortgage market presents evidence of a significant negative impact of competitive pressure from fintechs on the income of traditional banks.
- By taking innovation to a new level, a form of financial intermediation based on crypto assets, known as decentralized finance (DeFi), has had extraordinary growth in the past two years, potentially offering higher efficiency and investment opportunities. DeFi is increasingly interconnected with traditional financial intermediaries. While its market size is still relatively small, unregulated DeFi poses market, liquidity, and cyber risks, against a backdrop of legal uncertainties.
- Policies that target both fintech firms and incumbents proportionately are needed. For neobanks, more robust capital, liquidity, and operational risk-management requirements (at the entity and group levels) commensurate with their risks are desirable. For incumbents, prudential supervision may need greater focus on the health of less technologically advanced banks, as their existing business models may be less sustainable over the long term.
- The absence of centralized entities governing DeFi is a challenge for effective regulation and supervision. Regulation should focus on elements of the crypto ecosystem that enable DeFi, such as stablecoin issuers and centralized exchanges. Authorities should also encourage DeFi platforms to be subject to robust governance schemes, including industry codes and self-regulatory organizations. These entities could provide an effective conduit for regulatory oversight.

Introduction

Technological change has been reshaping banking services for years, but groundbreaking innovation and widespread adoption have accelerated this process globally. Fintech—technological innovation in financial activities—is increasingly disrupting core financial services traditionally provided by banks

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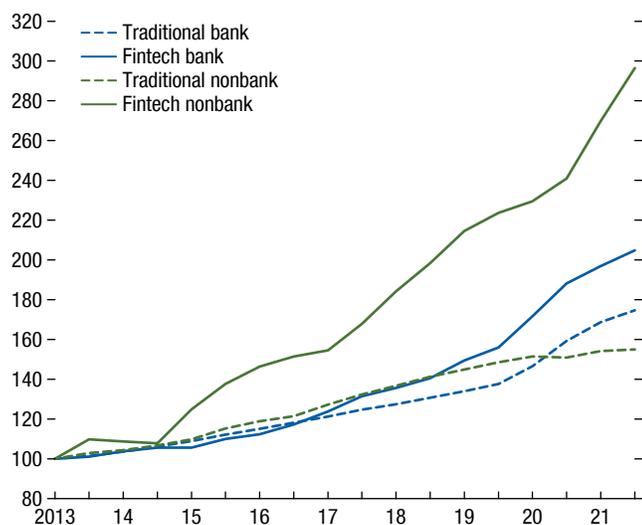
and has gained even more momentum during the COVID-19 pandemic (Figure 3.1, panel 1). At the frontier of technological advancement is decentralized finance (DeFi). DeFi is crypto-market-based financial intermediation in which all financial transactions are performed on a computer network without a central intermediary. DeFi has been growing rapidly, in tandem with the expansion of the crypto ecosystem (Figure 3.1, panel 2).

Fintech firms herald efficiency gains, progress in financial inclusion, and better customer experience (IMF 2018). Fintech firms (hereafter referred to as

Figure 3.1. The Rise of Fintech Firms and Decentralized Finance

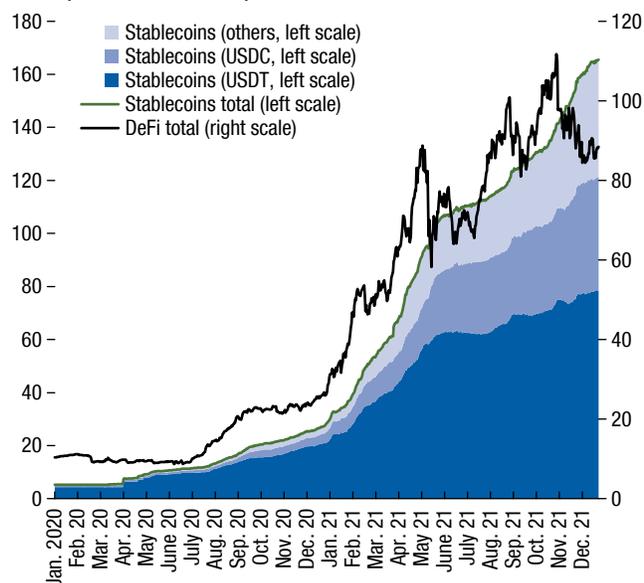
The growth of fintechs has accelerated in recent years ...

1. Growth of Assets of Fintech Lenders (2013:H1=100)



... as has the rise of assets in decentralized finance, driving growth in stablecoins.

2. Total Nominal Value of Assets in Decentralized Finance and Stablecoins (Billions of US dollars)



Sources: CoinGecko; DeFi Pulse; S&P Global Market Intelligence; and IMF staff calculations.

Note: In panel 1, the sample comprises 13 advanced economies and 7 emerging market economies. In panel 2, total nominal value of decentralized finance (DeFi) is the total value of all DeFi projects—all deposits and governance tokens held in a given platform on Ethereum blockchain as reported by DeFi Pulse. A stablecoin is a type of crypto asset that aims to maintain a stable value relative to a specified asset or a pool of assets. USDC = USD Coin; USDT = Tether.

fintechs) hold the promise of reducing costs and frictions related to informational asymmetry, increasing efficiency and competition, and broadening access to financial services, especially in low-income countries and for underserved populations. Users of fintech financial services more generally benefit from a better experience through online access to financial services on any device at any time. Taking financial innovation a step further, DeFi has experienced substantial growth in the past two years and has the potential to offer even more innovative, inclusive, and transparent financial services thanks to greater efficiency and accessibility.

The speed, reach, and depth of these changes give rise to systemic risks and pose challenges to financial stability. Fintechs are quickly making inroads into a wide range of critical financial services—sometimes aided by favorable regulatory treatment for specialized financial services. While some individual fintechs are still small, they have the ability to scale

up very rapidly—often across both riskier business segments and riskier clients than traditional lenders. The combination of fast growth and the increasing importance of fintech financial services for the functioning of financial intermediation gives rise to systemic risks. The speed and depth of such changes further pose challenges for traditional intermediaries.

In addition, DeFi often involves the buildup of leverage, and is particularly vulnerable to market, liquidity, and cyber risks as discussed in this chapter. DeFi activities are so far taking place mainly in crypto asset markets, but they can increase the interconnectedness of crypto investors. With the rapidly increasing adoption of DeFi by institutional investors, the linkages with traditional financial institutions are growing. DeFi may also accelerate the ongoing trend toward cryptoization in some economies (see Chapter 2 of the October 2021 *Global Financial Stability Report* [GFSR]).

As financial services move from regulated banks to less regulated—or even unregulated—entities and platforms, as in the case of DeFi, so do the associated risks. This poses challenges for financial authorities in the form of regulatory arbitrage, interconnectedness, and contagion that require supervisory and regulatory action, including better consumer and investor protection.

This chapter takes a deep dive into the vulnerabilities and financial stability implications of the rapid growth of fintech. It focuses on fintechs and fintech platforms (DeFi) that provide core banking services: deposit-taking and credit intermediation. While fintechs have made inroads into a broad range of financial services, deposit-taking and credit intermediation are central to both the functioning of an economy and to financial stability.¹ The chapter first lays out a conceptual framework for the different types of services provided by fintechs. It then presents two case studies of fintechs in competition with traditional banks: (1) digital banks (referred to as “neobanks”) in both advanced and emerging economies; and (2) the US mortgage origination market. The second half of the chapter focuses on lending services in the novel DeFi ecosystem, with a focus on its opportunities and risks. The chapter concludes with some policy recommendations.

Fintechs in Banking: Conceptual Framework and Risks

The core business model of banks is both to collect deposits and extend credit. In doing so, they fulfill the key economic function of financial intermediaries: the transformation of deposits (savings) into credit (investments), which entails liquidity, maturity, and credit risk transformation.

Fintechs insert themselves at various points along the financial intermediation chain, usually by providing specialized services (Figure 3.2). In doing so, fintechs can quickly develop innovative solutions that can offer efficiency gains or better customer experience.

¹Fintechs have made inroads into many other financial services, including payments, asset management, insurance, and crypto assets (Drakopoulos, Natalucci, and Papageorgiou 2021), which are beyond the scope of this chapter. Regarding data privacy concerns raised by technological developments in finance and the rise of large technological firms (big techs), the reader is referred to Haksar and others (2021).

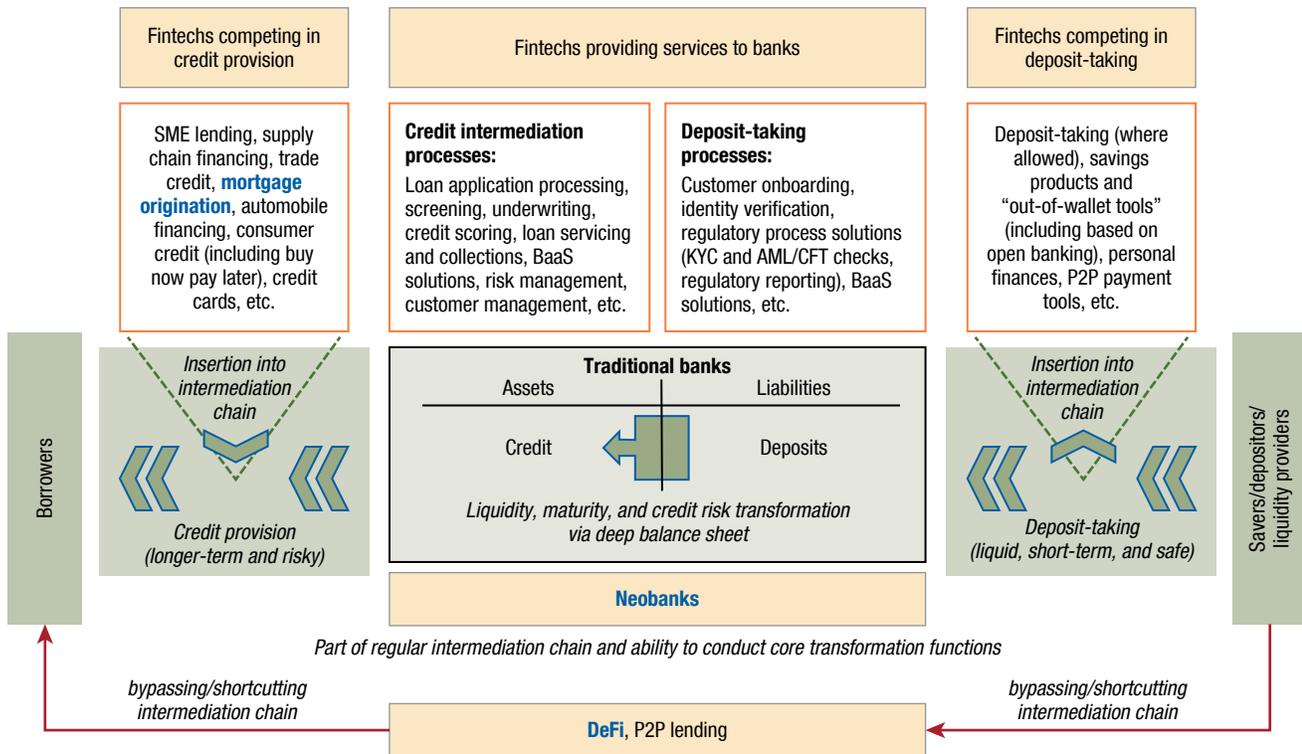
The increased competition traditional banks face from fintechs is generally beneficial from an economic point of view. Some fintechs might fall outside traditional banking regulations, as most jurisdictions allow for more lenient regulatory requirements, or can even be unregulated to some extent, as in the case of DeFi. The way in which fintechs insert themselves in the financial intermediation chain therefore has different implications for financial stability risks:

- The most common approach consists of banks cooperating with fintechs by using their services or through mergers and acquisitions. Although banks have been increasing IT-related expenditures,² using or acquiring the services of fintechs can be an effective means of technology adoption. Likewise, fintechs have been acquiring and using the services of banks. However, the use of third-party services presents challenges if they are an integral part of risk management, compliance, or fulfillment of regulatory requirements, such as “know your customer” or anti-money laundering/combating the financing of terrorism (AML/CFT). If a large number of banks rely on the same service providers, outages or cyber incidents could give rise to systemic risks.
- A more notable form of disruption arises from direct competition for the same services. Direct competition is more likely in jurisdictions where banks are less prevalent and in consumer-facing services (Boot and others 2021). In core banking services, some of the largest fintechs have grown very quickly in emerging markets—for example, Mercado Libre in Latin America, which offers a range of services, including credit to small and medium enterprises (SMEs). Direct competition in customer-facing services is lucrative for fintechs, thanks to typically higher margins than for business-to-business services.
- When fintechs provide bank-like services but operate under less stringent regulations than banks, financial stability risks can arise. The business model of fintechs relies on rapid growth, which—in the absence of appropriate regulations—can lead to excessive risk-taking, including by banks

²The largest US global bank is planning to invest \$12 billion to develop technological solutions (“JPMorgan plots ‘astounding’ \$12bn tech spend to beat fintechs” [*Financial Times*, January 15, 2022]).

Figure 3.2. Fintechs in the Core Banking Intermediation Chain

Fintechs insert themselves into the financial intermediation chain or circumvent it in the case of DeFi.



Services and institutions in blue are analyzed in this chapter

Source: IMF staff.

Note: AMF/CLT = anti-money laundering/combating the financing of terrorism; BaaS = Banking as a Service; DeFi = decentralized finance; KYC = Know Your Customer; P2P = peer to peer; SME = small and medium enterprise.

trying to defend their market position (see the case study on the US mortgage market). This can lead to capital erosion and higher systemic risk (Vives 2019).

- An important, special case of direct competition with banks is that of digital banks. They are often—but not always—fully licensed banks that compete with traditional banks across a broad range of core banking services and tend to follow a technology-driven business model with some inherent risks, as documented in the next section’s case study.
- In the most radical and disruptive approach fintechs *shortcut* the intermediation chain to remove the financial intermediary altogether. Peer-to-peer lending platforms, for instance, directly connect savers and investors with borrowers. In this case, investors commit their funds for a given time horizon and effectively assume credit and liquidity risks. In DeFi,

liquidity providers—depositors—are exposed to DeFi platforms’ run risk, while borrowers provide large amounts of collateral to eliminate credit risks (see the DeFi section later in this chapter).

Case Study: Neobanks

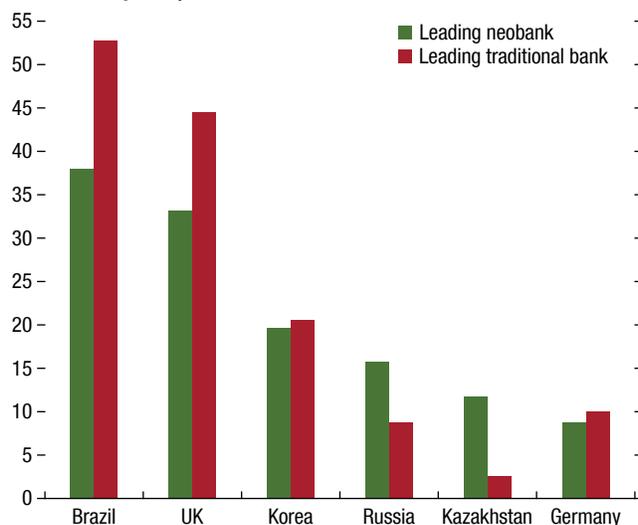
Digital banks, or *neobanks*, are direct—branchless—banks that acquire and serve customers primarily through digital touchpoints such as mobile apps.³

³This case study is based on 37 neobanks and 640 traditional banks in 18 economies. Neobanks, which have a higher-than-average risk profile (Figure 3.4), are compared against the asset-weighted average of the universe of traditional banks in their respective local markets (a measure of average bank risk). With the exception of one neobank regulated as a payment company, all other neobanks in our sample have banking licenses. Online Annex 3.1 describes both the data and methodology.

Figure 3.3. The Increasing Relevance of Neobanks

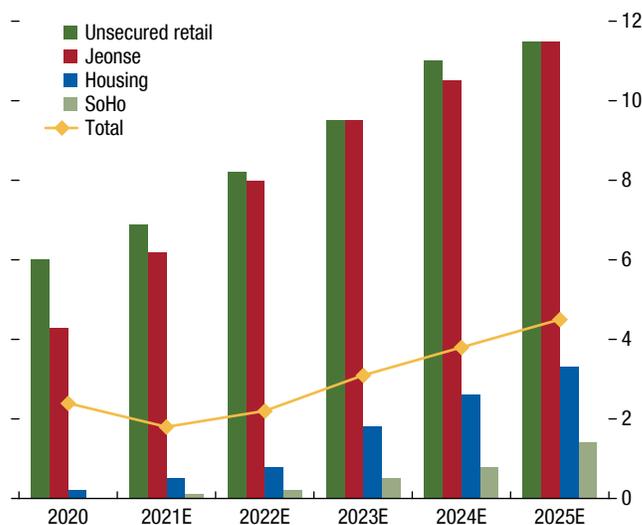
Some neobanks are among the largest players in their local markets and have large valuations ...

1. Valuation of Selected Leading Neobanks
(Billions of US dollars, as of late March 2022; for Russia: data as of January 2022)



... driven by expectations for strong loan growth, particularly in the unsecured segment.

2. Korean Digital Banks: Loan Market Share
(Percent of loans outstanding, 2021–25, expected)



Sources: Bloomberg Finance L.P.; Morgan Stanley Research; S&P Global Market Intelligence; and IMF staff calculations.

Note: Panel 1 shows the largest neobanks based on market capitalization or private valuation data. The leading traditional banks are the largest domestic banks according to assets (the second largest for Germany, Russia, and the United Kingdom). The sample of neobanks used in the case study includes the six shown above, with the exception of the UK one, for which the focus is just on its retail banking subsidiary that operates outside the UK and is significantly smaller in size (as the parent company is an e-money provider without a full banking license). In panel 2, SoHo refers to small professional businesses; Jeonse refers to special housing lease contracts in Korea. E = expected.

They aim to distinguish themselves from traditional banks through digital technologies, such as cloud computing, application programming interfaces, big data, and artificial intelligence, making banking services available on any device at any time. Neobanks tend to target financially underserved clients.

Neobanks are growing in systemic importance in their respective local markets. They have reached market capitalization nearly as large as that of some of the largest traditional banks (Figure 3.3, panel 1). Despite their currently relatively modest balance sheet size, the high valuations of some neobanks are driven by expectations for strong loan growth, particularly in the unsecured retail segment (Figure 3.3, panel 2).

Rapid scaling may be a source of value, but it may also carry higher operational risks. Rapid scaling is a key feature of neobanks, and of young firms more generally, as future growth is their main source of value. Rapid growth may also translate into the buildup of operational risks. Furthermore, evidence points to higher and increasing fraud through digital channels

(UK Finance 2021), suggesting that neobank clients may be more vulnerable to fraud than traditional bank clients.

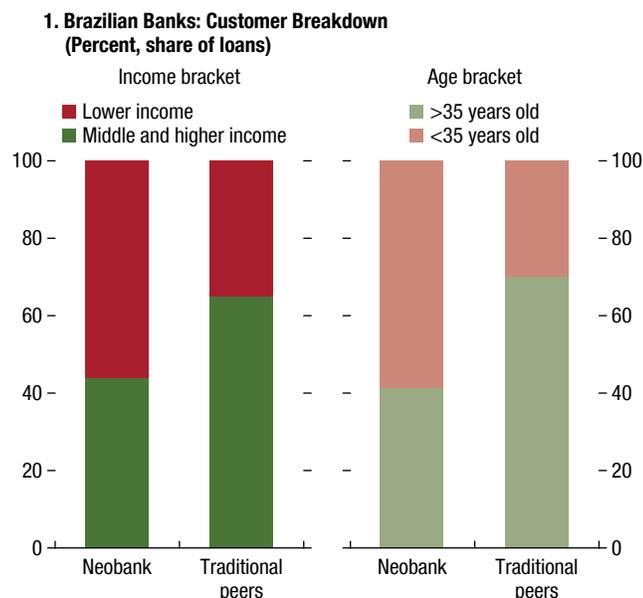
Credit Risk: High, Underprovisioned, and Underpriced

Neobanks target borrowers with a riskier credit profile. Neobanks tend to explicitly address financially underserved clients across the consumer/credit card and SME segments in the context of heavily skewed/concentrated—less diversified—loan portfolios. In practice, this means serving younger individuals⁴ with lower incomes (Figure 3.4, panel 1) and lower credit scores by granting them loans that are mostly unsecured (Figure 3.4, panel 2) or concentrated around risky sectors, such as commercial real estate (for example, SME loans by UK neobanks).

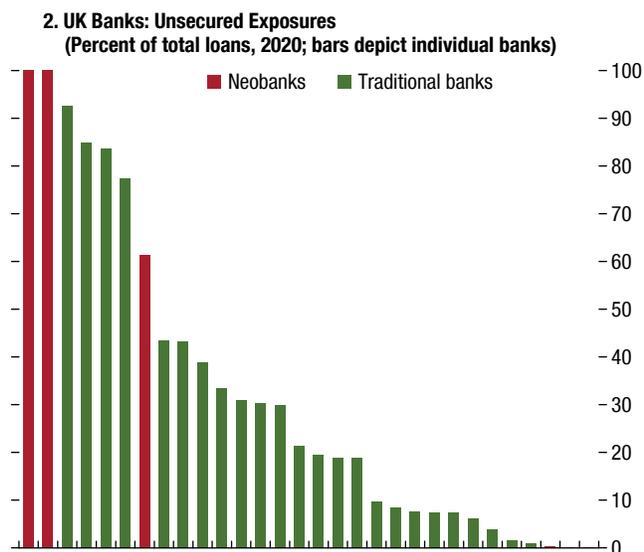
⁴While neobanks' exposure to relatively younger populations with lower incomes and credit scores poses risks, it may not only represent a higher appetite for risk but could also reflect higher technological literacy in this demographic group.

Figure 3.4. Client Profile of Neobanks

Clients are younger and have lower incomes ...



... and there is more focus on unsecured lending.



Sources: Company filings; Nu Holdings; S&P Global Market Intelligence; and IMF staff calculations.

Despite greater credit exposure, neobanks' overall credit risk coverage level remains significantly below that of traditional banks. Higher credit risk (Figure 3.5, panel 1) should translate into a higher expected loss and, in turn, into higher coverage ratios. However, neobanks' loan loss reserves as a proportion of their overall (risk-weighted) assets are well below those of traditional banks (Figure 3.5, panel 2), implying relatively looser provisioning standards or practices.⁵

Neobanks also seem to be underpricing credit risk. Neobanks feature asset yields that are typically higher than those of banks. This seems to be driven by higher yield on their securities portfolio rather than yields on their loan book, as the latter are broadly equal to those of banks. A meaningfully negative risk-adjusted net interest margin points to underpricing of credit risk in their lending business in parts of our sample as well as in some regions (Figure 3.6, panel 1). This could be due to competition vis-à-vis traditional banks and/or other neobanks. Importantly, their

⁵Neobanks also seem to operate with higher leverage (total equity/assets) ratios relative to traditional banks. This, however, seems related to the fact that they are young companies in their growth phase that are still loss-making for the most part (Figure 3.6, panel 3); hence they initially need higher equity. For mature neobanks, the capital advantage disappears.

risk-adjusted loan margins would be even lower if their cost of risk adequately reflected their more precarious credit-risk profile and their lower loan-related fee income were also accounted for (more on this later in the chapter). Ultimately, higher asset yields and overall net interest margins reflect an implicit cross-subsidy through neobanks' high-yielding (riskier) securities portfolios.

Liquidity Risks: Lower Liquidity Coverage Adds Risk

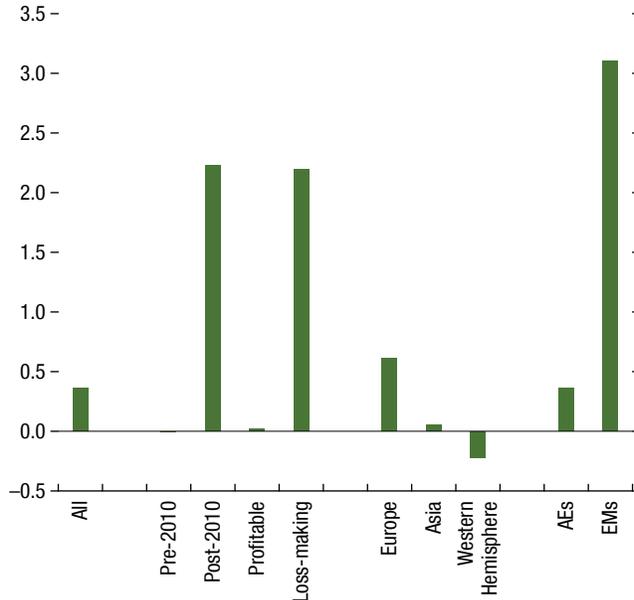
Lower liquidity coverage may pose additional risks. On the one hand, neobanks' client base is younger (Figure 3.4, panel 1) and likely to be less loyal, implying that their deposits could be less sticky. Therefore, caution would call for neobanks to operate with higher liquidity coverage ratios, in line with Basel III requirements.⁶ Instead, their ratio of liquid assets to total deposits—a measure of liquidity risk—is lower than that of banks (Figure 3.6, panel 4). On the other hand, the composition of their liquid asset portfolios shows that neobanks have a much larger share of interbank

⁶For the calibration of the liquidity coverage ratio under Basel III, "less stable deposits" (including "internet deposits") are assigned a runoff rate of at least 10 percent (3 percent for "stable deposits"); supervisors may assign higher rates.

Figure 3.5. Credit Risk Profile

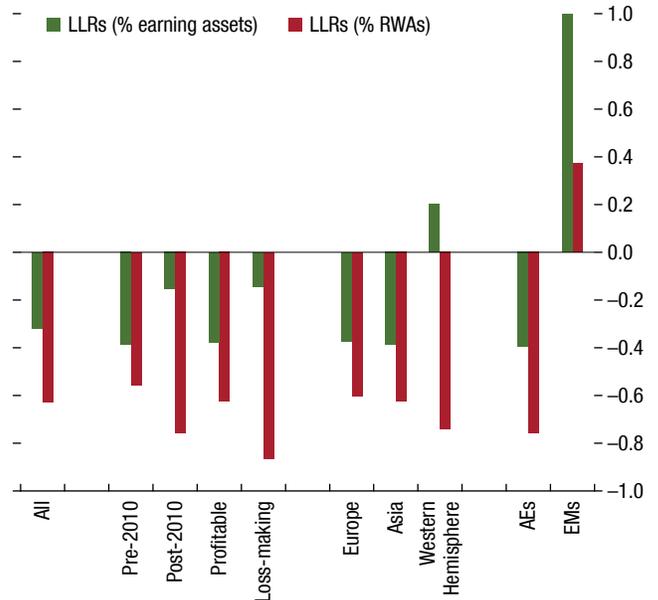
Neobanks have high credit costs and a riskier client base ...

1. Neobanks: Cost of Risk (CoR)
(Loan loss provisions/gross loans; in number of standard deviations vs. banks)



... but coverage falls short of traditional banks.

2. Neobanks: Coverage
(Loan loss reserves; in number of standard deviations vs. banks)



Sources: Company filings; S&P Global Market Intelligence; and IMF staff calculations.

Note: The figure panels show neobanks' distance (median number of standard deviations) from (the asset-weighted average of) traditional banks (see details in Online Annex 3.1). In panel 1, a positive (negative) number implies a higher (lower) cost of risk for neobanks compared with their respective traditional-bank peer group; the related exposures should be viewed as riskier (less risky). In panel 2, a positive (negative) number implies a higher (lower) coverage level at neobanks compared with their traditional-bank peer group, consistent with a higher (lower) expected loss. AEs = advanced economies; EMs = emerging markets; LLRs = loan loss reserves; RWAs = risk-weighted assets.

loans than traditional banks. This also suggests that neobanks are more interconnected than traditional banks with the rest of the banking system.

Weak Retail Banking Returns

Neobanks display higher operating expenses and lower potential for fee income generation. Somewhat counterintuitively, neobanks appear to be less cost-efficient than traditional banks (Figure 3.6, panel 2).⁷ This is driven by persistently higher nonstaff expenses⁸ on the back of either higher

customer acquisition costs (such as marketing)⁹ and/or higher compliance-related costs (such as those related to anti-money laundering and cyber-security). In addition, the lower income profile of neobank customers limits the potential for cross-selling insurance, wealth management, and other fee-income-generating products.¹⁰ If securities income is excluded, neobanks' margin advantage fades (Figure 3.6, panel 1). Overall, neobank returns appear weak (Figure 3.6, panel 3), with only a few neobanks generating profits.

Overall, emerging market neobanks tend to fare better than advanced economy neobanks. Emerging market neobanks display relatively lower liquidity risk than advanced economy neobanks with a stronger

⁷Our results are similar for overall operating expenses as a proportion of either total income or business volumes. Mature neobanks (defined as those established before 2010) remain more inefficient, but the difference is lower.

⁸Staff expenses are defined as "compensation & benefits" expenses for all (neo)banks with data available in the S&P Global Market Intelligence database. Nonstaff expenses are defined as the difference between staff and total operating expenses.

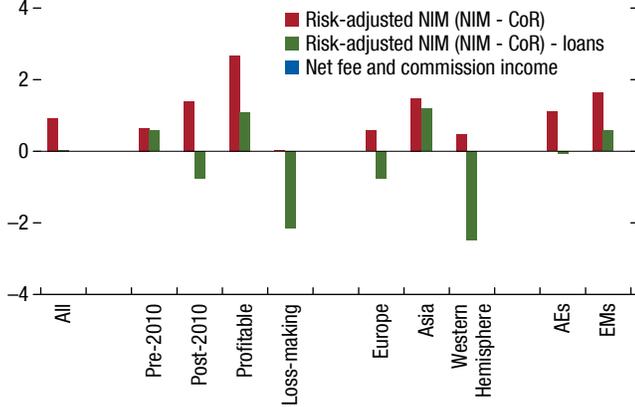
⁹These costs might constitute an initial investment needed to build up market share.

¹⁰Group-level consolidated data are used, with a few exceptions where only unconsolidated data were available.

Figure 3.6. Margins, Profitability, and Liquidity Profiles of Neobanks

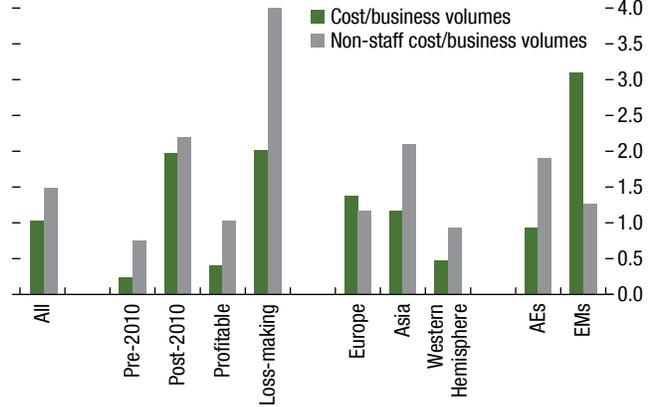
High net interest margins are driven by the securities portfolio.

1. Neobanks: Net Interest Margin (NIM)
(Percent of earning assets; in number of standard deviations vs. banks)



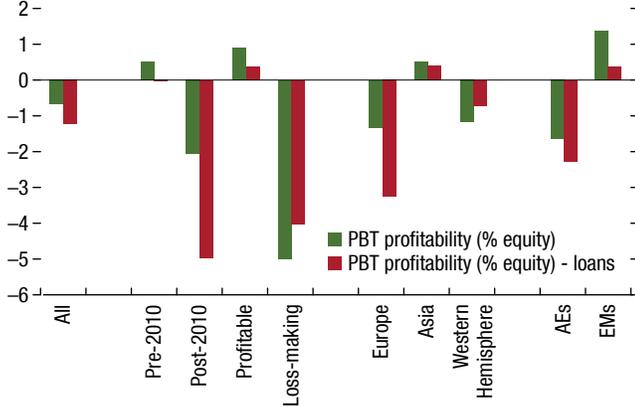
Neobanks tend to be less efficient ...

2. Neobanks: Operating Expenses
(Percent of business volumes; in number of standard deviations vs. banks)



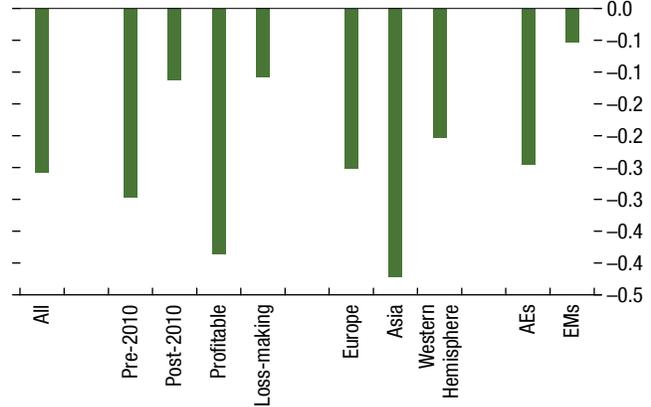
... and have underwhelming banking returns ...

3. Neobanks: Pre-Tax Return on Equity (ROE)
(Percent of total equity; in number of standard deviations vs. banks)



... as well as weaker liquidity ratios.

4. Neobanks: Liquid Assets over Deposits
(Percent of deposits; in number of standard deviations vs. banks)



Sources: Company filings; S&P Global Market Intelligence; and IMF staff calculations.

Note: The figure panels show neobanks' distance (median number of standard deviations) from traditional banks. In panel 1, a positive (negative) number implies a larger (lower) net interest margin relative to traditional banks. In panel 2, a positive (negative) number implies lower (higher) cost efficiency relative to traditional banks. In panel 3, a positive (negative) number implies a larger (lower/negative) return on equity than at traditional banks. In panel 4, a positive (negative) number implies a higher (lower) coverage than traditional banks. AEs = advanced economies; CoR = cost of risk; EMs = emerging markets; NIM = net interest margin; PBT = profit before tax.

revenue profile and wider loan and fee margins. This seems to be related to life cycle factors (in light of the larger portion of “mature” neobanks in the emerging market subsample), but also to business models (given the relatively strong performance of Chinese neobanks).¹¹

¹¹In China, neobanks and big tech overlap, with the three Chinese neobanks in our sample backed by major local big techs.

Case Study: Fintechs in the US Home Mortgage Market

Fintechs in the US home mortgage market have been active for more than a decade. Fintechs remove the need for physical branches in mortgage origination. The main advantage of fintech mortgage originators is arguably the use of technology (Buchak and others 2018). This has afforded them efficiency gains, as they process applications about 20 percent

faster than other lenders (Fuster and others 2019). A fintech firm has been the single largest originator for several years, even though banks have continued to wield a substantial market share (Figure 3.7, panel 1).¹²

Fintechs pursue an aggressive growth strategy and serve younger and riskier borrowers. Their mortgage originations have tended to substantially outpace those of banks and other nonbanks in periods of overall market expansion (Figure 3.7, panel 2).¹³ Their ability to grow rapidly thanks to their technology and internet-based business model is highlighted by the rapid growth of recently established fintech mortgage firms. Fintech mortgages, and particularly those originated by younger fintech firms, are more popular among relatively younger borrowers, who tend to have lower incomes (Figure 3.7, panel 3). Fintechs also originated riskier mortgages with higher loan-to-value ratios during 2018–20 (Figure 3.7, panel 4). At the same time, fintechs improve access to mortgages in less affluent neighborhoods (see Online Annex 3.2, which also provides a data description and details on the empirical analyses).¹⁴

Fintechs directly compete with banks, raising financial stability challenges. Fintechs are present in all locations, including those with a higher density of bank branches (Figure 3.7, panel 5, and Online Annex 3.2). Critically, competitive pressure from fintechs—measured as the (previous period) increase in fintech market share (by mortgage origination amount) in ZIP code areas where a given bank is active—appears to have had a significant effect on banks’ interest income from mortgages (Figure 3.7, panel 6). A 1 percentage point rise in the composite market share of fintechs is associated with a 0.4 percentage point decline in (gross) mortgage interest income—this is more than 2.5 percentage points of the sample median of 16.8 percent. Importantly, expenditures by banks related to data processing (operation or purchase of IT services and software) can offset the loss of

mortgage-related income.¹⁵ This points to the importance of technology adoption for traditional banks—either through organic solutions or third-party services (these results are robust across alternative specifications; see Online Annex 3.2).

Banks have not faced full-scale disintermediation despite intense competition from fintechs. The share of mortgage assets does not seem to have been significantly affected during 2007–20. This can also be attributed to the limited role of fintechs as originators, whereas banks retained about 40 percent of the mortgages they originated on their balance sheets (Online Annex 3.2). Banks also continue to attract deposits, since fintechs in the mortgage-origination market are not deposit-taking institutions.

Decentralized Finance: Vulnerable Efficiency

Decentralized finance (DeFi) refers to financial applications—called “smart contracts”—processed by computer code on blockchains, with limited or no involvement of centralized intermediaries. Key features of DeFi are automated and decentralized record keeping, risk-taking, and decision-making within the crypto ecosystem (Table 3.1). Operations within DeFi are automated via smart contracts, and all contractual and transaction details are recorded on the network. Decisions such as changes in collateral requirements or distribution of profits are made by users with voting rights, which often accompany use of the platform. Consequently, DeFi offers broad access to players of any size and has no need for custodian service, potentially improving efficiency and financial inclusion.

Three key technological advances have contributed to the expansion of DeFi. First, the launch of blockchain technology provided a digital infrastructure to record value on a distributed system open to everyone, and in which transaction records of crypto assets are validated without the need for a single trusted entity. Blockchain is a type of distributed ledger technology.¹⁶

¹⁵The regression results shown imply that banks with IT expenditures higher by about 3.7 percent of bank equity can fully make up for the loss of income from a 1 percentage point increase in the fintech composite market share. There is, however, no evidence that IT expenditures can reduce the marginal effect of competition itself—it can only offset the effect on income.

¹⁶Distributed ledger technology enables a single, sequenced, standardized, and cryptographically secured record of activity to be safely distributed to, and acted on by, a network of varied participants. See Garrido and others (2022).

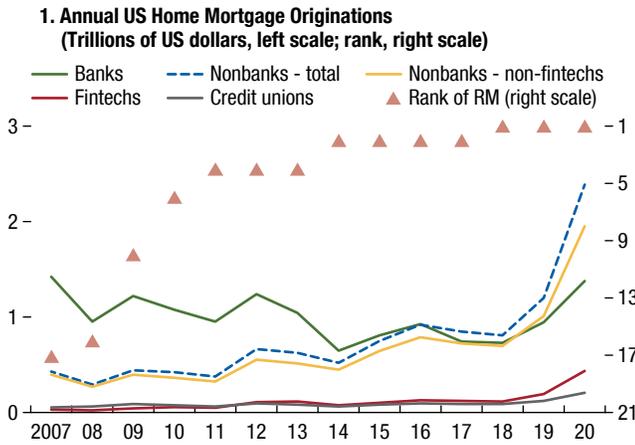
¹²The analysis uses Home Mortgage Disclosure Act data from 2007–20, covering more than 100 million US mortgage originations (see Online Annex 3.2).

¹³Nonbanks are financial institutions that do not take deposits. All fintechs are nonbanks.

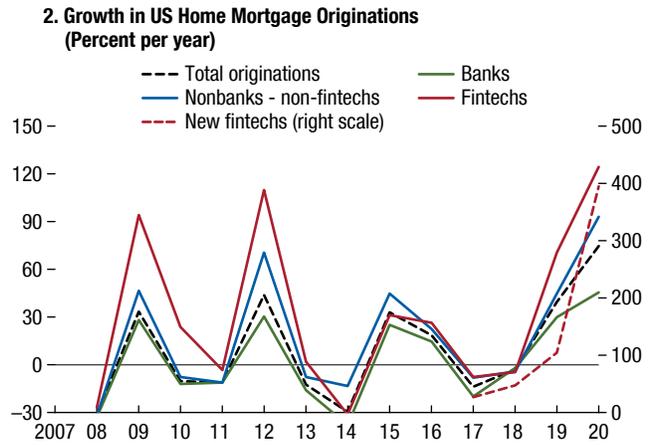
¹⁴Jagtiani, Lambie-Hanson, and Lambie-Hanson (2021) find that fintechs have high market shares in areas with low credit scores and high mortgage denial rates.

Figure 3.7. Fintechs in the US Home Mortgage Market

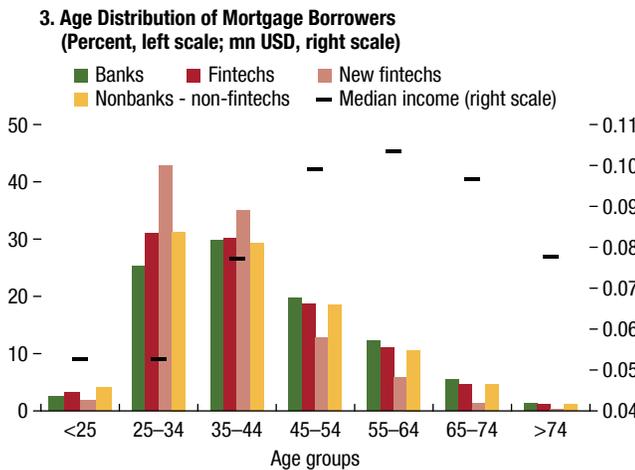
Fintechs and other nonbanks had a long-standing presence in the mortgage market.



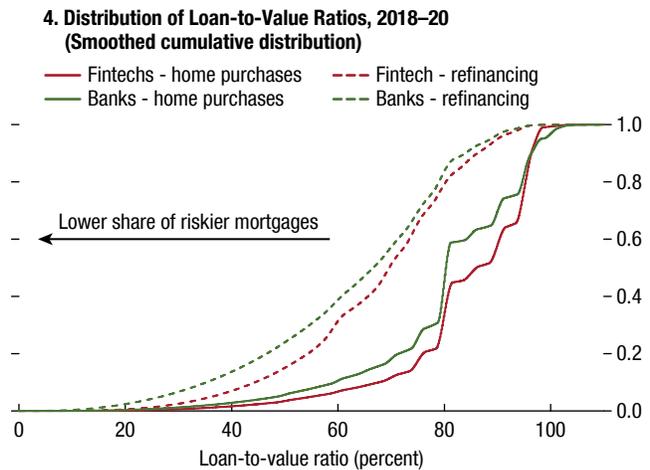
Originations by fintechs have been growing faster than banks, particularly during periods of high growth.



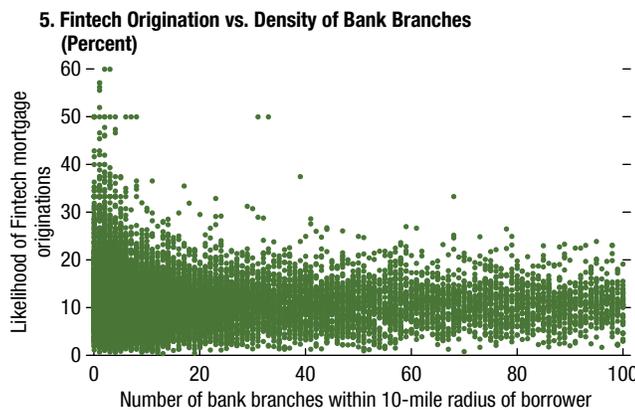
Fintechs are more prevalent among younger and lower-income borrowers.



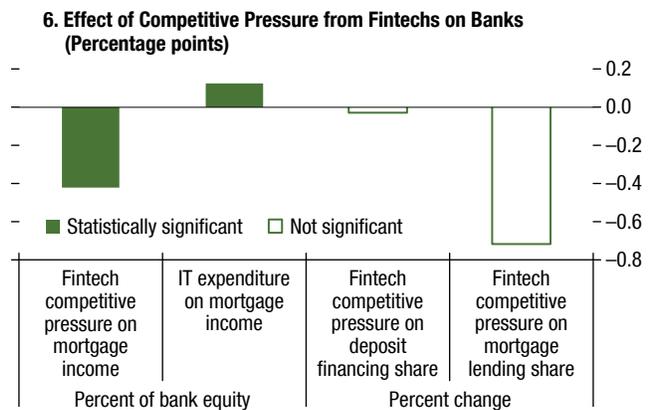
Fintechs have tended to originate riskier mortgages.



Fintech mortgage origination is only marginally lower in areas with high bank penetration.



Competitive pressure from fintechs has had a significant effect on banks' mortgage income.



Sources: Federal Deposit Insurance Corporation; National Bureau of Economic Research ZIP Code Distance Database; US call reports; US Census Bureau; US Home Mortgage Disclosure Act; and IMF staff calculations.
Note: In panel 1, RM is Rocket Mortgage. Originations include both refinancing and new purchases of one- to four-family homes. Definitions of variables and model specifications for panel 6 are provided in Online Annex 3.2. IT = information technology.

Table 3.1. Comparison of Decentralized Finance and Traditional Financial Services

	Decentralized Finance	Traditional Financial Services
Access	World Wide Web Permissionless and anonymized	Branch office Compulsory know your customer/anti-money laundering
Operation	Automated by smart contract	Mostly manual
Instruments	Crypto assets, including stablecoins	Fiat-currency-denominated financial assets
Record keeping	Distributed ledger (verified by multiple network participants)	Centralized ledger (verified by a single trustworthy entity that operates the platform)
Decision-making	Voting by users who own governing stakes	Governed by top management (such as the bank executive board)
Risk-taking	Distributed to users	Concentrated in a single trustworthy entity

Source: IMF staff.

Second, the invention of the smart contract made it possible for blockchain technology to change the manner of financial intermediation. A smart contract is computer code that allows for transactions to be executed when certain predetermined conditions are met. DeFi is the application of smart contracts for financial intermediation such as deposit-taking, lending, derivative trading, and the exchange of crypto assets. Third, offerings of stablecoins pegged to existing sovereign currencies were a key innovation. Stablecoins are used in DeFi as a unit of account, medium of exchange, and store of value. The growth of stablecoins and evolution of DeFi have evolved in tandem (Figure 3.1, panel 2).

DeFi has the potential to offer financial services with even greater efficiency, becoming a gravitational force that attracts a large number of crypto investors. However, it may also come at the cost of greater risks and uncertainties. This section will analyze some of the key risks and opportunities of DeFi lending and discuss how authorities should prepare for it.

A Primer on DeFi Lending

DeFi has expanded rapidly, offering blockchain-based financial services in the crypto ecosystem. Among many services, the debt outstanding of DeFi lending has increased markedly since 2020, supported by the wider use of stablecoins (Figure 3.8, panel 1). DeFi provides crypto asset holders the opportunity to earn interest by depositing crypto and/or borrowing more crypto by posting collateral.

DeFi lending platforms receive crypto assets as deposits and lend them out to borrowers who meet

certain collateral criteria. A DeFi lending service works as follows:

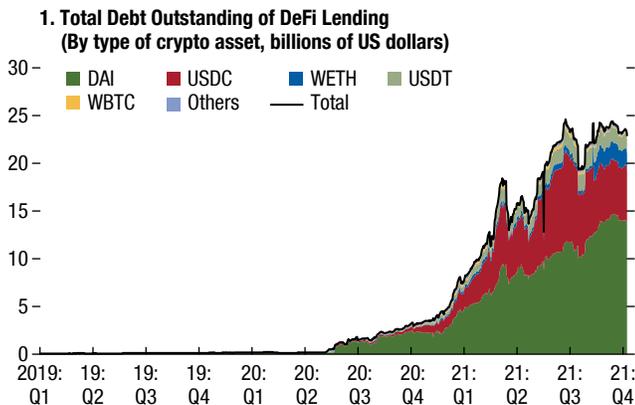
- *Deposits*: Users can earn interest by depositing their crypto asset in a “liquidity pool” specific to each type of crypto asset. Users with deposits in the same assets receive the same interest rate. In exchange, the depositor receives a platform-specific utility token that works as a certificate of deposit¹⁷ (Figure 3.8, panel 2, step 1). The token has a value equivalent to the underlying asset deposited but bears interest. A depositor can withdraw the deposit at any time (Figure 3.8, panel 2, step 2).
- *Borrowing*: A user with deposits (that is, a user who owns the utility token) can borrow a crypto asset from a liquidity pool by posting the deposited asset as collateral (Figure 3.8, panel 2, step 3). The lending interest rate varies, depending on the level of utilization for the borrowing asset.¹⁸
- *Collateral*: Collateralization is the key to safeguarding the platform from market risks associated with lending. Lending platforms often require overcollateralization by setting a discount factor (called a collateral factor) typically ranging from 0 to 0.8 across different types of assets. For example, when the collateral factor is 0.8, borrowers can borrow up to 80 percent of the collateral value posted; when a collateral factor is zero, however, as in the case of Tether (USDT) in some DeFi platforms, the user cannot borrow using the asset as collateral.

¹⁷For example, if a user deposits Ethereum (underlying asset) in a DeFi platform, such as Aave or Compound, the user will receive aETH and cETH (tokens), respectively.

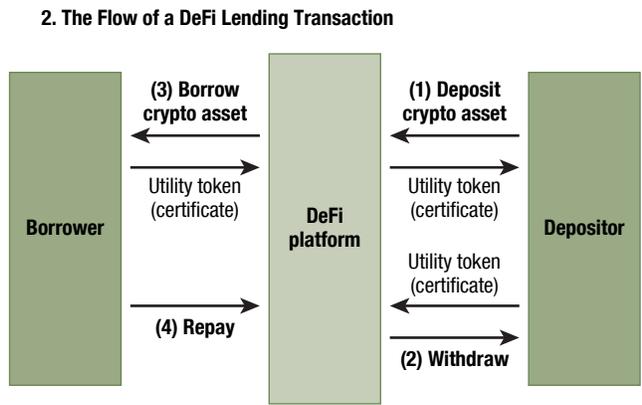
¹⁸The utilization rate of a crypto asset is the ratio of the total amount of loans to the total deposits of that asset in the platform. The lending rate is lower when the platform has more available liquidity in the deposit pool.

Figure 3.8. Recent Development of DeFi Lending

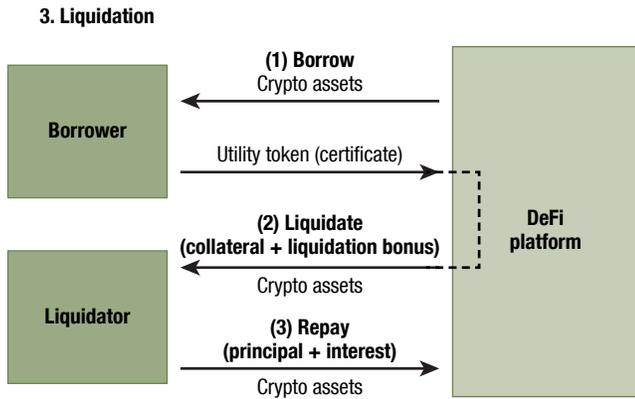
The volume of DeFi lending has increased rapidly, supported by wider use of stablecoins.



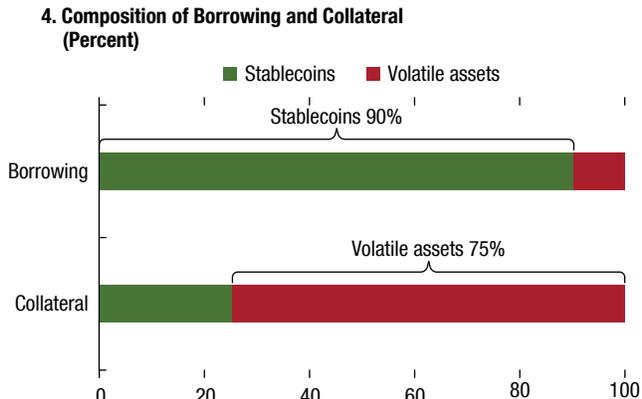
DeFi lending platforms receive crypto assets as deposits and provide collateralized loans.



If a borrower fails to maintain the required level of collateral, the position is liquidated.



Most lending is against stablecoins backed by volatile crypto assets.



Sources: Aave v2; Compound v2; C.R.E.A.M. Finance; DeFi Llama; DeFi Pulse; The Graph; and IMF staff calculations.

Note: In panel 1: DAI, USDC, USDT, WETH, and WBTC represent DAI, USD Coin, Tether, Wrapped Ethereum, and Wrapped Bitcoin, respectively. DeFi = decentralized finance.

- *Repayment and liquidation:* Borrowers can repay the debt at any time (Figure 3.8, panel 2, step 4). However, borrowers must meet the collateral requirements at all times. If at any time a borrower's collateral requirement falls below the required threshold as a result of adverse price movements, liquidation can be triggered by a liquidator who repays the debt and acquires the collateral in exchange for rewards—the liquidation bonus (Figure 3.8, panel 3).

Leveraged longs and short selling are frequent strategies employed by DeFi users. The DeFi lending platform offers services that allow investors with crypto

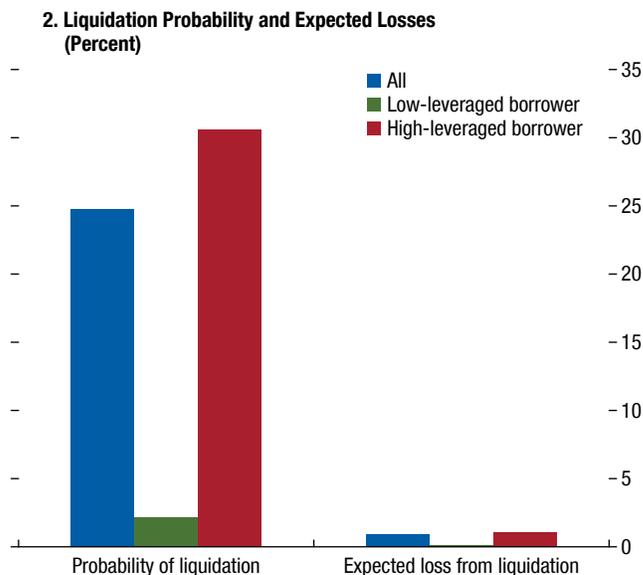
assets to borrow other crypto assets. Investors may form a *leveraged long* position (borrow stablecoins to buy risky crypto assets) or form a *short sell* position (borrow risky crypto assets and buy back later). The most typical position is to borrow stablecoins against volatile collateral. More than 90 percent of DeFi lending is denominated in stablecoins, while 75 percent of the collateral is denominated in volatile crypto assets (Figure 3.8, panel 4). As of the end of 2021, volatile crypto assets such as Ethereum and Wrapped Bitcoin were the dominant collateral. These use cases are often seen in activities such as trading and market making, which bring about higher market liquidity and efficiency, but also help build leverage and destabilize

Figure 3.9. Decentralized Finance Market Risks

High volatility of crypto asset prices leads to frequent liquidation of DeFi lending.



Lending to riskier borrowers tends to be liquidated more often with larger losses.



Sources: Aave v2; Bloomberg Finance L.P.; CoinGecko; Compound v2; C.R.E.A.M. Finance; The Graph; and IMF staff calculations.
Note: For panel 2, see Online Annex 3.3 for details on the probability and expected loss calculation. BTC = Bitcoin; DeFi = decentralized finance.

the market if used for speculation. Considering its potential and the ongoing trend toward cryptoization in some economies (see Chapter 2 of the October 2021 GFSR), DeFi lending could soon be expanded to broader financial activities, such as mortgage lending,¹⁹ consumer finance, and so on.

Similar to traditional lending, DeFi is not free from market, liquidity, credit, operational, and cyber risks. DeFi lending can incur losses under unfavorable market conditions, and liquidity mismatches can be a cause for failure to meet redemption requests. Moreover, it appears to be more vulnerable to cyber and AML/CFT risks, due to loopholes in computer code and the anonymity of the platform.

Market Risks: Vulnerable to Crypto Market Volatility

Volatile crypto asset prices lead to frequent liquidation of DeFi loans (Figure 3.9, panel 1). Liquidation is triggered when a borrower fails to maintain the collateral requirement or when the borrower’s

loan-to-value ratio breaches a certain threshold. The loan-to-value ratio is marked to market and can swing considerably during volatile market conditions. Large liquidations have occurred during sharp declines in crypto asset prices. During the January 2022 crypto sell-off, liquidation across platforms surged to the highest level since May 2021, erasing \$50 billion in asset value borrowed (Figure 3.9, panel 1). When the collateral shortfall is large during periods of high market volatility, liquidation can be costly. Without timely liquidation, the shortfall will be left unaddressed and could potentially undermine platform solvency.^{20,21}

Indeed, the asset quality of DeFi lending varies considerably across assets and borrower risk profiles.

²⁰Another source of liquidation risk comes from the precision of the information source used in the platform to value its loans and collateral. If the platform is misinformed about the asset prices used in loans and collateral, it may trigger a cascade of liquidations.

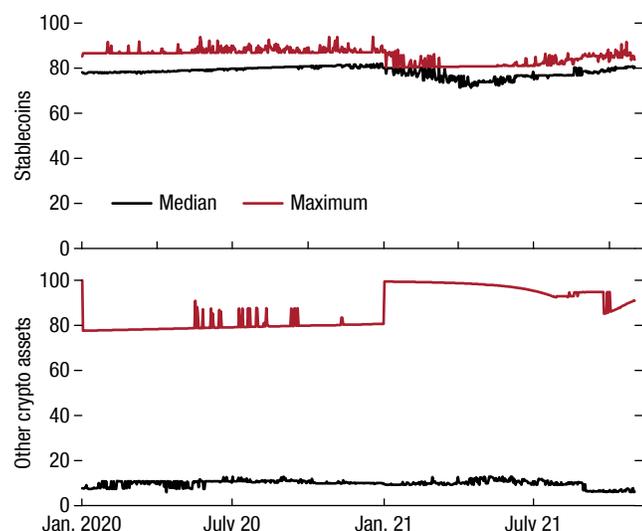
²¹The deterioration of the loan quality of the platform may not materialize as a credit loss. This is because the loan has no maturity, and there are no accounting rules for provisioning or recognition of fair value loss. However, it can potentially reduce the interest.

¹⁹MakerDAO, one of the largest DeFi platforms, has already started offering mortgage loans against existing real estate.

Figure 3.10. Decentralized Finance Liquidity Risks

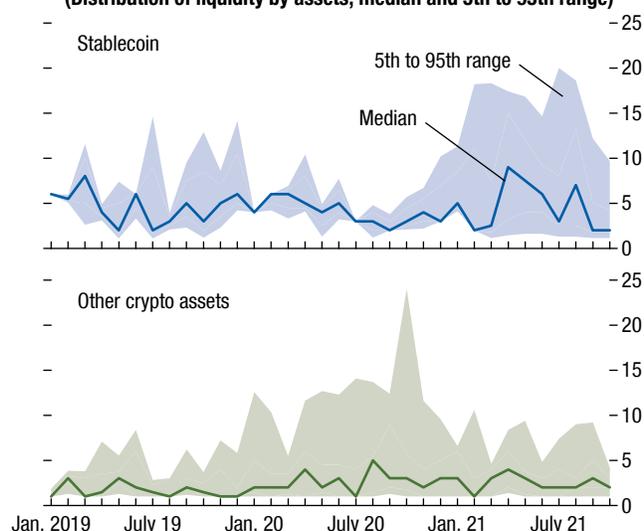
Liquidity could become insufficient during periods of market volatility.

1. Distribution of the Utilization Rate across Assets and Platforms (Median and maximum value)



Liquidity is highly concentrated in a small number of accounts.

2. Liquidity Concentration: Number of Accounts Providing 50 Percent of Liquidity (Distribution of liquidity by assets, median and 5th to 95th range)



Sources: Aave v2; Compound v2; C.R.E.A.M. Finance; The Graph; and IMF staff calculations.

Note: The utilization rate of a crypto asset is the ratio of total loans to total deposits of that asset in the platform.

Similar to the concept of default probability in traditional loans, the *probability of liquidation* is estimated in this section through a stochastic model. Liquidation is triggered when the total value of borrowing exceeds the threshold, defined as total collateral value discounted by collateral factors (see Online Annex 3.3 for details). The modeled probability of liquidation reflects the trend and volatility of the underlying crypto assets, as well as the initial balance of debt outstanding (the leverage). The *expected loss* reflects mainly the loss of collateral value upon liquidation. The results indicate that the one-year probability of liquidation is 24 percent on average, reflecting high volatility and a rising trend in crypto prices (Figure 3.9, panel 2). In particular, riskier (highly leveraged) borrowers tend to exhibit higher liquidation probability. The expected loss is largely mitigated by overcollateralization, but still averaged about 0.9 percent, with larger losses incurred by riskier borrowers.²²

²²Even though DeFi lending is overcollateralized, the value of borrowing and repayment depends on the remaining balance of collateral relative to the debt outstanding at the time of liquidation. If the value of the borrowed token and/or collateral change abruptly, timely liquidation will fail, resulting in liquidation losses.

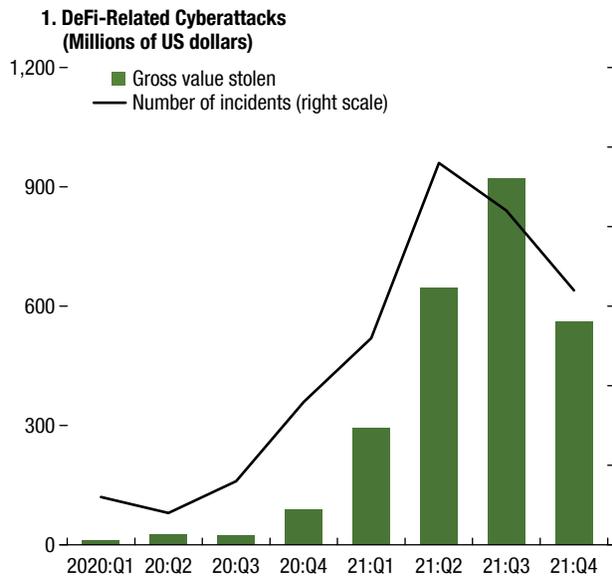
Liquidity Risks: Heavily Concentrated

Liquidity could become insufficient during periods of market stress. Depositors provide liquidity to DeFi lending platforms, which facilitates lending these deposits to borrowers. The total amount of loans that can be issued is capped by the total amount of deposited assets, or liquidity, on each platform. Similar to the loan-to-deposit ratio in traditional banking, the *utilization rate* measures how much of the liquidity for a particular crypto asset has been loaned out on each DeFi platform (Figure 3.10, panel 1).²³ When demand for borrowing a crypto asset increases, the utilization rate for its liquidity pool rises accordingly. However, a very high utilization rate could create problems for redemptions when many depositors try to withdraw at the same time. To minimize this risk, DeFi platforms set a *threshold utilization rate* above which the lending interest rate goes up steeply to discourage higher utilization. The median utilization rate is typically high for stablecoins and low for volatile assets; however, there have been instances for

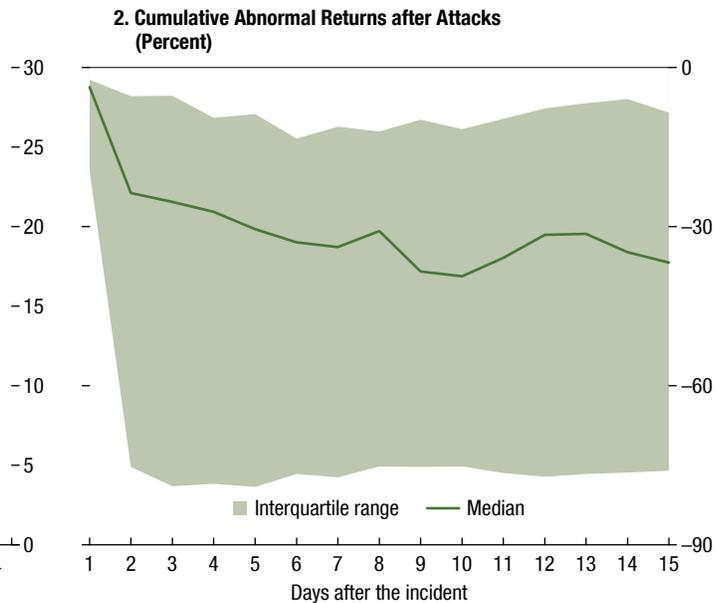
²³Each DeFi platform has its own interest rate model that determines loan and deposit rates based on the utilization rate.

Figure 3.11. Cyberattacks on Decentralized Finance

The frequency and scale of cyberattacks surged in 2021 and remain elevated.



In most cases, more than 30 percent of the deposit was lost or withdrawn after attacks.



Sources: Chainalysis; CoinGecko; CryptoSec.info; DeFi Llama; Immunefi; Rekt; and IMF staff calculations.
 Note: DeFi = decentralized finance.

both types of assets when utilization rates approached 100 percent during periods of market volatility (Figure 3.10, panel 1).

Liquidity provision is highly concentrated, making DeFi platforms ironically less decentralized than expected.²⁴ On average, half of the deposits are provided by fewer than 10 accounts, with even more concentrated in smaller and more volatile crypto assets (Figure 3.10, panel 2; see also Aramonte, Huang, and Schrimpf 2021; Gudgeon and others 2020). With higher concentration, an idiosyncratic withdrawal of funds by any of those large depositors can have a material impact on the liquidity condition of the platform. This, in turn, can exacerbate liquidity exhaustion, as illustrated by the occasional spikes in the utilization rate.²⁵ A more extreme outcome would be equivalent to a bank run—when participants rush to withdraw liquidity from the platform.

²⁴The liquidity providers cannot be identified due to DeFis' anonymous nature.

²⁵A spike can be triggered by other factors, such as changes in the threshold utilization rate of the interest rate model.

Cyber Risks: A Critical Risk of Decentralized Finance

Cyberattacks increased substantially in mid-2021 and remain elevated. The attacks are associated mostly with compromised wallet keys, vulnerabilities in computer code, and scams by developers (Figure 3.11, panel 1).

Cyberattacks cause large and often persistent losses. An event analysis shows a substantially adverse impact of cyberattacks on the excess growth of total value locked that represents the total value of crypto assets supplied to the platform, most of which are deposits.²⁶ The estimate suggests that, in most cases, 30 percent of the total value locked is lost or withdrawn (Figure 3.11, panel 2). Cyberattacks not only steal assets but also undermine the reputation of a platform, often triggering withdrawals by depositors as they fear not being able to redeem their deposits.²⁷ As indicated by the lower tail of the interquartile range, an entire platform can collapse in the aftermath of an attack.

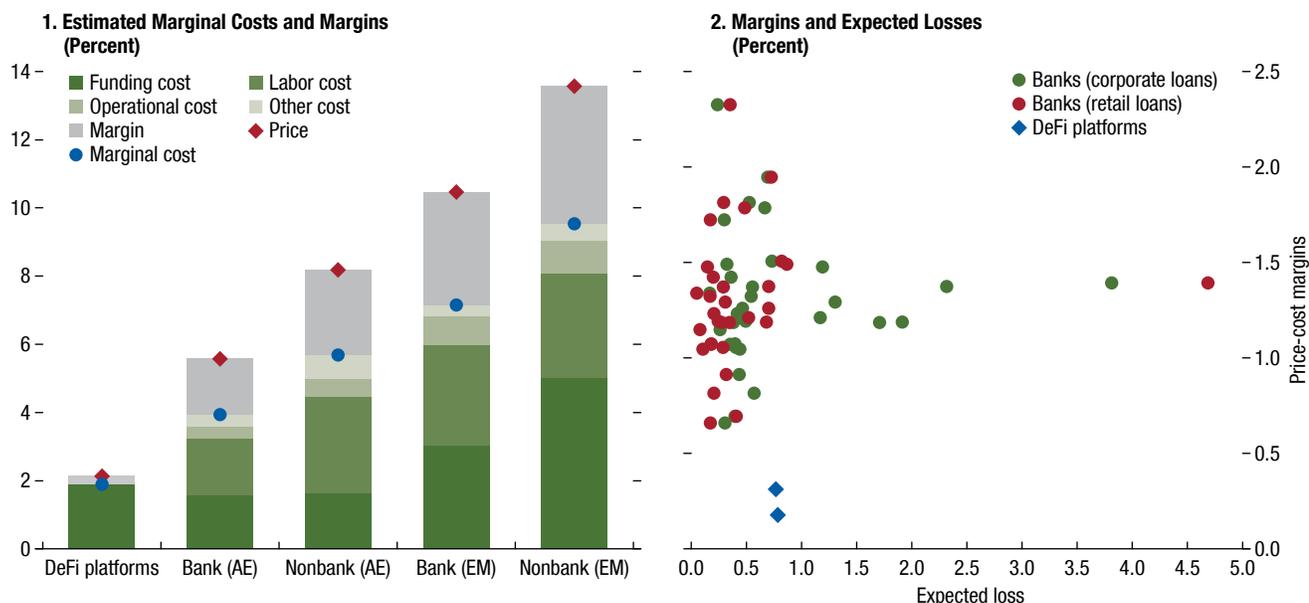
²⁶In addition to deposits, total value locked includes governance tokens (staking tokens) that are locked to the platform.

²⁷When a DeFi platform falls short of liquidity, depositors likely cannot withdraw, and they lose their assets. Deposits in DeFi platforms are not eligible for any deposit insurance or central bank liquidity support measures.

Figure 3.12. Efficiency and Risks of Decentralized Finance

DeFi has the lowest marginal costs due to the absence of labor and operational costs.

Despite high cost-efficiency, DeFi is exposed to riskier borrowers.



Sources: Aave; CoinGecko; Compound v2; European Banking Authority Risk Dashboard; Fitch Connect; and IMF staff calculations.
 Note: In panel 1, the sample is composed of banks from 37 advanced economies (AEs) and 100 emerging markets (EMs); nonbanks from 20 advanced economies and 26 emerging markets; and two DeFi platforms (Aave and Compound). See Online Annex 3.4 for technical details. In panel 2, expected losses of DeFi platforms are the estimates from Figure 3.10, panel 2. Each dot represents the average expected loss for banks in a country. DeFi = decentralized finance.

Efficient but Risky

DeFi has the potential to exhibit cost-efficient financial intermediation by bypassing and shortcutting the intermediation chain. However, comparing costs and prices between DeFi and traditional financial institutions is complex because the two currently operate in different ecosystems. To address this issue, price-cost margins and marginal costs are estimated, taking into account their distinct cost structures. Following Berger, Klapper, and Turk-Ariss (2009), prices are proxied by the ratio of total revenue to total assets, and marginal costs are estimated using a panel regression model of total cost functions.²⁸ The analysis shows that DeFi has the lowest marginal cost compared with incumbents in both advanced and emerging market economies, indicating the highest cost-efficiency (Figure 3.12, panel 1). The low marginal

costs of DeFi reflect their automated and unregulated operation, which contrasts with the high share of labor and operational cost of traditional financial institutions—including (at least in part) costs related to regulatory compliance (Figure 3.12, panel 1).²⁹ However, DeFi bears high funding costs that likely reflect higher risks, such as lack of access to central bank liquidity support, AML/CFT risks, and legal and jurisdictional uncertainties.

However, DeFi’s low margins raise concern about underpricing risk. DeFi margins are substantially lower than those of traditional financial institutions, offering favorable prices to borrowers (Figure 3.12, panel 1). DeFi currently must offer relatively high deposit interest rates while keeping lending margins low to attract

²⁸In the empirical approach used, liabilities are an intermediate input in the production of loans, total assets are the output, and the revenue associated with the output is interest and noninterest income. The marginal cost is defined as an incremental cost of additional loan production, and the margin is the difference between the price and marginal cost. See Online Annex 3.4 for details.

²⁹DeFi platforms can also incur episodic operational costs surrounding cyberattacks or program bugs. For example, about \$90 million was mistakenly distributed to Compound users as a result of program bugs after an update on October 1, 2021. Although the founder made a plea to users to voluntarily return the tokens, the value of tokens not retrieved would be considered a cost to the platform.

depositors and borrowers. Narrow margins are in part possible because DeFi does not have to maintain regulatory buffers. To assess margins against risk exposure, the estimated average expected losses of DeFi platforms are compared with those of banks. This comparison suggests that DeFi is significantly underpricing the riskiness of its lending (Figure 3.12, panel 2). Although lower margins can increase the popularity of DeFi, they come at a cost of thinner reserve buffers, which builds vulnerabilities during periods of market stress. At the same time, lower margins may pose significant competitive pressure to incumbents absent a (regulatory) level playing field.

Financial Stability and Policy Issues

The acceleration of digitalization in core banking services brings opportunities and risks. On the one hand, by strengthening and broadening financial development, fintechs can support more inclusive economic growth. On the other, the rapid growth of fintechs raises the risk of bank disintermediation. This is not necessarily a financial stability concern if fintechs are subject to appropriate regulatory oversight to ensure a level playing field. However, the rapid growth of fintechs does raise financial stability issues, including a potential buildup of vulnerabilities in new corners of the financial system and challenges to adapt regulatory and supervisory rules to new actors.

Regulatory Differences

Neobanks are sometimes subject to simpler and less comprehensive regulation and supervision. While neobanks in most jurisdictions are subject to banking requirements, these can be simpler than Basel III rules applicable to internationally active banks, mainly due to their current size. Conversely, in some jurisdictions neobanks operate without a banking license, some are not subject to liquidity risk requirements, and they may be subject to different loan classification and lower provisioning. Less comprehensive requirements may incentivize risk-taking in loan underwriting and securities investment.

These regulatory approaches may have been designed to be both conservative and simple for small and traditional banks. However, as the analysis in this chapter indicates, neobanks tend to be more aggressive than traditional banks in terms of loan underwriting, investment in riskier securities, and liquidity management. This suggests that although authorities may have targeted a proportional approach to regulation so as not to hinder

innovation, in practice some of this proportionality is not sufficiently risk-based to address different business models and the risk-taking appetite of neobanks.³⁰

Adapting Policies to Address Risks in Neobanks and Fintech Mortgage Firms

The rapid growth of fintechs worldwide has led to interconnectedness within the financial sector, which could exacerbate financial stability challenges. The neobank case study unveils vulnerabilities across at least four dimensions: (1) higher risk-taking in retail loan originations without appropriate provisioning and pricing standards; (2) higher risk-taking in the securities portfolio as a way to cross-subsidize their lending business in order to support its price-competitiveness vis-à-vis traditional banks; (3) potential underspending in critical functions (such as AML/CFT and IT/cybersecurity) as they fail to match market expectations for meaningful efficiency gains down the road; and (4) liquidity buffers that do not appear to be well calibrated to neobanks' less sticky retail deposit base. In addition, neobanks are providing funding to traditional banks through the interbank market. Moreover, a small number of fintech firms provide critical services (such as cloud services) to financial institutions.

Even if regulation delivers a level playing field for fintechs and incumbents, the scalability of technology-enabled business models allows fintechs to grow fast, putting pressure on incumbents. The competitive pressure on traditional banks can be significant. As the case study of the US mortgage market shows, there is strong evidence of a negative impact on banks' income as a result of competition from fintechs. Importantly, evidence also shows that banks adopting fintech-like technologies are less affected. Excessive risk-taking by both fintechs and incumbents to gain or defend market share could lead to a fast buildup of systemic risk (Vives 2019).

The rapidly changing risks in fintechs require policy action to tighten and clarify fintech regulation, as well as enhanced monitoring of incumbents, which might be more vulnerable under pressure from rapid fintech development. First, prudential regulations at both the entity and group levels should be reviewed to address fintechs' key risks in a forward-looking manner. This will likely mean more robust capital, liquidity, and operational risk-management requirements, commensurate with

³⁰Many neobanks are not subject to group-wide supervision, which creates regulatory arbitrage opportunities.

the risk taken by neobanks in several jurisdictions. Second, the health of technology laggards and smaller banks could be particularly at risk as they may not have the resources and know-how to adapt to technological changes. This may require supervisors to closely monitor less technologically advanced incumbents.

Regulating Decentralized Finance

DeFi poses unique challenges to regulators. DeFi's elevated market, liquidity, and cyber risks may need adjustment to the regulatory perimeter, but DeFi's anonymity, lack of a centralized governance body, and legal uncertainties render the traditional approach to regulation ineffective.

As DeFi, stablecoins, and traditional financial entities have grown ever more interconnected, enhanced regulatory surveillance and globally consistent regulatory frameworks will be necessary. Stablecoins are backed or collateralized by cash and financial instruments, and regulated financial institutions are increasing their exposure to and funding from stablecoins (Aramonte, Huang, and Schrimpf 2021). This linkage can lead to stronger interconnectedness between DeFi and the financial sector. Basel Committee on Banking Supervision (BCBS) proposals on banks' crypto asset exposures are a significant step toward global standards to help address some cross-border issues.³¹

As a first step, regulation should focus on some elements of the crypto ecosystem that have enabled the development of DeFi. These include stablecoin issuers (which define technical specification and use cases); centralized crypto exchanges and hosted wallet service providers (which connect crypto markets with the broader financial system); and reserve managers, network administrators, and market makers (which play important roles in operationalization and stability). These entities would benefit from robust and comprehensive national regulatory frameworks delivered through common global standards by standard-setting bodies. Those centralized entities in the crypto asset ecosystem could be an effective liaison for regulators to address the risk of rapid DeFi growth.

³¹In 2021, the BCBS consulted on a preliminary proposal for a prudential treatment of banks' crypto asset exposures. The proposed standards reflect the high risk of some crypto assets, while taking a more proportional approach to those that are anchored on real-world assets. After this initial public consultation, the Committee has reviewed the comments received and is now working to further specify a proposed prudential treatment, with a view to issuing a further consultative paper by mid-2022.

As a second step, authorities can directly regulate key functions within DeFi. To manage the risks generated by protocol developers, measures could include public-private collaboration on code regulation through either ex ante guidelines on operational and risk parameters (including operational and cyber resilience) or ex post code reviews and audits that can identify areas vulnerable to risk and help deliver policy objectives. Ex ante measures can be combined with greater disclosure and user education to help identify platform-specific risks, closing the information gap between retail and institutional investors.

Authorities should encourage DeFi platforms to adopt robust governance through industry codes and build effective public-private collaboration to establish self-regulatory organizations. A transparent and credible governance system could improve risk management, facilitate good conduct of financial transactions, and eventually attract more users and capital to the platforms. Such a governance system could be a natural entry point for regulators to interact either directly or through the development of industry codes or self-regulatory organizations. For example, their governance token holders can form decentralized autonomous organizations with voting rights, like traditional securities.³² These organizations may provide authorities with a conduit for regulatory oversight, ensuring that DeFi platforms enhance disclosure and have suitable controls. Much as in traditional securities markets, self-regulatory organizations for centralized crypto exchanges would lead to more robust listing standards for (tokens of) DeFi platforms and thereby improve their governance and quality. Regulators should monitor the effectiveness of industry codes and self-regulation and enhance supervision intensity when necessary.

Enforcing regulations—including restrictions—in DeFi markets is challenging, as experience from crypto markets shows.³³ One potential approach is to restrict the exposure of regulated firms to DeFi markets (especially markets not subject to proper regulation or self-regulation), which could slow the pace of growth while addressing the risks of interconnectedness with regulated markets.

³²In some jurisdictions, such as the state of Wyoming in the United States, decentralized autonomous organizations are considered legal entities.

³³Despite the implementation of restrictions, an estimated 1.7 million Egyptians hold crypto assets (TripleA 2022). Many crypto asset service providers operate offshore; users can take advantage of virtual private networks to obscure their location, demonstrating the difficulty in enforcing regulations.

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