Monetary Policy Transmission Through Online Banks *

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Abstract

Financial technology has the potential to alter the transmission of monetary policy by lowering search costs and expanding banking markets. This paper studies the reaction of online banks to changes in the federal funds rate. We find that a 100 basis points increase in the federal funds rate leads to a 30 basis points larger increase in the deposit rates of online banks relative to traditional banks. Consistent with the rate movements, online bank deposits experience inflows, while traditional banks experience outflows. Results are similar across markets of different competitiveness and demographics but vary with the stickiness of banking relationships.

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1 Introduction

A large number of studies have found that monetary policy transmission is imperfect. In particular, market concentration in deposits (Drechsler et al., 2017), search costs (Duffie and Krishnamurthy, 2016), lender market power (Scharfstein and Sunderam, 2016), duration (Binsbergen and Grotteria, 2023), and human frictions (D'Acunto et al., 2021) have all been shown to affect how monetary policy is transmitted through market interest rates. Monetary policy is mainly transmitted through the regulated banking system. However, recent technological advances that have revolutionized traditional banking services have the potential to radically alter this transmission process as well. Individuals can now transfer funds via mobile devices and compare investments online, which dramatically lowers search costs, weakens banking relationships, and increases geographic scope and financial market competitiveness. How does this unprecedented growth in financial technology (FinTech) in banking impact monetary policy transmission?

Standard models predict that the increased reliance on financial technology in 21st century banking would dramatically impact how monetary policy is transmitted.[1] Consistent with increases in competition and lower search frictions, online banks offer significantly higher rates on deposits than traditional banks do through their branches. In this paper, we explore how the increasing share of online banks affects monetary policy transmission. Specifically, we study whether online banks' deposit rates respond differently relative to traditional brick-and-mortar banks. We exploit changes in the Federal Funds Rate (FFR) in the U.S., with a rapid increase from zero in March 2022 to 5 percent in April 2023. Our main finding is that a 100 basis point increase in the federal funds rate leads to an approximate 30 basis point increase in deposit rates offered by online banks, relative to traditional brick-and-mortar lenders.

[1]By 2022, online bank deposits constituted about 5 percent of the total deposits held by commercial banks in the US. While many regulated commercial banks in the US now start their operations almost exclusively online, offering online deposits and loans, we also observe many traditional banks switching from brick-and-mortar branches to online deposits. In other areas of the world online banks have a larger market share. This is particularly true in Latin America, where 17% of individuals use digital banks as their primary financial institution. Demographics suggest that this share will continue to grow, as more than half (54%) of Latin American adults under the age of 35 prefer to use online banks as their primary financial institution.

We begin by providing a stylized theoretical framework that follows Drechsler et al. (2017), where the key insight is that depositors of online banks adjust their deposit holdings in response to changes in interest rates, while depositors in traditional brick-and-mortar commercial banks are generally sticky.[2] Comparing rates at online banks to those at traditional banks, we see parallel trends prior and significant divergence following the 2022-2023 hikes in the FFR. Consistent with the deposit channel, we find that interest-rate passthrough is significantly larger for online banks than traditional brick-and-mortar banks. Using a difference-in-differences empirical design, we show a 22 to 35 basis points larger increase in rates of various types of deposits offered by online banks, compared with ones offered by traditional banks, due to a 100 basis points increase in the FFR.[3]

An implication of our framework is that, along with differential changes in deposit rates, there should be significant differences in levels of deposit flows between online banks and banks with brick-and-mortar branches. We show that deposits of online banks have been growing at a much faster rate than that of traditional banks in the last decade. Moreover, supporting our framework's predictions, this growth continued and got steeper after the rate hikes for online banks while traditional banks experience net deposit outflows. We also show that the increase in overall deposits for online banks during interest hikes is due to inflows to their interest-bearing deposits being larger for them than for traditional banks.

Our paper's main contribution is to show that monetary policy transmission is distinct for online banks, which have been growing at an enormous pace. We also discuss several potential mechanisms for higher interest rate passthrough at online banks. First, we demonstrate that online banks behave qualitatively differently even compared to competitive brick-and-mortar banks. Drechsler et al. (2017) argue that the deposit channel of monetary policy exists due

[2]This is not the only framework which can generate a spread between rates at online and traditional banks following monetary policy shocks. In section 2.2, we also discuss alternative channels, building on different theoretical frameworks, that lead to divergent rate adjustments for online banks.

[3]An important implication of our results is that online banks share features with Money Market Mutual Funds (MMMFs). MMMFs passed through Fed Funds Rate increases nearly one-for-one in 2022 and subsequently saw large investment inflows, similar to online banks. Even though online banks share a regulatory environment with traditional banks, their economic behavior may more closely resemble other types of investments.

to market power of traditional banks over deposits. Hence, we repeat our tests using subsamples of bank branches in counties with high versus low banking concentration, in all banking markets or only in areas where online banks target their marketing efforts. Our finding of significantly larger transmission of policy through online banks holds with similar economic magnitudes when we exclude concentrated banking markets as well.

Our model's key assumption is that depositors of brick-and-mortar banks are stickier than those of online banks. A natural reason for this less sticky customer base is that banking with online banks is different, for example, because funds in online accounts are easier to move due to easier online access or lack of personal relationships with the bank. Another possible reason is that online banks serve different customers. Their customers may be younger and more educated and therefore engage in more search. To address this we test for differences in demographics between clienteles as a potential mechanism. Specifically, we repeat our main regressions first with the addition of ZIP code level demographic controls, and interact these controls with changes in rates. We also match online banks to traditional banks that reside in ZIP codes with similar demographics. Our estimates remain remarkably similar when we control for demographics. With the caveat that regional data is an imperfect proxy for the characteristics of individual bank customers, these findings suggest that our main results are not driven by different rate sensitives by demographic groups, and that differential responses of online banks are indeed driven by differences in technology and market power. Providing further suggestive evidence for the role of less sticky customers, we find smaller effects when we limit the sample to online banks that offer a variety of different consumer loan products, since the customers of these banks may be more likely to have a multi-product relationship with the bank.

Finally, we also consider the possibility that online banks experienced better investment opportunities than brick-and-mortar banks following increases in the FFR, which could provide an alternative explanation for why they would raise deposit rates. Using various measures, we show that lending opportunities and profitability of online and brick-and-mortar banks changed in similar ways during the time period we study. In other words, we find no evidence that their investment opportunities improved disproportionately.

To understand the implications of online banking for the pass-through of monetary policy to loans, we also analyze rates on auto loans and mortgages for the subset of lenders for which data is available. We find that the sensitivity of loan rates to the FFR is also larger for online banks than traditional ones.

Our paper mainly contributes to the extensive literature on monetary policy transmission. The existing literature has documented several channels of monetary policy passthrough to the supply of bank loans, namely, the bank lending channel (Bernanke and Blinder 1988, Kashyap and Stein 1994, Kashyap and Stein 1995),[4] the bank capital channel (Bolton and Freixas 2000, Van den Heuvel et al. 2002, Brunnermeier and Sannikov 2016), communication (Neuhierl and Weber, 2019; Coibion et al., 2022; Cieslak and Schrimpf, 2019), perceptions (Bauer et al., 2022), the deposit market power channel (Drechsler et al. 2017), and the loan market power channel (Scharfstein and Sunderam 2016). Using a structural model, Wang et al. (2022) quantify the relative importance of each channel on the sensitivity of bank lending to changes in the federal funds rate.[5] The authors show that the deposit market power channel is the most powerful one, explaining much of the transmission to bank borrowers. Focusing on the recent increases in the FFR, a contemporaneous paper by Greenwald et al. (2022) studies the effect of banks' securities holdings on monetary policy transmission. The authors show that banks that experienced larger losses on their securities holdings due to the rate hikes, contracted their commercial lending relatively more. Another related literature (e.g., Hannan and Berger 1991 and Neumark and Sharpe 1992) studies the rigidity of the banks' deposit rates against regulatory rate changes, especially in concentrated banking markets. Some recent papers such as Begenau and Stafford (2022), Granja and Paixao (2023), and d'Avernas et al. (2023), on the other hand, provide strong evidence on uniform deposit pricing across banking markets of

[4] Federal Reserve's 2020 decision to completely eliminate reserve requirements ended the discussion on the lending channel based on reserve requirements, which had been also criticized to be too low to be effective.

[5] A related literature focuses on monetary policy and asset returns, for example Pflueger and Rinaldi (2022), Cieslak (2018) and d'Avernas and Vandeweyer (2023). See Cieslak and Pflueger (2023) for a recent review.

especially large banks. Our contribution to this literature is to show that financial technology and the growing utilization of online services can have a dramatic impact on the transmission of monetary policy. As online banks expand, the passthrough of monetary policy to rates and loans may change, requiring updated models and policy guidance.

We also contribute to the literature on the growing role of FinTech in banking. The majority of this literature focuses on the increasing role of unregulated financial institutions in direct lending to small and medium-sized businesses, especially after the 2008 Financial Crisis and how they expand access to finance for consumers.[6] Papers that focus on the role of FinTech in providing liquid claims – i.e, deposits – are rare, as providing deposits comes with regulation and FinTech lenders are typically shadow banks. Xiao (2020) builds a structural model incorporating the role of unregulated shadow banks in monetary policy transmission. He argues that deposit-like claim holders in shadow banks (e.g., money market mutual funds) are more sophisticated and hence more yield sensitive. His paper shows that monetary tightening drives more deposits into the uninsured shadow banking sector, which passes through rate hikes more to its rate-sensitive clientele. To our knowledge, Abrams (2019) is the only paper on the growth of regulated online banks. In this paper, we also concentrate on regulated banks that utilize FinTech to operate almost exclusively online and compare them with traditional banks that operate mostly through their brick-and-mortar branches in terms of their interest rate passthrough. We find that the transmission of monetary policy on deposit rates is much more effective for online banks. This implies that the rapid growth in the utilization of financial technology may have important effects on policy.

Our paper is most related to a contemporaneous paper by Koont et al. (2023) who show that the introduction of digital platforms by brick-and-mortar banks has reduced their franchise value of deposits. They identify a bank as digital if it provides a mobile app with at least 300

[6] Research on business lending includes Buchak et al. (2018); Fuster et al. (2019); Stulz (2019); Chernenko et al. (2022); DeFusco et al. (2022); Gopal and Schnabl (2022). Papers about increasing financial access include Buchak and Jørring (2016), D'Acunto et al. (2019), Stein and Yannelis (2020), D'Acunto and Rossi (2023), Bartlett et al. (2022), Granja et al. (2022), Fuster et al. (2021), and Erel and Liebersohn (2022), among others. But, Ben-David et al. (2022) show that there is funding fragility for unregulated FinTech lenders during the COVID crisis.

reviews (see also Koont 2023). These digital banks are generally the largest banks (Haendler, 2023). Their main focus is on the deposit outflows from banks –i.e., how the digitization of traditional banks through these apps leads to faster deposit outflows in times of monetary tightening and how these outflows can affect the stability of the banking sector in general.[7] Our focus is on online banks, whose share has been growing in the U.S., and how deposit rates that they offer react to changes in federal funds rates. We find that online banks increase their rates significantly more than traditional banks do and do not experience deposit outflows, contrary to the findings of Koont et al. (2023) for traditional banks with a digital presence. Therefore, our papers are complementary and both findings should be incorporated in an equilibrium model of welfare effects of FinTech banking.

The remainder of this paper is organized as follows. Section 2 discusses institutional details and presents a motivating framework. Section 3 presents our main empirical strategy. Section 4 describes the main data sample used. Section 5 presents the main results while section 6 discusses the potential mechanisms. Section 7 includes robustness tests and tests on loan rates. Section 8 concludes.

2 Institutional Details and Motivating Framework

2.1 Online Banking

Internet banking has dramatically increased in importance over the past twenty years. Bhutta et al. (2020) show that nearly 80% of households used online banking services in 2019 and 45% used the internet for investment advice, a threefold increase since 2001.[8] In response to growing comfort with mobile and internet banking, a growing number of online banks have begun to compete with traditional brick-and-mortar banks. A major advantage of purely-online

[7] See, also, e.g., Caglio et al. (2023), Cookson et al. (2023), Drechsler et al. (2023), Jiang et al. (2023) and Benmelech et al. (2023) on the fragility of especially uninsured deposits, motivated by the recent failure of the Silicon Valley Bank.

[8] At the same time, 79% of households that used internet banking still visited a bank branch at some point in the year (Bhutta et al., 2020), indicating that many households use both physical and online services.

internet banks is that they do not have to maintain branches, lowering the cost of providing banking services. Moreover, they have to offer attractive rates as they cannot rely on relationships with customers and sticky depositors.

Figure 1 shows nominal deposit growth in online and brick-and-mortar banks indexed to 2001. The figure shows the rapid and large growth of online banks since 2001, growing by a factor of 20 over this time, over triple the deposit growth in brick-and-mortar banks. It is important to note though that purely online banks are still a small share of total bank deposits as we still have almost 4,000 traditional banks in the U.S. The banks we identify as purely online represent about 5% of total system deposits as of March 2023.[9] However, during the past two decades, the combined effects of rising mobile usage and new entry into the field of online banking have led to a dramatic increase since even ten years ago. Disruptions of the COVID-19 pandemic also accelerated demand for internet and mobile banking. According to the industry publication *American Banker*, the COVID-19 pandemic increased the share of households using mobile banking apps from 2019-2020. There seems to be little evidence of a slowdown, and if anything deposits at online banks appear to be growing at a faster rate relative to traditional banks. Online banks will thus likely be even more important in the future.

Even though our focus in this paper is on pure-play online banks, takeaways could also apply to traditional banks that shift towards digitization in general. However, online banks differ from brick-and-mortar banks, even with their growing online services presence, in several ways that affect their competitive landscape. Important differences include their reliance on technology in raising funds and the lack of personal relationships through bank branches, both of which could make their customers less sticky. The cost of comparing deposit rates with alternative investment options –such as mutual fund returns or rates offered by competitors– is lower when consumers can move their money at the click of a button. Therefore, improvements in outside investment opportunities are more likely to force online banks to raise rates when brick-and-mortar banks' rates remain low. Consumers of online banks may also be dif-

[9] See Figure 2 for total deposit dollar amounts.

ferent than consumers of brick-and-mortar banks — for example, they may be younger, better educated, or simply more sophisticated investors. If these different demographics represent lower search costs for online banking consumers, this difference could also force online banks to compete more when outside opportunities improve. In the next section, we provide a theoretical framework which formalizes the intuition that search costs are lower for customers of online banks.

Finally, online banks have different assets than traditional banks because they have poorer access to local lending markets which require a physical presence. Differences in investment opportunities between online and brick-and-mortar banks could lead to differences in deposit demand which are reflected in deposit rates. The model can accommodate differences in investment returns, but empirical results will not provide much reason to think that time-varying investment returns explain the findings.

2.2 Theoretical Framework

There are several non-mutually exclusive channels through which monetary policy transmission through interest rates may differ for online banks than traditional brick-and-mortar institutions. For example, the deposit channel, the costly search channel, or the shadow banking channel, building on different theoretical frameworks, all would predict differences in depositor behavior leading to divergent rate adjustments for online banks.

The deposit channel of monetary policy (Drechsler et al. (2017)) is a very natural mechanism through which monetary policy transmission may differ for online and brick and mortar institutions. The relevant insight for our setting is that the spread s_{trad} between the FFR f and the deposit rates at traditional brick-and-mortar institutions is given by

$$s_{trad} = \delta^{\frac{\varepsilon}{\varepsilon-1}} \left[\frac{\mathscr{M} - \rho}{\varepsilon - \mathscr{M}} \right]^{\frac{1}{\varepsilon-1}} f \tag{1}$$

where ε is the elasticity of substitution between cash and deposits, δ is the liquidity of deposits relative to cash. $\mathscr{M}$ is the market power of the representative bank. The key difference between traditional and online banks is that $\mathscr{M}$, market power, would be much lower for online banks than traditional banks. This is because, for users of online banks markets are national and not local. It is frictionless to withdraw and transfer funds using apps. Traditional measures of local market power will not affect online banks. Online bank deposits are also not sticky, like traditional bank customers that might enjoy banking relationships.

From Equation (1), we know that spread on deposits increases with the FFR. Moreover, Drechsler et al. (2017) show that the sensitivity of spreads to the changes in the FFR is lower as $\mathscr{M}$ decreases. Since online banking is more competitive in terms of managing deposit funding relative to traditional banking, we would expect changes in deposit spreads due to changes in the FFR to be lower for online banks. In other words, online banks adjust their deposit rates more than traditional banks do, leading to larger (lower) changes in deposit rates (spreads) due to increases in the FFR. In the remainder of the paper, we test for differential passthrough of the fed funds rate in rates for online and traditional banks.[10] One reason why online banks may be more competitive than brick-and-mortar banks is that online banking customers are less likely to have an established relationship with their bank and can switch banks more easily. We provide suggestive evidence that banking relationships matter for the transmission of deposit rates.

A second channel is search costs, which can affect rates (Argyle et al. (2023)). Argyle et al. (2023) demonstrate that local bank branches continue to be important and have real effects on rates through costly consumer search. Moving deposits is effectively frictionless at online banks, while visiting a bank branch incurs costs, primarily in terms of time. Search costs can lead to consumers accepting lower rates on deposits than they would otherwise. Costly search in traditional markets can also amplify rate passthrough in the online sector, as more more

[10]While the framework above has unambiguous effects on rates, it is important to note that the effect of the transmission of the FFR to deposit rates can have ambiguous effects on the real economy. On the one hand, increasing rates may increase savings and reduce consumption. On the other hand, higher passthrough to rates may reduce transmission and bank lending through the deposit channel. Moreover, other frameworks may also generate our key empirical results — that there is greater pass — through of monetary police to interest rates.

rate-sensitive customers move towards online banks (Argyle et al. (2023)).

A final channel through which passthrough may differ at online banks is the shadow banking channel, proposed by Xiao (2020). This channel operates through different demographics of customers at online banks. Contrary to traditional banks, the clientele of shadow banks, including online banks, are more sophisticated and, as a result are more yield-sensitive. Following the rise in the federal funds rate, traditional banks exploit the market power and yield-insensitivity of their depositors, restricting the passthrough of the interest rate shock to the deposit rates, leading to deposit outflow (Xiao (2020)). In contrast, shadow banks increase rates to keep their yield-sensitive clientele from switching to other markets. Our focus in this paper is on regulated financial institutions as monetary policy is mainly transmitted through them; however, depositor demographics of regulated online banks in our sample could resemble the clientele of shadow banks.

3 Empirical Strategy

We compare how interest rates evolve at online and brick-and-mortar banks during times of monetary tightening. Specifically, we exploit the difference in rates between online and brick-and-mortar banks following the increase in the Federal Funds Rate (FFR) beginning in March 2022. In early March 2022, the FFR was almost zero. On March 17, 2022 the Federal Reserve raised the benchmark rate by 25 basis points to 0.50%. This change was followed by even larger rate hikes in May and June, by 50 and 75 basis points respectively. By the end of our sample period in April 2023, the Fed raised rates nine times to 5%, with the last one being on March 22, 2023, by 25 basis points. This rapid increase over a year led to the highest FFR since 2007. We explore how lending and deposit rates changed following this historically quick increase in rates.

More formally, we employ a difference-in-differences empirical strategy. For a given financial product, let i index banking institution and t index month-year. We model annual percentage yields, APY_{it}, as:

$$APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \varepsilon_{it}, \tag{2}$$

where $1[Online]_i$ is an indicator for whether institution i is classified as an online bank and $1[PostMarch2022]_t$ is an indicator for whether the month is March 2022 or later. The main coefficient of interest is β, which captures the spread in APY following the increase in interest rates. We include institution and time (month) fixed effects, α_i and α_t respectively. Time fixed effects α_t capture temporal shocks which affected online and traditional banks in a similar fashion. Institution fixed effects α_i capture time-invariant banks-specific factors. For example, some banks may provide better services and charge higher rates on average. We cluster standard errors at the institution level.[11] In some specifications we replace $1[PostMarch2022]_t$ with the FFR. The coefficient on this term captures the relative increase in spreads between online and traditional banks for a one percentage point increase in the FFR.

The key identifying assumption is parallel trends. That is, the strategy assumes that in the absence of federal funds rate changes the annual percentage yields of online and brick-and-mortar banks would have trended similarly. To establish pre-trends and visualize effects over time we estimate a dynamic difference-in-difference specification using the equation:

$$APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it} \tag{3}$$

with the January 2022 coefficient normalized to zero. This specification is run separately for each financial product offered and uses each month between April 2021 and April 2023 inclusive. We additionally plot raw means of APY_{it} for online and traditional banks.

[11] An advantage of our strategy is that the policy occurs at a single point in time, and is not conditional on further covariates. Our analysis is thus robust to considerations regarding biases arising from staggered implementation of policies, as two-way fixed effects estimators with heterogeneous treatment effects could lead to negative weights on treatment effects (de Chaisemartin and D'Haultfoeuille, 2020).

4 Data

4.1 Deposit and Rate Data

To create our analysis sample, we start with the set of online and brick-and-mortar banks that have Federal Financial Institutions Examination Council (FFIEC) Call Reports as of March 2021. To this list, we add Alliant Credit Union, which we identify as a FinTech and has deposit rate data available. Using the Call Reports data, we measure banks' total assets, total deposits, interest-bearing deposits and non-interest bearing deposits by quarter. We collect similar data on Alliant using data from the National Credit Union Administration.

We match the Call Reports data at the institution level to interest rate data from Ratewatch, a division of Standard & Poor's. Ratewatch collects data on deposit and loan interest rates on a regular basis (typically weekly) for a national sample of bank branches. Ratewatch is widely used in academic research on branch rates (e.g., Drechsler et al. 2017), but is also in industry by banks to stay informed about their competitors' rates.[12] In recent years, their coverage has expanded to include rates from online banks and a variety of loan products. We match Ratewatch data to data from Call Reports at the institution level, keeping only those banks whose rates are available consistently throughout our sample period. We then aggregate this data set to the month-by-institution level, taking the simple average of rates across each institution's branches. In robustness checks, we consider different specifications, for example using deposit quantity weights.

For each branch that Ratewatch surveys, data is collected on rates by product (e.g., checking, savings, or CD), amount and, if applicable, maturity. We study rates at $2,500 savings, $10,000 money market savings accounts, 6-month $10,000 certificates of deposit, 24-month $10,000 certificates of deposit and 12-month IRAs. We take these to be representative of the

[12] Ratewatch does not survey *every* branch for any particular bank, but only a sample. Surveyed branches are denoted as "rate-setting branches" and other branches are assumed to follow nearby rate-setting branches. Ratewatch conducts local market research to ensure that non-surveyed branches have rates that are very close to their assigned rate-setting branches.

landscape of consumer deposits.[13] To understand the lending practices of the banks in our sample we construct a measure of total consumer loans by summing reported auto loans, credit cards, mortgages and 'other consumer loans' as defined by the FDIC Call Reports. Using this measure we construct a specialized lender indicator that indicates if a bank has more than 90% of their consumer loans concentrated in a single consumer loan category. It is likely that customers of multi-product banks are more likely to be sticky than customers of single-product banks.

We further use data from the FDIC Summary of Deposits (SOD) database to calculate the location and deposits of brick-and-mortar bank branches. SOD data includes a unique branch identifier which is readily matched to Ratewatch data. We calculate county-level Herfindahl Indexes using deposits data from all the branches in each county. Local demographic information about ZIP code characteristics comes from the 2017-2021 American Community Survey. We match this survey data by ZIP code to the ZIP code of each bank branch.

4.2 Classifying Online Banks

In order to identify online banks, we begin with a sample of 15 online banks identified by Abrams (2019) and supplement this sample with banks whose online platforms are reviewed by the consumer finance web site Nerdwallet.[14] The Nerdwallet list includes some large brick-and-mortar banks that have popular online products, so we drop any banks from the Nerdwallet list that have more than 30 branches in SOD data. Of this list, we find that 17 have consistent coverage in Ratewatch data. These 17 banks comprise the online banks in our main analysis sample.

Table 1 shows the online banks in our main analysis sample. Ratewatch provides their own classifications, and most of the banks we identify are classified by Ratewatch as an "Internet

[13] S&P acquired Ratewatch shortly before our sample begins and integrated the Ratewatch platform into their software in the middle of our sample. We discovered several missing data points in the middle of the sample that are the result of the integration, which reduced the number of banks and products we were able to consistently match between Call Reports and Ratewatch.

[14] See https://www.nerdwallet.com/best/banking/best-online-banks.

Bank." A few are classified as "Bank" or "Credit Union" and one (Quontic Bank) is classified as a Savings & Loan. With few exceptions — e.g., Capital One and CIT Bank — the online banks have few branches. Most of them in fact operate fully online, with only one or two administrative branches. For example, Ally Bank, American Express National Bank, and Axos Bank are typical online banks with only one branch. There is variation in year of establishment among online banks in our sample. While some are established in 2000s (e.g., Ally Bank and Axos Bank), some are established much earlier in time (e.g., American Express National Bank in 1989). Two of the online banks (CIT and E*Trade) were acquired in January, 2022, so we do not have data for them in 2023. In the appendix, we also show that our results are robust to excluding any particular online bank.

For our additional tests, we almost double the online bank sample size by manually collecting data from website histories of online banks which are not covered by Ratewatch. For example, Marcus by Goldman Sachs and Charles Schwab Bank are in this extended sample, which covers majority of regulated online banks in the U.S. In section 7.2, we show that our results for deposit rates are very similar when we use the extended sample.

We further use annual advertising data from Nielsen to identify our online bank's target markets. The Nielsen Ad$pender data set is comprised of advertising spending across various media platforms including television, radio, and digital at the zip code level. We identify 15 of our online banks in this data set and use the zip codes they advertise in to infer where their brick-and-mortar competitors are located. Additionally, we match local demographic information from the 2017-2021 American Community Survey to these zip codes to estimate the demographics of the online bank's customers. The demographics of the online banks that are not found in the Nielsen data are supplemented using the individuals in the 2019 Survey of Consumer Finance who reported using online banking over the prior year.

Table 2 presents summary statistics for the main analysis sample, split by bank type. The table shows cross-sectional means of annual percentage yields by product and bank type in April of 2021, before the Federal Reserve began rapid rate hikes. The top panel shows traditional brick-and-mortar banks, while the bottom panel shows online banks. Online banks tend to have higher rates on average, and they are also much larger, with an order of magnitude larger deposits and assets. For example, mean APR for 6-month (24 month) CDs was 19 (39) basis points for brick-and-mortar banks while it was 28 (46) basis points for online banks in April 2021 and total deposits of traditional banks were around $4.11 billion while its was $52.6 billion for online banks, on average.

5 Main Results

5.1 Deposit Rates for Online and Traditional Banks

We begin by showing raw means over time in Figure 3. The top left panel shows the Federal Funds Rate (FFR) over time. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. As was discussed in section 3, there is a sharp increase in the FFR starting in March 2022, from almost zero to five percent in April 2023. The remainder of the panels show APY for different product types broken down by online versus traditional brick-and-mortar banks. We examine rates on savings accounts (regular passbook savings and money market deposit accounts) as well as 6 and 24-month Certificates of Deposits (CDs). 12-month Fixed IRA, presented in the last panel, is a type of CD covered by Ratewatch as well. The solid lines show rates for online banks, while the dashed lines show rates for traditional banks.

For all products, we see a similar pattern of change starting in March 2022. For both online and traditional banks, rates trend similarly while the FFR is at the zero lower bound. Following the increase in the FFR, rates rise for both types of banks. However, the rise is much faster and sharper for online banks. By the end of the sample period, there is a much larger spread between rates at online and traditional banks. This is most evident for Savings and Money Market Deposit Accounts, while the spread is smaller for CDs. For savings accounts, rates for online banks reach to 200-250 basis points while they stay at or below 50 basis points for brick-and-mortar banks by April 2023. For 6-month CDs, the interest gap raises to about 150 basis points, with rates for online banks exceeding 200 basis points. Note that banks raise rates on time deposits, which are typically higher, more in response to a higher fed funds rate (Kang-Landsberg et al., 2023).[15] In Appendix Figure A.8, where we present similar graphs weighted by each bank's total deposits, the difference in rates are much larger, with the rate for 6-month and 24-month CDs, for example, reaching to 300-400 basis points while remaining under 100 basis points for traditional banks.

Table 3 makes this graphical evidence more explicit. The top panel of the table shows estimates of equation 2, specifically of the main interaction coefficient β, which captures the spread in APY between online and traditional banks. For all products studied, we see significant effects, with a difference in APY which is significant at the 5% level or higher. The bottom panel of Table 3 replaces the indicator of a time period being post March 2022 with the fed funds rate (FFR). The coefficient on this interaction can be interpreted as the differential passthrough of the FFR for online relative to traditional banks. Across various products, we see an approximate 22 to 35 basis point relative increase in rates for online banks.

Figure 4 presents the results of a dynamic difference-in-difference estimator. The figure plots coefficients from equation 3, along with a 95% confidence interval. Consistent with the raw means, we see no difference between online and traditional banks prior to the increase in rates. This evidence is consistent with the identifying parallel trends assumption. Following March 2022, we see a sharp increase in rates for online banks relative to traditional brick-and-mortar institutions. By the end of the sample period, there is a 100 basis point spread for 6-month CDs, and an approximate 150 basis point spread for 24-month CDs, Money Market Deposit Accounts and Savings. In Appendix Figure A.9, where we present similar graphs, deposit weighted, the difference exceeds 200 basis points for savings accounts or 6-month CDs and 250 basis points for 24-month CDs.

[15]We only observe banks for one year after the rate increase, and ultimately, they may raise rates to be closer to rates offered by online banks. This would be consistent with Neumark and Sharpe (1992), who show that market power leads to delayed deposit passthrough, not just lower passthrough.

5.2 Deposit Growth at Online and Traditional Banks

An implication of our framework is that deposit growth at online banks is also expected to be larger as their depositors are more rate sensitive and we see larger rate changes for them than for traditional banks. Figure 1 presents total deposit growth for both types of banks since March 2001.[16] The dashed vertical line in the figure indicates March of 2022 which is when the Federal Reserve began the rate hikes to tighten its monetary policy. There are two important facts we learn from this figure. The first is that online banks' deposits grew at a much faster rate than that of traditional banks over the last decade. Second, confirming the implication of our framework discussed above, this deposit growth continued for online banks after the Fed started increasing the Fed funds rate targets in March 2022, at even a steeper rate. For traditional banks, though, we see a contraction in their deposits.

This decline (increase) in deposits due to the rate hikes is also evident in Figure 2, where we present the deposit quantities, rather than the growth, for both types of banks. We observe a steady increase in the total deposits of traditional banks until the first quarter of 2022. Their deposits totaled over $15 trillion dollars, almost $1 trillion of which left by the third quarter of 2023. Online banks' deposits increased by about $200 billion — similar in magnitude to the change over the previous decade.

We estimate the following difference-in-differences specification to show the effect on deposit levels more formally. For a given financial product, letting i index banking institutions and t index month-years, we estimate:

$$Deposits_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \varepsilon_{it}, \tag{4}$$

where $1[Online]_i$ is an indicator for if institution i is classified as an online bank and $1[PostMarch2022]_t$ is an indicator for if the month is March 2022 or later. As above, standard errors are corrected for clustering of observations at the bank level. We run this specification

[16] As our deposit quantities data source is the Call Reports, we provide quarter-over-quarter changes in the figure.

for total deposits first and present the results in Column 1 of Table 4. The coefficient on the interaction of the online and post dummy is positive and significant, showing about $6 billion of larger net deposit inflows to online banks.

In columns (2) and (3) of Table 4, we present results of the same difference-in-differences estimation for interest-bearing and non-interest bearing deposits separately.[17] For both types of banks, we would expect a shift from the former to the latter due to increases in rates in general. But we would also expect the shift to be larger for online banks as their response to rate hikes in terms of raising their deposit rates is larger. Findings are consistent with our prediction that inflows to interest-bearing deposits are larger for online banks than for traditional banks. There is no difference for non-interest bearing deposits. See also Appendix Figure A.3 showing the evolution of quantities for interest-bearing and non-interest-bearing deposits. For both types of banks, we see an outflow of non-interest bearing deposits while inflows of interest bearing ones happen at a much larger scale for online banks.[18]

6 Mechanisms

The preceding analysis shows that interest rate pass-through at online banks is higher. This finding could be due to several reasons. First, online bank customers could be more willing to switch banks when rates change as they may face lower search costs than clients of brick-and-mortar banks. These lower costs may arise because of the technology online banks use: as they rely on FinTech and digital platforms rather than brick-and-mortar branching, their clientele can easily leave when deposit rates are unattractive. Search costs may also be lower for depositors of online banks because they tend not to be in multi-product relationships, unlike

[17] A natural comparison group to online banks is Money Market Mutual Funds (MMMFs). Online banks share a regulatory environment with brick-and-mortar banks but our findings show that they respond to monetary policy differently. Instead of traditional banks, a better comparison group may be MMMFs. MMMFs pass through interest rates nearly one-for-one, making them attractive to customers of brick-and-mortar banks. Figure A.12 shows that MMMFs experienced inflows following rate increases, somewhat more slowly relative to online banks.

[18] Note that interest bearing deposits were 92.69% of total deposits for online banks while it was 67.05% for traditional banks, as of 2021Q4.

depositors of brick-and-mortar banks.

Other possible explanations concern local banking market concentration and demographics. Online banks' customers might behave differently because they are younger and more tech-savvy, or because they mostly compete with brick-and-mortar banks that operate in less competitive markets. These channels could also lead to lower search costs, but they have different implications for the future of online banking. In particular, if results are driven by online banks operating in more competitive brick-and-mortar markets, or if online banks attract different clientele, then as the share of individuals using online banks increases, they may start to behave more like brick-and-mortar banks. Finally, monetary policy might increase online banks' return on assets compared to traditional banks, leading them to attract deposits by raising rates. This section explores these different mechanisms.

6.1 Passthrough and Competition

One potential channel for the difference in passthrough by online banks is the difference in competitiveness of the banking markets for online and traditional banks. Hence, we repeat our tests using bank branches in counties with high versus low banking competition using the median Hirfindahl-Hirschman Index (HHI).[19] Table 5 presents results, where we create splits based on the HHI at the branch level. Panels A and B split branches below and above the sample's median HHI, while Panels C and D restricts these same splits to the zipcodes where online banks advertise. The results are similar for both splits. In unreported robustness tests, we ran similar subsamples to the ones in Panels A and B using bank level HHI rather than branch level and also found similar results. Our finding of significantly larger transmission of policy on rates through online banks holds, with similar economic magnitudes, even when we exclude concentrated banking markets.

This finding provides strong evidence that greater transmission of monetary policy through

[19]HHI for branches is calculated at the county level. For each county we calculate the HHI as $HHI = \sum_{i=1}^{N} S_i^2$ where i indexes the N branches in each county and S_i is the share of total county deposits held by branch i.

online banks is qualitatively different than brick-and-mortar banking markets, even relatively competitive ones. Even for traditional banks that operate in very competitive markets, we see differences in monetary policy transmission relative to online banks. However, this result does not rule out the important role of competition for online banks– indeed it is possible that competition affects all of our results, and that no traditional markets are as competitive as the online, possibly national market. What Table 5 shows is that, at the very least, even the most competitive traditional banks, with branch networks and reliance on banking relationships, differ from online banks in their interest-rate pass-through.

6.2 Passthrough and Demographics

New technology is not the only difference between online and brick-and-mortar banks. Another difference is that the types of people who use online banks are different from those who use brick-and-mortar banks. Anenberg et al. (2018) show that younger and higher-income people engage in more online banking. If the users of online banks are more financially sophisticated, they might have an easier time moving their money or finding the best rates. Therefore, demographic differences between the customers of online banks and brick-and-mortar banks could affect their rates, in a fashion similar to technology.

Section 2.2 discusses various channels through which monetary policy may have differing passthrough for online and traditional banks. Market power, search costs or demographics could lead online banking customers to act differently than the customers of brick-and-mortar banks. While our results are consistent with both channels, these explanations have different implications for the future of banking. If the difference between online and brick-and-mortar banks is mostly a matter of the types of customers using them, online banks might increasingly resemble brick-and-mortar banks as they expand in the future and acquire more customers. On the other hand, if differences are driven by technology changing market structure, then we should expect the equilibrium to shift towards online banks as the sector grows.

Data from the Survey of Consumer Finances indicate that individuals who utilize online banking are more likely to be young, high-income and educated, and less likely to be racial minorities.[20] We then explore how these variables, as well as variables related to computer use, are associated with monetary policy passthrough. We repeat our main regression with the addition of interactions with the ZIP code level demographic controls. Table 6 presents these results. The results in Table 6 are quite similar to our main results, and the coefficients are statistically indistinguishable from those presented in our main tables. This suggests that differences between online and brick-and-mortar branches are not primarily due to demographics, and are rather driven by other channels such as the sticky deposit channel or decreased search costs.

We conduct further tests, in which we generate pseudo-online banks, assigning a 'placebo online' indicator to branches in ZIP codes that are most similar to depositors of online banking. To find similar branches we run nearest neighbor matching using ZIP code averages of having a computer in the home, access to Internet, being older than 65, having a college degree, minority status, and having low income status (i.e., having household income of below $30,000). We again have the annual percentage yield offered as our dependent variable of interest and the interaction of post dummy and the placebo-online indicator as the main explanatory variable of interest. The results, presented in Table 7, are generally insignificant at conventional levels; they even have a negative sign. Given the weight of the evidence, we conclude that the differences between online and brick-and-mortar branches are not primarily due to demographics, albeit with the caveat that regional data is an imperfect proxy for the characteristics of individual bank customers. It is possible that there is within-Zip code selection to online banking which we cannot control for.[21]

[20] See Table B.1 for average SCF demographics among online bank users.

[21] We discuss these points in more detail in Appendix C. In addition to the results in the main text, run our main regression using only traditional banks that reside in ZIP codes with demographics similar to users of online banking. We use Nearest Neighbor Matching to assign zip codes with similar demographics. In both cases the effect of being an online bank remains large and significant.

6.3 Sticky Customers

Brick-and-mortar banks are more likely to form relationships with customers that are located geographically close to their branches (Petersen and Rajan, 2002). Banking research has emphasized the importance of banking relationships for small business customers, but it is natural to think that relationships could matter for retail depositors as well. One reason that online banks' market power might be lower than traditional banks' is that their customers are less sticky because they have a shorter relationship with them, or only use them for a particular product (such as deposits) rather than a variety of financial services provided on both sides of the balance sheet.

To provide suggestive evidence for the importance of banking relationships with their retail customers, we create proxies for relationships that vary among online banks. Specifically, we classify online banks into those that offer a variety of financial products versus those that are focused narrowly on taking deposits or making loans in a single category. Customers are likely to be sticky for online banks that offer a larger variety of products, since the customers are more likely to have a multi-product relationship with the banks. Therefore, if the relationships are a source of banks' market power, we expect that passthrough will be lower at online banks that offer many financial products as compared to those that offer only a few. Importantly, we do not argue that offering multiple products is the *only* reason that customers may be less sticky at online banks; rather, this is just one factor which can be measured reliably in the data.

As described in Section 4, we classify specialized lenders, or banks that focus narrowly on one loan category, as those that have more than 90% of their consumer loans concentrated in a single loan category.[22] Table 8 Panels C and D repeat our main regression splitting the online banks by specialized lender status. We find that specialized lenders, who presumably have less relationships, are significantly more sensitive to rate hikes than lenders that offer a variety of loan products. The coefficients for all products are smaller for general online lenders than

[22]Online banks typically focus on consumer, rather than commercial loans, in addition to their securities holdings. The consumer loan categories we consider are auto loans, credit cards and mortgages.

specialized ones, with coefficients significantly indifferent from zero for two of the products.

As an alternative measure of banks' relationship lending, we also measure the share of banks' total assets that are consumer loans. We measure the share of consumer loans as the sum of mortgage loans, credit cards and auto loans, divided by total assets. Banks that offer more consumer loans, rather than investment in securities, in general are more likely to have sticky customers. Appendix Table A.3 Panels C and D show estimates where online banks are split based on their share of total consumer lending. We find that online banks with a lower share of consumer loans to assets also tend to be more sensitive to rate hikes.

These results are only suggestive but provide some support for the view that loan relationships reduce interest rate passthrough by creating market power. These findings support an interpretation of our results along the lines of the model in Drechsler et al. (2017), whereby market power reduces the passthrough of deposit rates to retail customers.

6.4 Return on Assets

Our model assumes that the return on assets for online and brick-and-mortar banks are the same. If this is not the case, it could provide another explanation for the differences in deposit rates offered by these types of banks. If online banks' investment opportunities improved relative to brick-and-mortar banks after the federal funds rate increased, this could explain why they rais rates to attract deposits.[23]

We explore the role of time-varying investment opportunities in Figure A.4. This figure shows event study figures of the quarterly return on assets (ROA) for online banks as compared to brick-and-mortar banks, calculated from Call Reports data. It also shows the ROA for credit cards and for personal loans. If a sudden improvement in loan opportunities were the reason that online banks increased deposit rates, we would expect a corresponding increase in the ROA

[23] Drechsler et al. (2017) control for differences in lending opportunities using bank-by-time fixed effects in their regression specifications. Their identifying variation comes from within-bank, across-region variation in local concentration. Such specifications are not possible for online banks, which have branches in a single "location" — i.e., the Internet.

for these types of investments. The event study figures show that the ROA is somewhat noisy but mostly flat over the time period we study. There is little evidence investment opportunities are different for online and brick-and-mortar banks.

Overall, the results in this section suggest that varying local competition or demographics has little effect the results. We do not investigate the role of technology directly, but provide indirect evidence that the stickiness of customers matters. When we limit the sample of online banks to those whose customers have many different types of loans – and may therefore be more locked into multi-product relationships – they respond to monetary policy more like brick-and-mortar banks do. Finally, we show that the investment returns of online banks and brick-and-mortar banks are affected similarly by monetary policy. For these reasons, it is likely that an important mechanism is differences in search costs, in part explained by customer stickiness.

7 Additional Tests

7.1 Robustness Tests

Online banks are yet small in number but not in size. As presented in Table 2, the average online bank has about $66 billion in assets, more than ten times as large as the average brick-and-mortar bank in our sample. To alleviate the concern that our findings are due to size differences between two types of banks in our sample, in Panel A of Table 8, we use only large traditional banks with total assets of $40 billion or over in our sample. The findings remain similar in terms of both economic and statistical significance. Moreover, in Panel B of Table 8, we alternatively run our main tests using the deposits of branches to weigh bank level rates.[24] Results largely remain similar to our baseline estimates.

Additional robustness tests are presented in the Appendix. For example, we test whether our results are driven by one particular online bank in Appendix Table A.1. Presented in this

[24] This is done using branch level SOD data. Because some banks book deposits at their headquarters location we exclude branches with deposits above $10 billion. We then average annual percentage yields at the bank-month level weighted by the total deposits each rate setting branch and repeat our main tests.

table are estimates from our main difference-in-differences specification in each case with a sub-sample leaving out one of the online banks. We see that betas remain significant and similar to each other in across almost twenty sub-samples, indicating that our results are not driven by any particular online institution. We also test if our findings are due to online banks being younger – i.e., using only 665 banks established after 2000 as our sample of brick-and-mortar banks. Additionally, we also consider subset of traditional banks that offer higher rates –i.e., offering rates greater than the 75th percentile prior to March 2022. Appendix Table A.3 repeats our main analysis using only these young banks (Panel A) and banks offering high interest rates prior to March of 2022 (Panel B). If online banks were to be similar to young brick-and-mortar banks, which are eager to gain new customers, we would expect effects to decrease significantly. In general, our estimation provides no evidence of a decrease in effects. On the contrary, coefficients for almost all products remain both statistically and economically significant.

Finally, we also implement matching techniques to select a subset of brick-and-mortar banks that resemble online banks in terms of not only rates that they offer but also their balance sheet characteristics. Results presented in Appendix Table A.5 include online banks with the matched traditional banks identified using nearest neighbor matching (with the smallest Euclidean distance). Establishment year, total deposits, share of total assets that are consumer loans, and rates offered in April of 2020 are the matching variables. We continue finding highly significant results for savings accounts and 24-month CDs and weakly significant results for 6-month CDs.

7.2 Online Bank Sample Extension

Due to the limitations of the RateWatch surveys we are not able to included every online bank in our main sample. However, online banks often list deposit rates on their websites. Using the Internet Archive 'Wayback Machine' we hand collect the rates of the online banks which were excluded from our main sample due to lack of coverage by RateWatch.

We begin with the list of online banks reviewed by Nerdwallet and check individual banks' websites for the deposit rates offered on the five products in our analysis. We then use the Internet Archive to obtain snap shots of these web pages in each month between April 2021 and April 2023 and record historical rates by hand. Banks and products that do not have Internet Archive coverage prior to March 2022, when the rate hike occurred, are removed. For banks with gaps in Internet Archive coverage we linearly interpolated missing rate observations. Through this process we add an additional 12 online banks to our sample. Of these banks 11 having savings account coverage, 4 have 6 month CD coverage, and 7 have 24 month CD coverage. We do not find sufficient coverage to increase observations for money market accounts and fixed IRA accounts. The banks in our extended sample and their websites are displayed in Table C.4. Notable banks in this extended sample include Charles Schwab Bank and Marcus by Goldman Sachs.

Using this extended sample we repeat our main analysis. Results are presented in Table 9. The results using the extended sample are very similar to those using the main sample and even appear to be stronger for savings account and 6 month CD rates. Using this larger sample, we find that a 100 basis points increase in the FFR leads to 32-39 basis points larger increase in rates of online banks than traditional banks.

7.3 Comparison to Loan Market

Online banks are a growing presence in the retail loan market as well. The online loan market is similar to the online deposit market in some ways since accounts can be opened electronically and search frictions may be lower. However, effects of lowering search frictions on lending rates are more ambiguous. On the one hand, more competition should push down rates if consumers search more. On the other hand, increased search for higher deposit yields and higher costs of funds may push up lenders' costs, leading to higher rates.

To understand the implications of online banking for the passthrough of monetary policy to loans, we repeat our main analysis for loan rates. We study two markets where Ratewatch data is available for online banks: the auto loan market and the mortgage market. We look at rates for 5-year new auto loans, 2-year used auto loans, 15-year mortgages and 30-year mortgages, where sufficient data is available. The main results are shown in Table 10. The estimates are noisy, but consistently positive, suggesting that increases in deposit rates and costs of funds pass on to higher lending rates. The elasticity of auto loan rates with respect to the Fed Funds Rate is larger for online banks by about 0.2, and the elasticity of mortgage rates for online banks is larger by between 0.15-0.18. The greater elasticity suggests that online lenders price loans closer to marginal cost, as we would expect from a more competitive market.[25] Our results are supported by event study plots shown in Figure A.5.

Our findings also show that monetary policy passthrough is greater among online banks in *both* the loan and the deposit markets. Online banks pass through cost shocks from borrowers to savers to a greater extent than brick-and-mortar banks. This fact potentially has important distributional consequences, both in terms of age and wealth. Since savers are older and wealthier than borrowers on average (Doepke and Schneider, 2006), redistribution from savers to borrowers is potentially regressive. Effectively high rates transfer to older and wealthier savers, and away from younger and poorer borrowers.

8 Concluding Remarks

An increasing share of lending is done by online institutions, and the increasing use of financial technology may have important implications for policy transmission. This has the potential to to massively alter the transmission of monetary policy on deposit rates, as banking markets become national and search frictions dissipate. In this paper, we study how monetary policy is transmitted through online versus traditional brick-and-mortar institutions. We find that monetary policy transmission on rates is significantly greater for online banks. A 100 basis point increase in the fed funds rate leads to between a 22 and 35 basis point larger increase in

[25] All the lenders in our loan sample also take deposits except Quicken/Rocket Mortgage. When we repeat the analysis excluding Quicken/Rocket Mortgage, the mortgage rate coefficients increase in magnitude and statistical significance, suggesting that there is some passthrough of deposit rates to loan rates. These results are shown in Table A.4.

annual percentage yields for online banks relative to traditional institutions.

The growing utilization of online banks and financial technology in general, will likely change the efficacy of central bank policy in the future. We show that increased interest rate passthrough for online banks. But the effect of interest rate hikes on online bank lending is unclear, given larger deposit inflows but at a larger cost with relatively larger deposit rates offered, and is yet to be studied. We further provide evidence that monetary policy passthrough is greater also for loan rates of online banks. But, overall, there remains much important work to be done in exploring how financial technology will shape policy in the future. In particular, old policy rules and forward guidance may have different effects on lending, growth, and employment than policymakers' expectations. Additionally, the transmission of monetary policy into deposit rates may in theory have ambiguous effects on the real economy. The theoretical channels affecting monetary policy transmission may also change in the future, if financial technology leads to less bank market power.

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Table 1: Online Banks

Institution Name	Type	Branches	2001 Total Deposits	2018 Total Deposits	2023 Total Deposits	Est. Date	Acquisition Date
Alliant Credit Union	Credit Union	2	2.75	8.93	13.98	January 01, 1935	
Ally Bank	Internet Bank	1		98.64	158.49	August 02, 2004	
American Express National Bank	Internet Bank	1	2.25	22.95	130.16	March 20, 1989	
Axos Bank	Internet Bank	1	0.13	8.01	16.86	July 04, 2000	
Bank5 Connect	Internet Bank	13	0.31	0.77	1.31	January 02, 1981	
CIBC Bank USA	Bank	25	0.68	17.82	39.98	February 06, 1991	
CIT Bank	Internet Bank	92		32.21		March 19, 2009	January 04, 2022
Capital One, National Association	Bank	446	12.11	235.56	371.64	January 01, 1934	
Discover Bank	Bank	2	14.17	62.94	98.49	January 01, 1934	
E*Trade Bank	Internet Bank	1	7.79	43.45		January 01, 1933	January 01, 2022
Farm Bureau Bank, FSB	Internet Bank	2	0.16	0.66	0.99	March 15, 1980	
First Internet Bank of Indiana	Internet Bank	1	0.20	2.20	3.64	December 28, 1998	
LendingClub Bank, National Association	Internet Bank	1	0.21	0.97	7.24	August 26, 1987	
NBKC Bank	Bank	4	0.05	0.41	0.86	March 30, 1999	
Quontic Bank	Savings and Loans	3		0.30	0.47	March 14, 2005	
Synchrony Bank	Internet Bank	3	0.02	57.96	77.64	August 01, 1988	
TIAA, FSB	Internet Bank	12	0.22	23.11	25.22	October 01, 1998	

Notes: This table displays information on the 17 online banks we identify in our study. Deposits are reported in billions and are sourced from FFIEC Call Reports. Deposits for banks previously regulated by OTS come from FDIC Summary of Deposits. Online banks are identified using NerdWallet, RateWatch institution type and Abrams 2019. All banks take deposits. Alliant Credit Union and Ally Bank are used for mortgage analysis (that also includes Quicken Loans, which is not presented in the table as it is not a deposit taking regulated bank). Alliant Credit Union and Farm Bureau Bank are used for auto loan analysis.
Source: RateWatch & FFIEC

Table 2: Summary Statistics

	Mean	SD	Max	Min	Median	Obs
Bank Type: Brick and Mortar						
6 Month CD	0.19	0.11	0.83	0.01	0.15	3851
12 Month Fixed IRA, 10K	0.30	0.17	1.91	0.01	0.25	3002
24 Month CD	0.39	0.18	1.26	0.01	0.35	3812
10K MM	0.11	0.09	0.80	0.01	0.10	3681
2.5K Savings	0.09	0.08	0.75	0.00	0.07	3920
Total Deposits	4.10	52.83	1986.41	0.00	0.30	4005
Total Assets	5.43	76.43	3207.52	0.01	0.35	4005
Bank Type: Online						
6 Month CD	0.28	0.15	0.60	0.10	0.25	13
12 Month Fixed IRA, 10K	0.39	0.18	0.65	0.15	0.50	11
24 Month CD	0.46	0.17	0.70	0.20	0.50	16
10K MM	0.33	0.17	0.60	0.03	0.35	11
2.5K Savings	0.37	0.18	0.61	0.03	0.40	15
Total Deposits	52.60	77.20	306.69	0.51	27.48	17
Total Assets	66.39	94.49	369.91	0.77	39.16	17

Notes: This table displays cross-sectional summary statistics of annual percentage yields by product and bank type in April of 2021. Total assets and deposits are reported in billions. Source: RateWatch & FFIEC

Table 3: Main Results

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Panel A: Post Interaction					
Online × Post March 2022	0.905***	0.663***	0.566**	1.058***	0.652**
	(0.203)	(0.214)	(0.223)	(0.247)	(0.307)
Panel B: FFR Interaction					
Online × FFR	0.348***	0.255***	0.219**	0.333***	0.219**
	(0.079)	(0.083)	(0.086)	(0.080)	(0.109)
Observations	98397	92456	96747	95723	75428
Bank FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. Panel B replaces $1[PostMarch2022]_t$ with the actual federal funds rate at time t.
$^{*}p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$

Table 4: Deposits

	(1) Total Deposits	(2) Interest Deposits	(3) Non-Interest Deposits
Panel A: Post Interaction - Level			
Online × Post March 2022	5.978**	6.034**	-0.055
	(2.374)	(2.434)	(0.131)
Panel B: FFR Interaction - Level			
Online × FFR	2.235**	2.297**	-0.062
	(0.886)	(0.931)	(0.067)
Observations	34728	34728	34728
Bank FE	✓	✓	✓
Quarter FE	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $Deposits_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \varepsilon_{it}$ where $1[Online]_i$ is an indicator for if institution i is classified as an online bank and $1[PostMarch2022]_t$ is an indicator for if the month is March 2022 or later. Deposits are reported in billions. Standard errors are in parentheses and are clustered at the institution level. Panel B replaces $1[PostMarch2022]_t$ with the actual federal funds rate at time t. $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$

Table 5: Passthrough and Competition

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Panel A: Low Competition Branches					
Online × Post March 2022	1.077***	0.706***	0.795***	1.327***	0.620**
	(0.164)	(0.213)	(0.178)	(0.205)	(0.303)
Observations	60795	56418	59781	59464	47439
Panel B: High Competition Branches					
Online × Post March 2022	1.100***	0.722***	0.885***	1.439***	0.683**
	(0.164)	(0.213)	(0.178)	(0.205)	(0.303)
Observations	60532	55979	59403	58814	47137
Panel D: Low Competition Branches (In Advertised Zip Code)					
Online × Post March 2022	1.088***	0.717***	0.811***	1.350***	0.621**
	(0.164)	(0.213)	(0.178)	(0.205)	(0.303)
Observations	44330	40957	43668	43195	34840
Panel E: High Competition Branches (In Advertised Zip Code)					
Online × Post March 2022	1.099***	0.720***	0.877***	1.427***	0.677**
	(0.164)	(0.213)	(0.178)	(0.205)	(0.303)
Observations	49896	46291	48944	48875	39338
Branch FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. The top two panels split branches by median county HHI and the bottom two panels restrict these splits to the zip codes where online banks advertise. Standard errors are in parentheses and are clustered at the institution level. $^{*}p < .1$, ** $p < .05$, *** $p < .01$

Table 6: Demographics and Rates

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Online × Post March 2022	1.074***	0.714***	0.771***	1.299***	0.647*
	(0.197)	(0.213)	(0.258)	(0.300)	(0.357)
Observations	121378	112599	119332	118384	94476
× Has Computer	✓	✓	✓	✓	✓
× Internet Access	✓	✓	✓	✓	✓
× Age 65+	✓	✓	✓	✓	✓
× College Degree	✓	✓	✓	✓	✓
× Minority	✓	✓	✓	✓	✓
× Low Income	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \sum_j \delta_j Demographic_{ji} \times 1[PostMarch2022] + \epsilon_{it}$ for the six products listed in each column where j indexes population averages of having a computer at home, access to Internet, being older than 65, having a college degree, minority status, and having low income status (with below \$30,000 household income) within the ZIP code for which branch i resides. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. Demographic averages for online banks are calculated using averages from the SCF. $^* p < .1$, $^{**} p < .05$, $^{***} p < .01$

Table 7: Zip Codes with Demographics Similar to Online Banks

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Pseudo-Online × Post March 2022	-0.001	0.014	-0.012	0.050	0.000
	(0.017)	(0.030)	(0.055)	(0.071)	(0.082)
Observations	120878	112324	118882	117859	94151
Branch FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[PlaceboOnline]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. The 'placebo online' indicator is assigned to branches that reside in ZIP codes that are most similar to the users of online banking. Selection of similar banks is done using nearest neighbor matching (with the smallest Euclidean distance) on ZIP code averages of having a computer in the home, access to internet, being older than 65, having a college degree, minority status, and being low income status (below $30,000 household income). APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 8: Robustness Checks

	(1)	(2)	(3)	(4)	(5)
	Savings, 2.5K	Money Market, 10K	6-Month CD, 10K	24-Month CD, 10K	12-Month Fixed IRA, 10K
Panel A: Large Banks Only					
Online × Post March 2022	0.904***	0.729***	0.646***	1.180***	0.861**
	(0.209)	(0.219)	(0.242)	(0.274)	(0.328)
Observations	1750	1595	1675	1775	1425
Panel B: Deposit Weighted					
Online × Post March 2022	0.906***	0.626***	0.538**	1.017***	0.615**
	(0.203)	(0.216)	(0.218)	(0.248)	(0.297)
Observations	97620	91729	95972	94868	74853
Panel C: Specialized Online Lender					
Online × Post March 2022	1.004***	0.840**	0.986***	1.500***	1.041***
	(0.265)	(0.358)	(0.210)	(0.231)	(0.357)
Observations	98222	92306	96572	95523	75303
Panel D: General Online Lender					
Online × Post March 2022	0.859***	0.515**	0.206	0.757**	0.469
	(0.275)	(0.238)	(0.315)	(0.359)	(0.448)
Observations	98222	92331	96597	95548	75303
Bank FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. Panel A restricts brick-and-mortar banks to those with total assets worth at least 40 billion (58 total banks). Panel B weights average bank rates by the total deposits under each rate setting branch. Panels C and D split the online bank sample by specialized lenders and general lenders. An online bank is considered a specialized lender if more than 90% of their consumer loans are concentrated in one loan product. The loan products considered are credit cards, auto loans, and mortgages. *$p < .1$, ** $p < .05$, *** $p < .01$

Table 9: Extended Online Sample Results

	(1) Savings, 2.5K	(2) 6-Month CD, 10K	(3) 24-Month CD, 10K
Panel A: Post Interaction			
Online × Post March 2022	1.038***	0.889***	1.024***
	(0.167)	(0.247)	(0.227)
Panel B: FFR Interaction			
Online × FFR	0.386***	0.319***	0.315***
	(0.061)	(0.088)	(0.073)
Observations	98672	96872	95873
Bank FE	✓	✓	✓
Month FE	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. Panel B replaces $1[PostMarch2022]_t$ with the actual federal funds rate at time t.

* $p < .1$, ** $p < .05$, *** $p < .01$

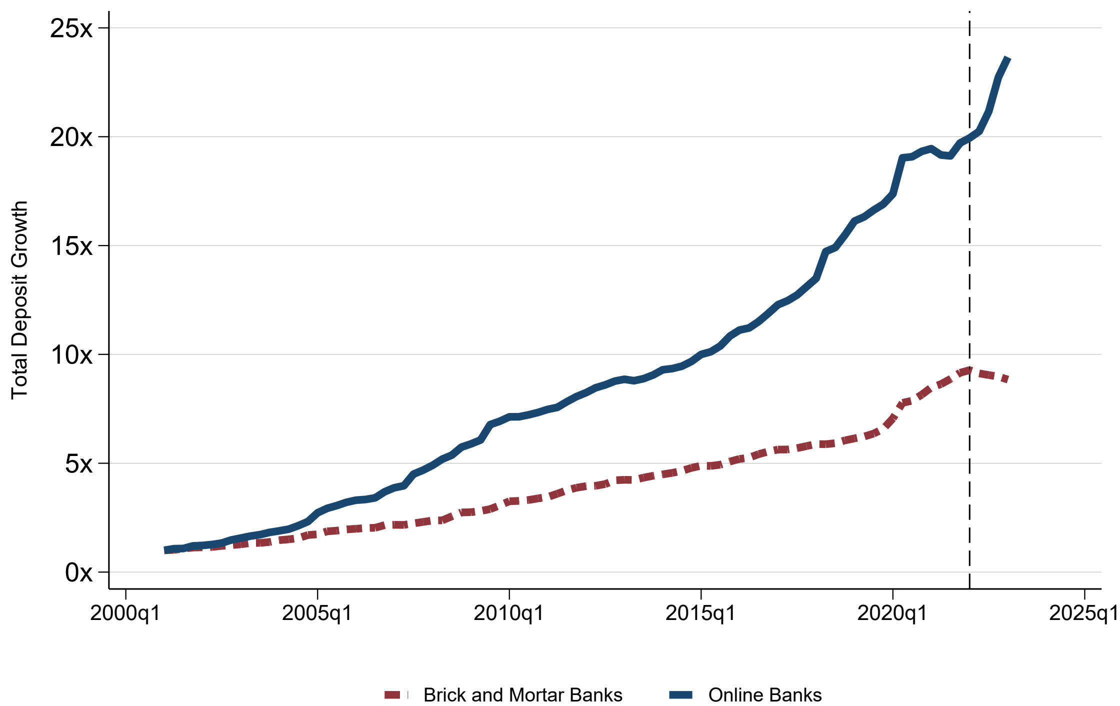
Table 10: Loans

	(1) 5-Year Auto Loan, New	(2) 5-Year Auto Loan, 2-Year Used	(3) 15-Year Mortgage	(4) 30-Year Mortgage
Panel A: Post Interaction				
Online × Post March 2022	0.427**	0.440**	0.708	0.571
	(0.202)	(0.176)	(0.594)	(0.567)
Panel B: FFR Interaction				
Online × FFR	0.224***	0.217***	0.176	0.149
	(0.063)	(0.062)	(0.189)	(0.183)
Observations	46637	42572	22673	19759
Bank FE	✓	✓	✓	✓
Month FE	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APR_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APR_{it} is the annual percentage rate offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. Panel B replaces $1[PostMarch2022]_t$ with the actual federal funds rate at time t.

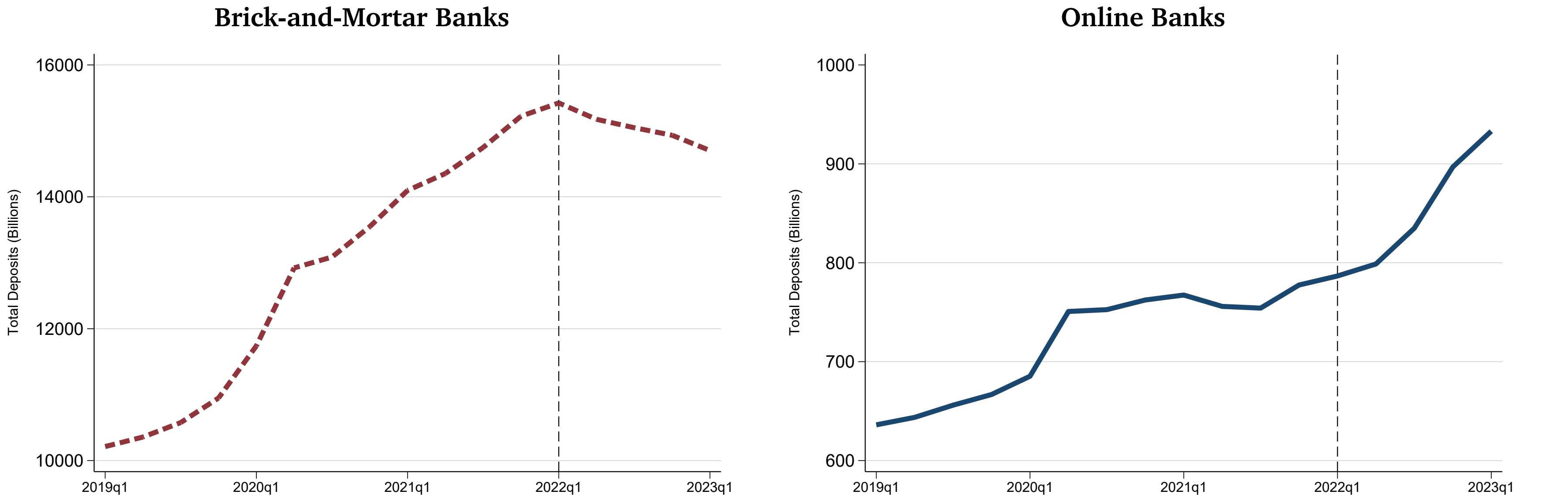
$^{*}p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$

Figure 1: Total Deposit Growth



Notes: This figure shows total deposit growth since March 2001 by bank type. The dashed vertical line indicates when the federal reserve began increasing rates in March of 2022. The online banks that are included are listed in Table 1. CIT Bank and E*Trade were both acquired in 2022 and have been excluded. In 2007 Capital One acquired North Fork bank and in 2012 they acquired ING bank nearly doubling their total deposits each time. For this graph North Fork bank and ING bank deposits prior to their acquisitions have been included in Capital One's deposits. Deposits for banks regulated by Office of Thrift Supervision (OTS) prior to 2011 have been linearly interpolated from annual Summary of Deposits data. Source: FFIEC & FDIC

Figure 2: Total Deposit Levels

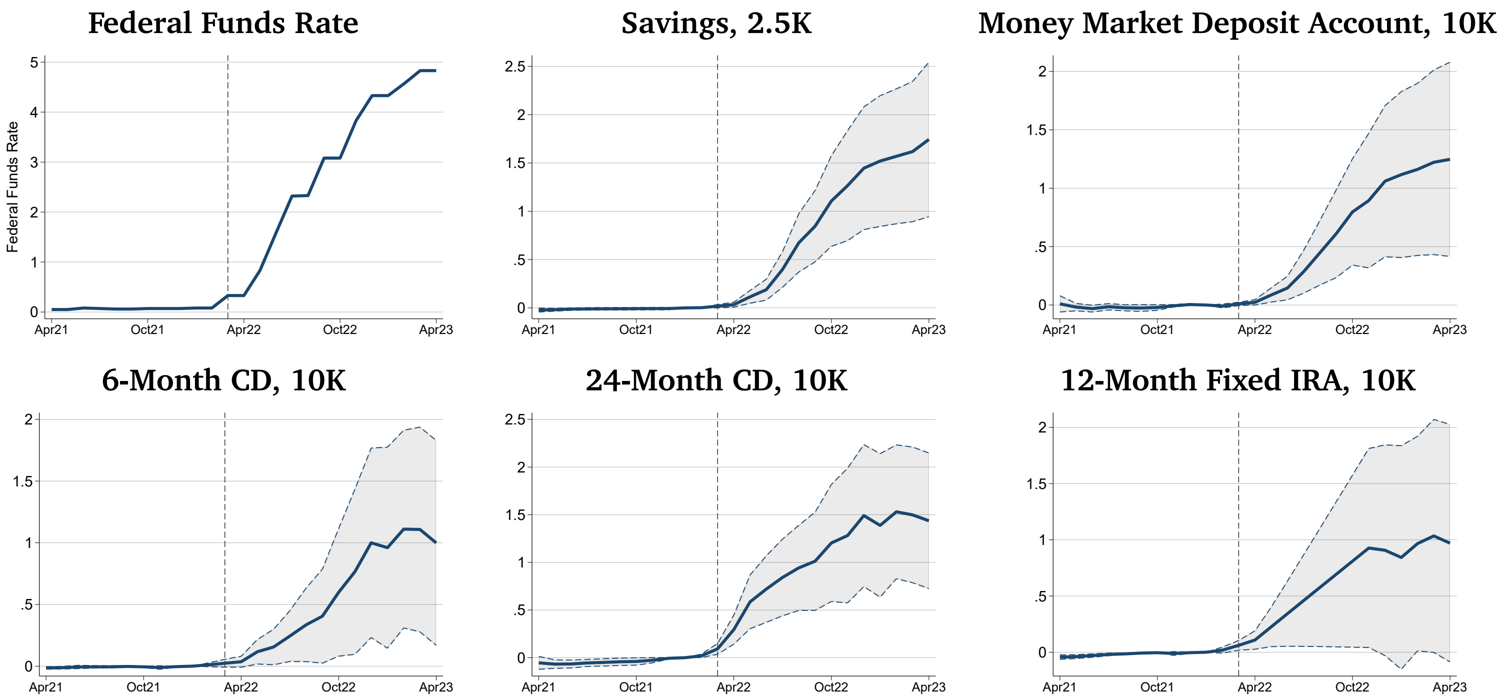


Notes: This figure shows total deposits by bank type. The dashed vertical line indicates when the federal reserve began increasing rates in March of 2022. The online banks that are included are listed in Table 1. CIT Bank and E*Trade were both acquired in 2022 and have been excluded. Source: FFIEC

Figure 3: Levels for Rates (Raw Means)

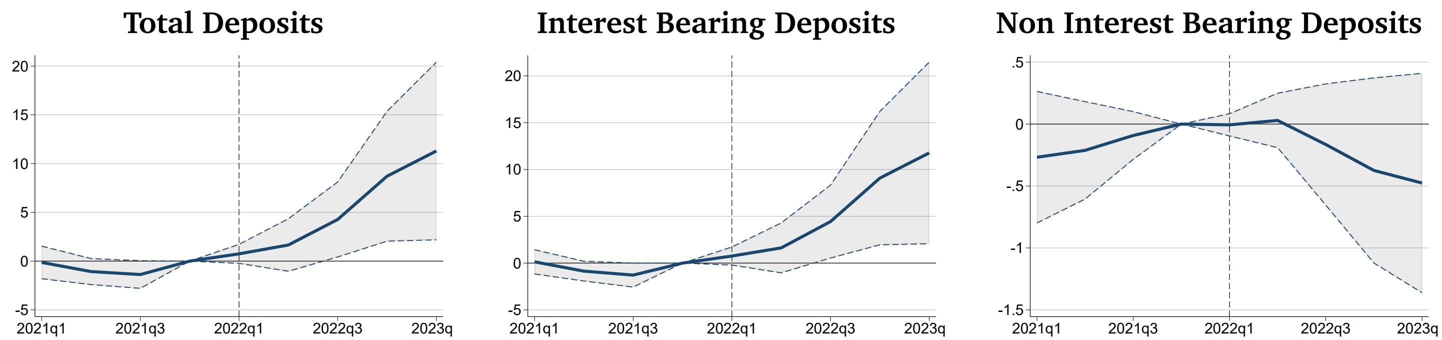
Notes: This figure plots the average annual percentage yield for each product broken down by online banks and brick-and-mortar banks. The solid blue lines show the average APY for online banks and the dashed red lines show average APY for brick-and-mortar banks. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch & FRED

Figure 4: Event Studies using Rates



Notes: This figure plots β_t from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it}$ along with a 95% confidence interval. APY_{it} is the annual percentage yield offered by institution i at time t. $Online_i$ is an indicator for if institution i is an online bank. α_i and α_t are institution and time fixed effects. Standard errors are clustered at the institution level. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch

Figure 5: Event Studies using Total Deposits



Notes: This figure plots β_t from the OLS regression $Deposits_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it}$ along with a 95% confidence interval. $Deposits_{it}$ is the total deposits held by institution i at time t in billions. $Online_i$ is an indicator for if institution i is an online bank. α_i and α_t are institution and time fixed effects. Standard errors are clustered at the institution level. The dashed vertical line indicates when the federal reserve began increasing interest rates in March of 2022. Source: FFIEC

Appendix

A Additional Tables and Figures

Table A.1: Drop One Robustness Check

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Alliant Credit Union					
Online × Post March 2022	0.875***	0.663***	0.566**	1.003***	0.528*
	(0.215)	(0.214)	(0.223)	(0.257)	(0.311)
Observations	98372	92456	96747	95698	75403
Ally Bank					
Online × Post March 2022	0.863***	0.584***	0.513**	1.047***	0.547*
	(0.213)	(0.221)	(0.235)	(0.263)	(0.319)
Observations	98372	92431	96722	95698	75403
American Express National Bank					
Online × Post March 2022	0.858***	0.663***	0.566**	1.005***	0.652**
	(0.212)	(0.214)	(0.223)	(0.257)	(0.307)
Observations	98372	92456	96747	95698	75428
Axos Bank					
Online × Post March 2022	0.975***	0.749***	0.651***	1.171***	0.777**
	(0.205)	(0.217)	(0.225)	(0.235)	(0.311)
Observations	98372	92431	96722	95698	75403
Bank5 Connect					
Online × Post March 2022	0.975***	0.663***	0.651***	1.171***	0.652**
	(0.205)	(0.214)	(0.225)	(0.235)	(0.307)
Observations	98372	92456	96722	95698	75428
CIBC Bank USA					
Online × Post March 2022	0.972***	0.741***	0.567**	1.076***	0.601*
	(0.206)	(0.220)	(0.242)	(0.262)	(0.333)
Observations	98372	92431	96722	95698	75403
CIT Bank					
Online × Post March 2022	0.975***	0.745***	0.651***	1.171***	0.652**
	(0.205)	(0.219)	(0.225)	(0.235)	(0.307)
Observations	98372	92431	96722	95698	75428
Capital One, National Association					
Online × Post March 2022	0.859***	0.663***	0.503**	0.993***	0.758**
	(0.212)	(0.214)	(0.233)	(0.254)	(0.319)
Observations	98372	92456	96722	95698	75403
Discover Bank					
Online × Post March 2022	0.855***	0.578***	0.531**	1.005***	0.541*
	(0.211)	(0.218)	(0.239)	(0.257)	(0.317)
Observations	98372	92431	96722	95698	75403
E*Trade Bank					
Online × Post March 2022	0.975***	0.663***	0.566**	1.058***	0.652**
	(0.205)	(0.214)	(0.223)	(0.247)	(0.307)
Observations	98372	92456	96747	95723	75428

Table A.2: Drop One Robustness Check (Continued)

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Farm Bureau Bank, FSB					
Online × Post March 2022	0.905***	0.745***	0.602**	1.116***	0.702**
	(0.203)	(0.219)	(0.239)	(0.256)	(0.333)
Observations	98397	92431	96722	95698	75403
First Internet Bank of Indiana					
Online × Post March 2022	0.950***	0.577***	0.471**	0.999***	0.652**
	(0.213)	(0.217)	(0.221)	(0.256)	(0.307)
Observations	98372	92431	96722	95698	75428
LendingClub Bank, National Association					
Online × Post March 2022	0.836***	0.663***	0.566**	0.989***	0.652**
	(0.205)	(0.214)	(0.223)	(0.253)	(0.307)
Observations	98372	92456	96747	95698	75428
NBKC Bank					
Online × Post March 2022	0.905***	0.661***	0.651***	1.073***	0.761**
	(0.203)	(0.235)	(0.225)	(0.262)	(0.317)
Observations	98397	92431	96722	95698	75403
Quontic Bank					
Online × Post March 2022	0.849***	0.584***	0.519**	1.019***	0.777**
	(0.210)	(0.220)	(0.237)	(0.260)	(0.311)
Observations	98372	92431	96722	95698	75403
Synchrony Bank					
Online × Post March 2022	0.844***	0.638***	0.471**	1.003***	0.528*
	(0.208)	(0.234)	(0.220)	(0.257)	(0.311)
Observations	98372	92431	96722	95698	75403
TIAA, FSB					
Online × Post March 2022	0.916***	0.688***	0.581**	1.086***	0.649*
	(0.217)	(0.234)	(0.241)	(0.261)	(0.337)
Observations	98372	92431	96722	95698	75403
Bank FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[FFR]_t + \epsilon_{it}$ for the six products listed in each column. In each row one online bank is excluded from the regression as indicated in the top left corner. Standard errors are in parentheses and are clustered at the institution level.*$p < .1$, ** $p < .05$, *** $p < .01$

Table A.3: Additional Robustness Checks

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Panel A: Young Banks Only					
Online × Post March 2022	0.870***	0.620***	0.486**	0.944***	0.521*
	(0.204)	(0.215)	(0.225)	(0.249)	(0.309)
Observations	12387	12285	12201	12334	10626
Panel B: High Rate Banks Only					
Online × Post March 2022	0.884***	0.604***	0.360	0.841***	0.422
	(0.203)	(0.214)	(0.224)	(0.247)	(0.308)
Observations	41536	24082	24320	24166	20045
Panel C: Low Consumer Loans to Assets					
Online × Post March 2022	1.205***	0.657***	0.504*	1.080***	0.878**
	(0.228)	(0.243)	(0.291)	(0.284)	(0.354)
Observations	98197	92356	96597	95548	75353
Panel D: High Consumer Loans to Assets					
Online × Post March 2022	0.718***	0.673*	0.638*	1.137***	0.509
	(0.271)	(0.407)	(0.342)	(0.388)	(0.525)
Observations	98247	92281	96572	95523	75253
Bank FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. Panel A restricts brick-and-mortar banks to those established after 2000 (665 banks). Panel B uses only brick-and-mortar banks offering rates greater than the 75th percentile prior to March 2022. Panels C and D split the online bank sample by the median share of consumer loans to total assets.* $p < .1$, ** $p < .05$, *** $p < .01$

Table A.4: Loans (Deposit Lenders Only)

	(1) 5-Year Auto Loan, New	(2) 5-Year Auto Loan, 2-Year Used	(3) 15-Year Mortgage	(4) 30-Year Mortgage
Panel A: Post Interaction				
Online × Post March 2022	0.427**	0.440**	1.433***	1.258***
	(0.202)	(0.176)	(0.051)	(0.104)
Panel B: FFR Interaction				
Online × FFR	0.224***	0.217***	0.407***	0.367***
	(0.063)	(0.062)	(0.018)	(0.055)
Observations	46637	42572	22648	19734
Bank FE	✓	✓	✓	✓
Month FE	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APR_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APR_{it} is the annual percentage rate offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. Panel B replaces $1[PostMarch2022]_t$ with the actual federal funds rate at time t.

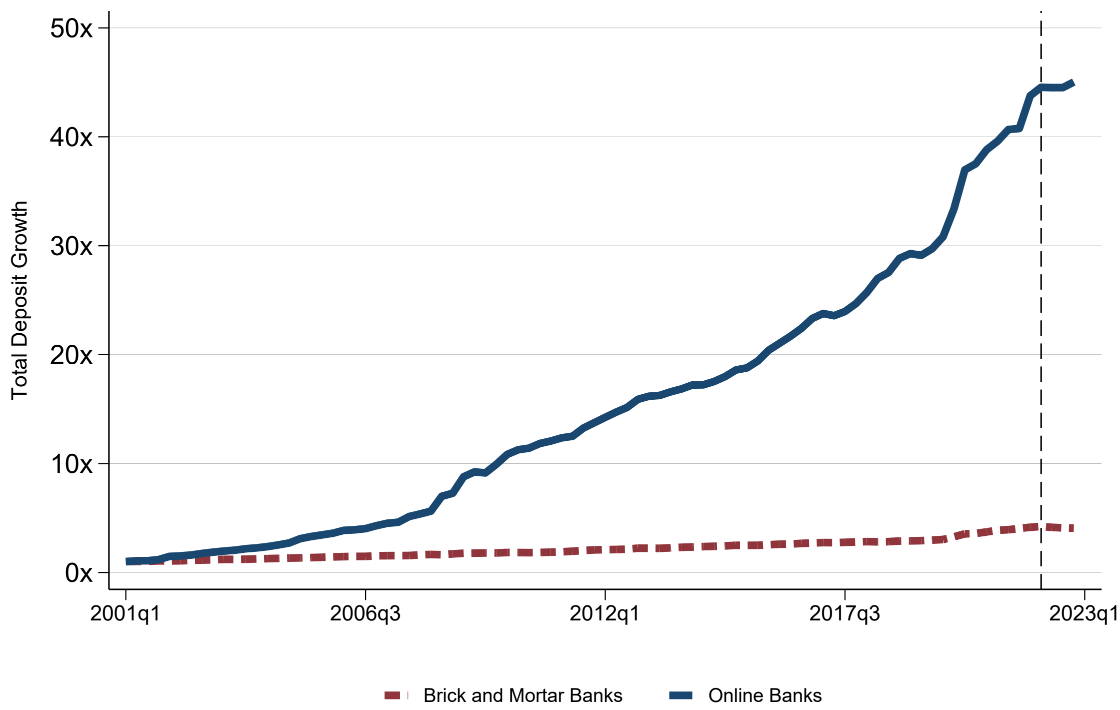
$^{*}p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$

Table A.5: Banks Matched on Rates and Other Characteristics

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Panel A: Post Interaction					
Online × Post March 2022	0.840***	0.625***	0.415	1.009***	0.537
	(0.215)	(0.223)	(0.253)	(0.277)	(0.345)
Panel B: FFR Interaction					
Online × FFR	0.321***	0.244***	0.167*	0.333***	0.187
	(0.084)	(0.087)	(0.097)	(0.091)	(0.123)
Observations	1372	1070	1295	1475	1023
Bank FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

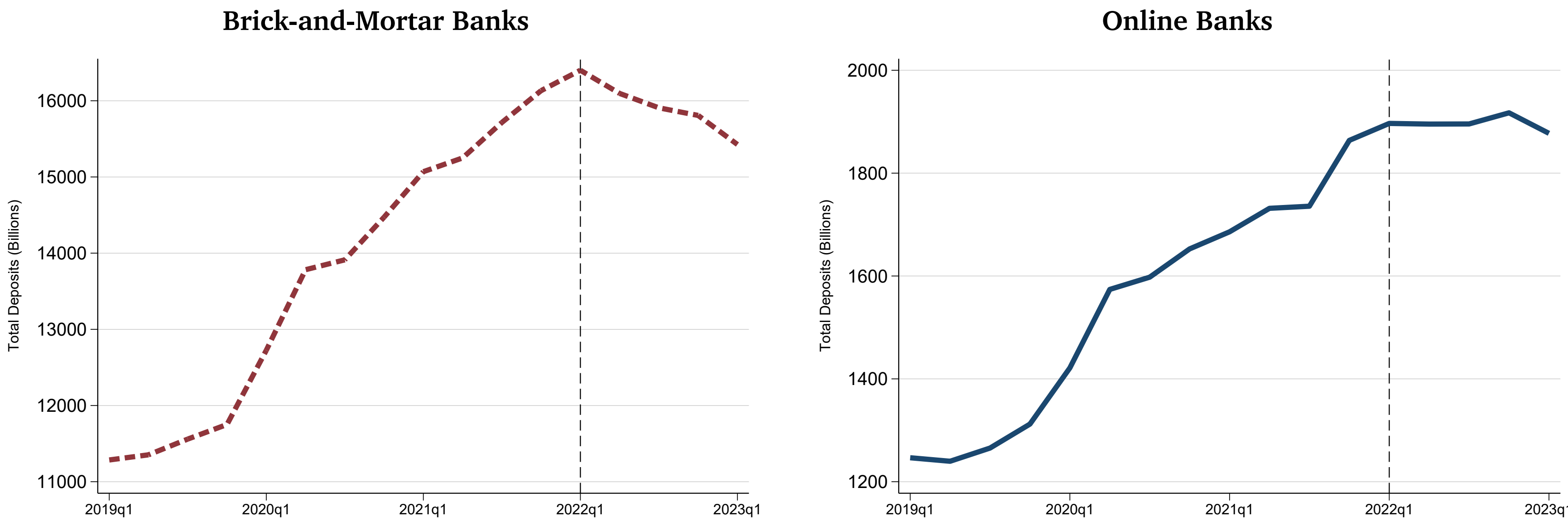
Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. The sample is restricted to brick-and-mortar banks that matched to online banks using nearest neighbor matching (with the smallest Euclidean distance). The variables used for matching are bank establishment year, total deposits, share of total assets that are consumer loans, and rates offered in April of 2020. $^{*}p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$

Figure A.1: Total Deposit Growth (Out of Sample Banks)



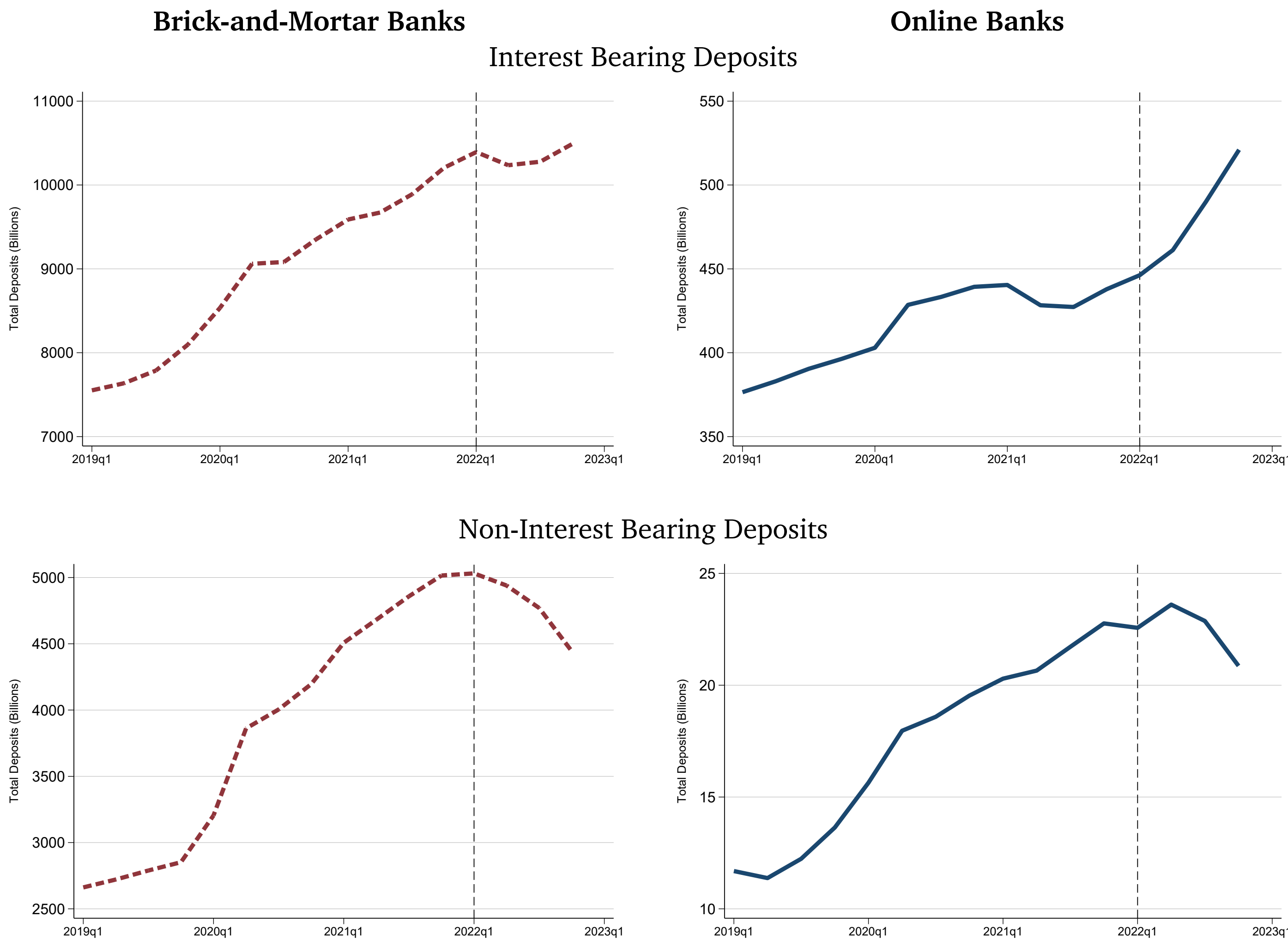
Notes: This figure shows total deposit growth since March 2001 by bank type using all available banks in the FFIEC Call Reports (not just those with RateWatch coverage). The dashed vertical line indicates when the Federal Reserve began increasing rates in March of 2022. The online banks that are included are listed in Table 1. CIT Bank and E*Trade were both acquired in 2022 and have been excluded. Deposits for banks regulated by OTS prior to 2011 have been linearly interpolated from annual Summary of Deposits data. Source: FFIEC & FDIC

Figure A.2: Total Deposit Levels (Out of Sample Banks)



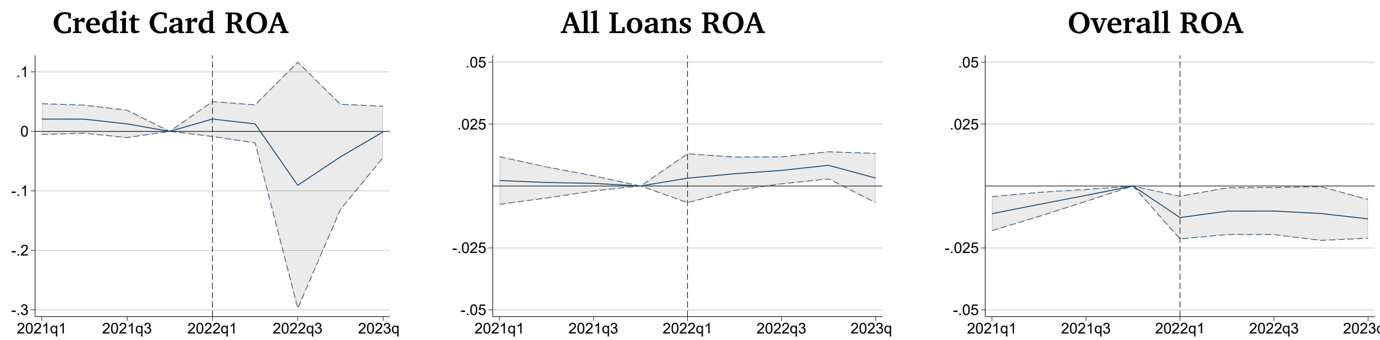
Notes: This figure shows total deposits since March 2019 by bank type using all available banks in the FFIEC Call Reports (not just those with RateWatch coverage). The dashed vertical line indicates when the Federal Reserve began increasing rates in March of 2022. CIT Bank and E*Trade were both acquired in 2022 and have been excluded. Source: FFIEC & FDIC

Figure A.3: Deposit Type Breakdown



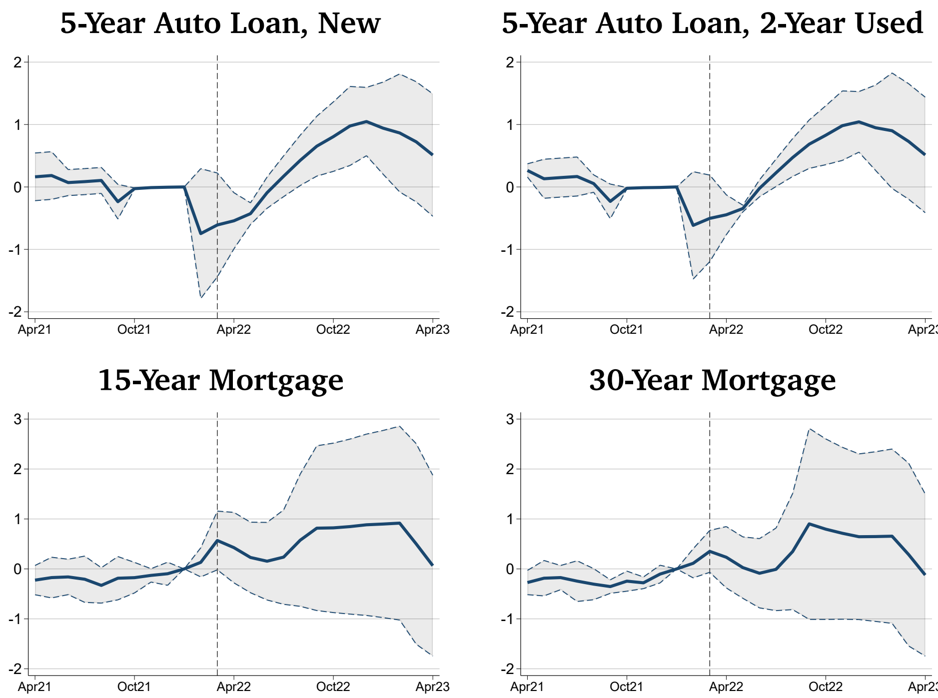
Notes: This figure shows total deposits since March 2019 by bank type and deposit type. The dashed vertical line indicates when the Federal Reserve began increasing rates in March of 2022. The online banks that are included are listed in table 1. CIT Bank and E*Trade were both acquired in 2022 and have been excluded. Source: FFIEC

Figure A.4: ROA Event Studies



Notes: This figure plots β_t from the OLS regression $ROA_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it}$ along with a 95% confidence interval. ROA_{it} is the return on assets for institution i at time t. $Online_i$ is an indicator for if institution i is an online bank. α_i and α_t are institution and time fixed effects. Standard errors are clustered at the institution level. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: FDIC

Figure A.5: Loan Event Studies

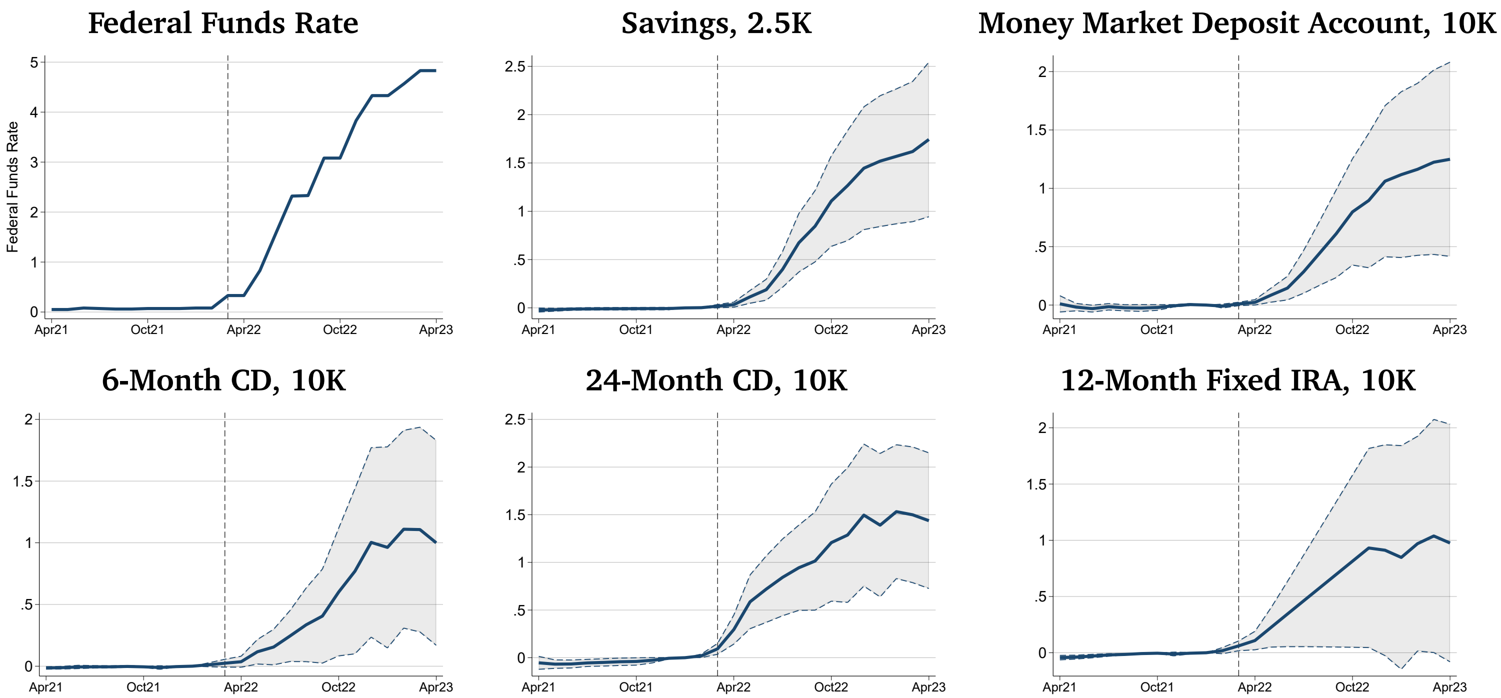


Notes: This figure plots β_t from the OLS regression $APR_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it}$ along with a 95% confidence interval. APR_{it} is the annual percentage rate offered by institution i at time t. $Online_i$ is an indicator for if institution i is an online bank. α_i and α_t are institution and time fixed effects. Standard errors are clustered at the institution level. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch

Figure A.6: Levels Raw Means - No Asset Threshold

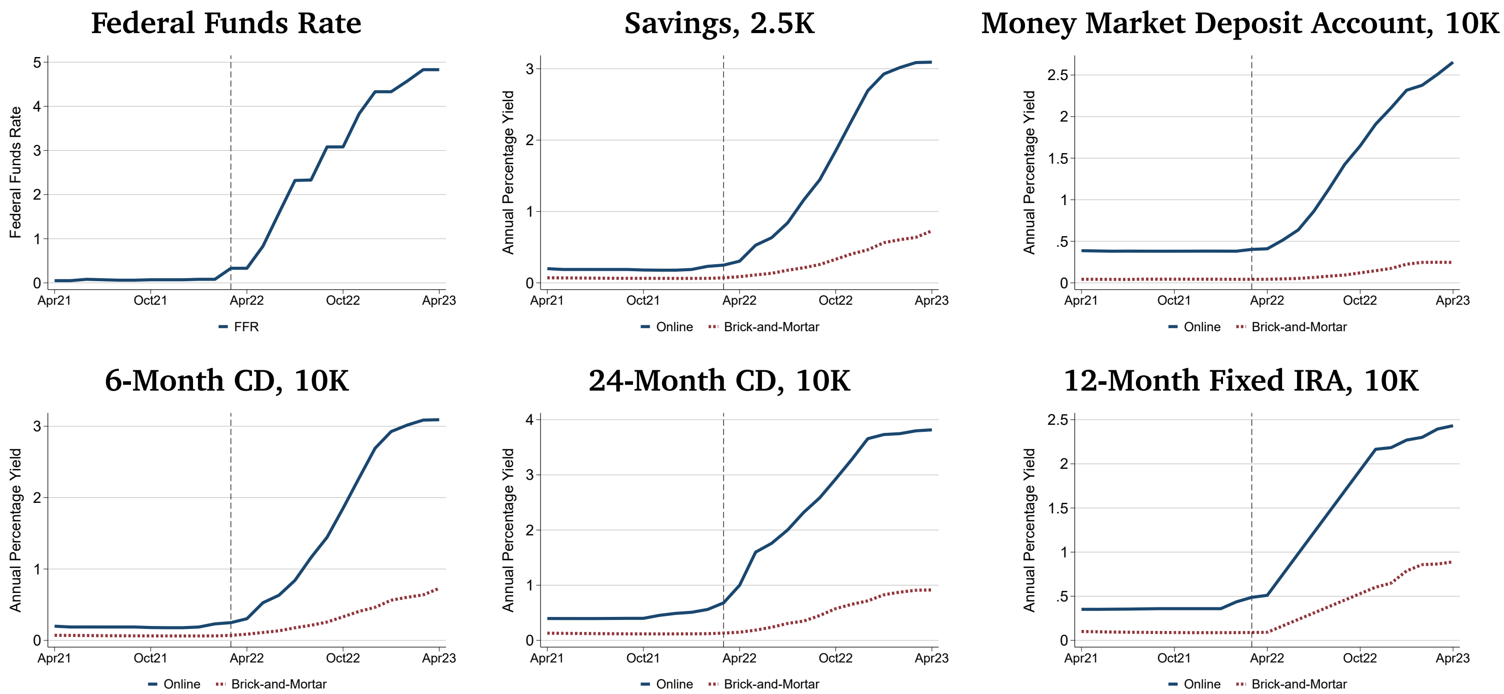
Notes: This figure plots the average annual percentage yield for each product broken down by online banks and brick-and-mortar banks. The solid blue lines show the average APY for online banks and the dashed red lines show average APY for brick-and-mortar banks. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch & FRED

Figure A.7: Event Studies - No Asset Threshold



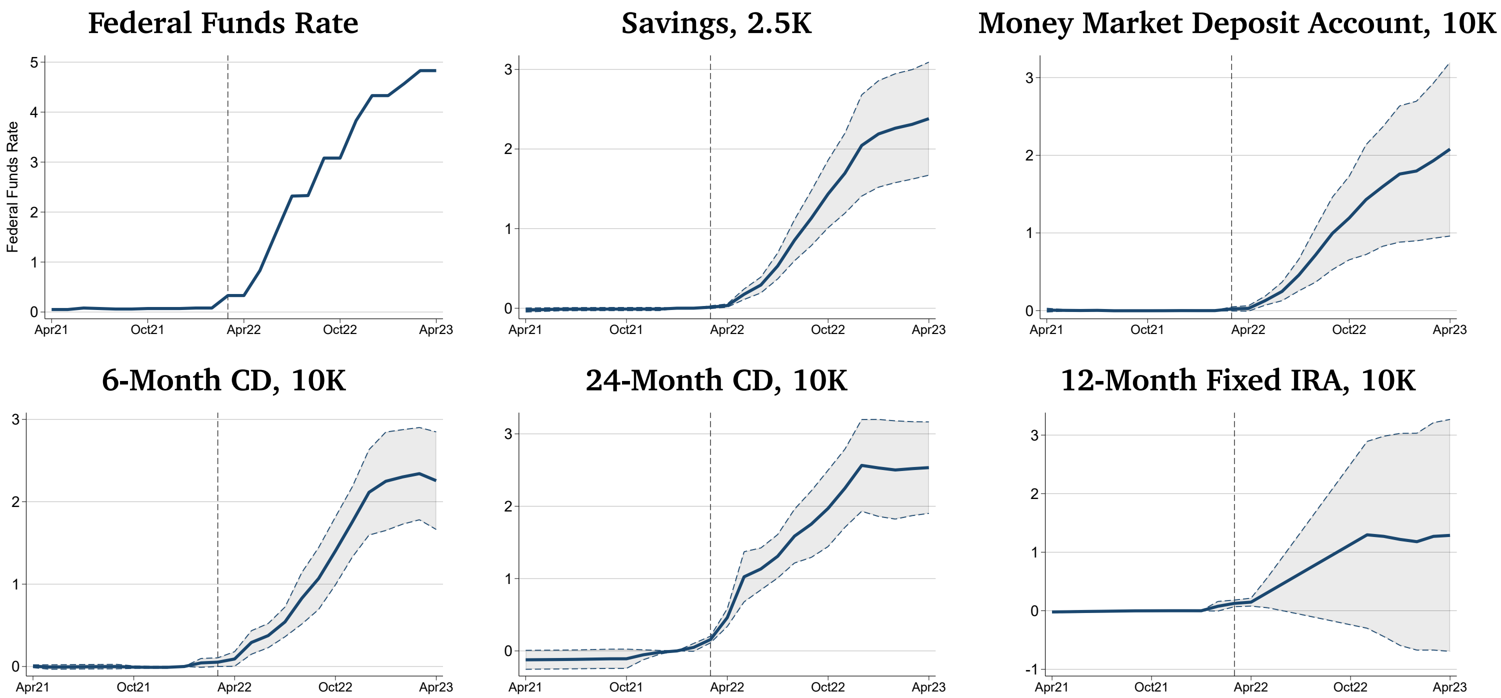
Notes: This figure plots β_t from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it}$ along with a 95% confidence interval. APY_{it} is the annual percentage yield offered by institution i at time t. $Online_i$ is an indicator for if institution i is an online bank. α_i and α_t are institution and time fixed effects. Standard errors are clustered at the institution level. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch

Figure A.8: Levels Raw Means - Total Deposits Weighted



Notes: This figure plots the average annual percentage yield for each product broken down by online banks and brick-and-mortar banks, weighted using each bank's total deposits. The solid blue lines show the average APY for online banks and the dashed red lines show average APY for brick-and-mortar banks. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch & FRED

Figure A.9: Event Studies - Total Deposits Weighted

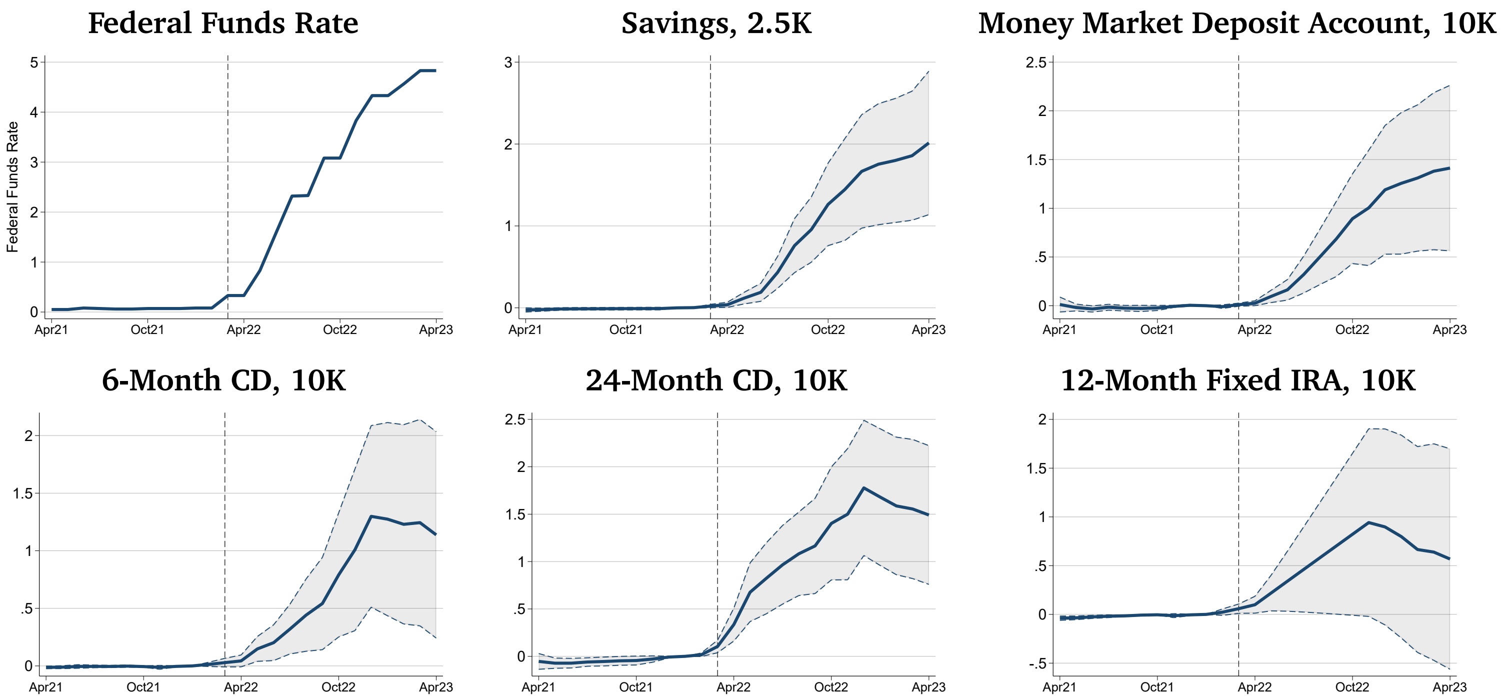


Notes: This figure plots β_t from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it}$, weighted using the each bank's total deposits, along with a 95% confidence interval. APY_{it} is the annual percentage yield offered by institution i at time t. $Online_i$ is an indicator for if institution i is an online bank. α_i and α_t are institution and time fixed effects. Standard errors are clustered at the institution level. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch

Figure A.10: Levels for Rates (Raw Means) using Online Banks from Abrams (2019) Sample

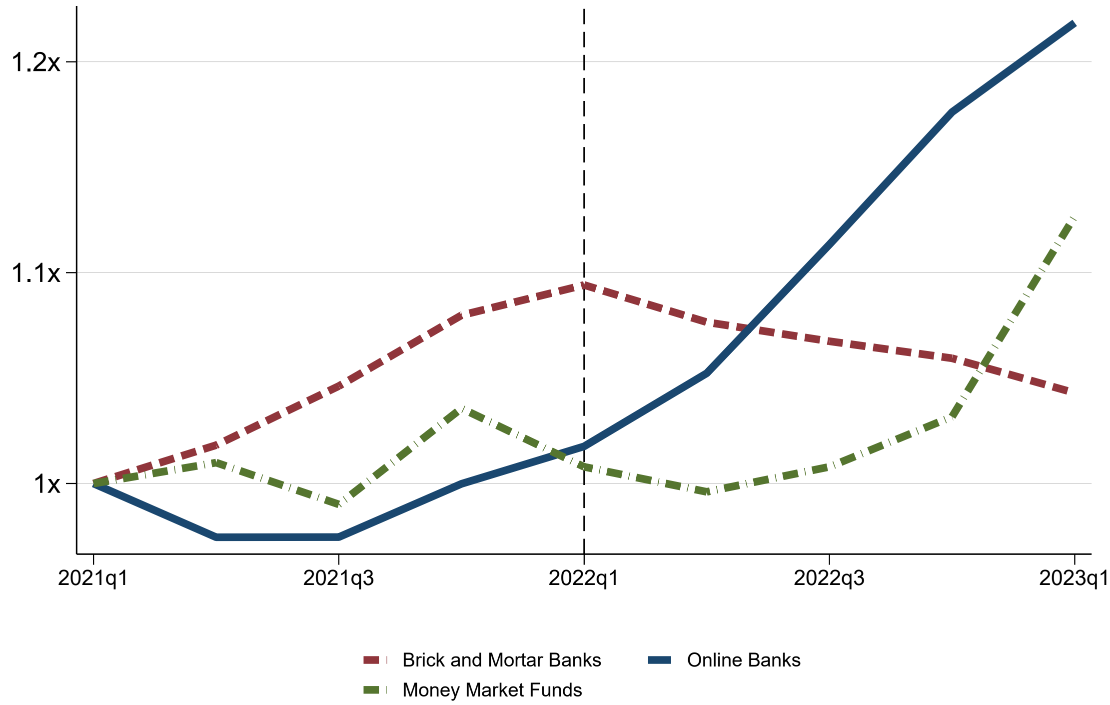
Notes: This figure plots the average annual percentage yield for each product broken down by online banks and brick-and-mortar banks. The solid blue lines show the average APY for online banks and the dashed red lines show average APY for brick-and-mortar banks. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch & FRED

Figure A.11: Event Studies for Rates using Online Banks from Abrams (2019) Sample



Notes: This figure plots β_t from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it}$ along with a 95% confidence interval. APY_{it} is the annual percentage yield offered by institution i at time t. $Online_i$ is an indicator for if institution i is an online bank. α_i and α_t are institution and time fixed effects. Standard errors are clustered at the institution level. The dashed vertical line indicates when the Federal Reserve began increasing interest rates in March of 2022. Source: RateWatch

Figure A.12: Money Market Fund Growth



Notes: This figure plots brick-and-mortar bank deposits, online bank deposits, and money market fund growth indexed at quarter 1 of 2021. Source: FFIEC & financialresearch.gov

B Demographics and Passthrough

To study the role of demographics, we use household-level data from the Survey of Consumer Finances (SCF). Note that the SCF does not ask whether individuals use an online-only bank, but rather whether they use online or mobile banking services, regardless of whether their bank also has physical branches. Nonetheless this question is also informative about the types of households that are likely to use purely online banking.

Using the provided population weights we calculate averages across four key demographics: an older than 65 indicator, having a college degree, being a minority, and being low income status (below $30,000 household income). Table B.1 shows the statistics. The SCF averages suggest that users of online banking services tend to be younger, more educated, and have a higher income. Additionally, minorities use online banking services less than non-minority individuals.

The ideal way to study the effect of these demographics on deposit rates would require data about the demographic composition of each bank. Given such data, we could match brick-and-mortar banks with very similar customers as online banks. If demographically-similar brick-and-mortar banks offer rates that are similar to the rates of online banks, we could conclude that demographics play an important role. But if their deposit rates are more similar to the rates at other brick-and-mortar banks, it would imply that demographics are not very important.

Data about the demographics of different banks' customers is not available. We therefore take a second-best approach and use data on the demographic composition of the ZIP codes where bank branches are located. If demographics are important for interest rates, we might expect that branches in higher-income, younger and more educated areas are more sensitive to the federal funds rate. To study this, we use ZIP code level demographic data from the 2015-2019 ACS. Similar to our SCF estimates, we use data on average household income, minority share, age distribution, and average education levels. We also look at variables measuring computer use and internet availability.

For each product we re-estimate our main results adding in demographics controls using the following specification:

$$\text{APY}_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \sum_j \delta_j Demographic_{ji} \times 1[PostMarch2022] + \epsilon_{it} \quad (5)$$

where j indexes population averages of having a computer in the home, access to internet, being older than 65, having a college degree, minority status, and being low income status (below $30,000 household income) within the ZIP code for which branch i resides. Standard errors are clustered at the bank level.

Results are shown in Table 6. If the demographics of users explains online bank's passthrough we would expect the addition of demographics controls to decrease the magnitude and significance of the coefficient of interest β. We find no such decrease in magnitude or significance with the addition of demographics controls leading us to believe that demographics do not drive online bank passthrough. As an additional test we repeat our main regression using only traditional banks that reside in ZIP codes similar to users of online banks. Results are shown in in Table C.1. Estimates again remain large and significant.

Table B.1: Online Banking Demographics

	Mean	SD	Max	Min	Median	Obs
SCF: Never Used Online Banking						
Age 65+	0.46	0.50	1.00	0.00	0.00	5492
College Degree	0.14	0.35	1.00	0.00	0.00	5492
Minority	0.41	0.49	1.00	0.00	0.00	5492
Low Income	0.52	0.50	1.00	0.00	1.00	5492
SCF: Used Online Banking						
Age 65+	0.19	0.39	1.00	0.00	0.00	23393
College Degree	0.43	0.49	1.00	0.00	0.00	23393
Minority	0.29	0.46	1.00	0.00	0.00	23393
Low Income	0.17	0.37	1.00	0.00	0.00	23393
Online Bank Sample						
Age 65+	0.19	0.01	0.20	0.17	0.19	17
College Degree	0.35	0.08	0.44	0.21	0.37	17
Minority	0.24	0.07	0.32	0.09	0.26	17
Low Income	0.20	0.04	0.30	0.16	0.19	17
Matched Brick-and-Mortar Branches						
Age 65+	0.18	0.02	0.24	0.12	0.18	80
College Degree	0.31	0.08	0.48	0.19	0.30	80
Minority	0.22	0.08	0.35	0.08	0.23	80
Low Income	0.21	0.06	0.33	0.11	0.22	80

Notes: The first two panels of this table presents SCF summary statistics split by those who use online banking and those who do not use online banking. Statistics are calculated using the provided population weights. Low income status is defined as having a household income below $30,000. The third panel presents the summary statistics of the nearest neighbour (with the smallest Euclidean distance) matched brick-and-mortar branches. Source: 2019 SCF & ACS

C Detailed Data Construction

C.1 Main Sample

Using the RateWatch provided institution details, we first identify major online banks. Our primary source of online banks comes from the 15 online banks identified by Abrams (2019). We identify an additional 18 large online banks using the popular consumer finance website nerdwallet.com.[26] Because of low RateWatch coverage only these 17 banks are used during our analysis.[27]

Aside from Alliant Credit Union, we do not include any credit unions in our sample. Additionally, banks not headquartered in the U.S., such as Bank of China, are excluded. For each bank we average their annual percentage yields across rate setting branches at the product and month level.

Next we identify products that allow us to compare rates between online banks and brick-and-mortar banks. The criteria for these products is that they must be consistently reported in RateWatch by at least 10 online banks between April 2021 and April 2023. To enforce consistent coverage, we remove all banks's products that have less than 19 months of coverage during this 25 month period. Missing gaps in banks' reported annual percentage yields are then linearly interpolated.

Lastly we merge Call Report information from the FFIEC onto our main data set. Using the total assets reported in the March 2021 Call Reports, we remove all banks with less than 50 million dollars in total assets. This removes approximately 4% percent of brick-and-mortar banks and no online banks. The deposits and assets of banks regulated by Office of Thrift Supervision (OTS) prior to 2011 have been supplemented with the annual summary of deposits for each respective year. For this subset of banks, quarter to quarter observations have been linearly interpolated.

[26] See https://www.nerdwallet.com/best/banking/best-online-banks.

[27] See Table 1 for a complete list of these 17 banks and their overlap with Abrams (2019).

C.2 Matched Demographics

In Table C.1 we restrict the brick-and-mortar sample to branches that reside in zip codes who's demographics are similar to online banks. This is done through nearest neighbor matching (with the smallest Euclidean distance) on zip code level demographics data. Because online banks do not have physical locations we use the average demographics of the zip codes in which each online bank advertises. To calculate the distance of each brick-and-mortar branch's zip code demographics to the demographics of an online bank we calculate the euclidean distance across demographic averages using the following formula:

$$d_i = \sqrt{\sum_j (q_j - p_{ij})^2} \tag{6}$$

where j indexes across the demographic averages of having a computer in the home, access to internet, being older than 65, having a college degree, minority status, and being low income status (below \$30,000 household income). q_j is the demographic average of online banks users reported by the SCF. p_{ij} is the demographic average of the zip code in which branch i resides. Once distances have been calculated, we consider the eight nearest branches to each online bank 'similar' branches [28]. The summary statistics of these 'similar' branch's demographics are reported in Table B.1.

[28] There are 80 unique 'similar' branches due to overlap between matched branches across different online banks.

Table C.1: Matched ZIP Codes Similar to Online Users

	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Online × Post March 2022	1.090***	0.701***	0.857***	1.340***	0.659**
	(0.167)	(0.218)	(0.188)	(0.219)	(0.318)
Observations	2500	2175	2425	2500	1800
Branch FE	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓

Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column using only traditional banks that reside in ZIP codes with demographics similar to users of online banking. Selection of similar banks is done using Nearest Neighbour Matching using ZIP code averages of having a computer in the home, access to internet, being older than 65, having a college degree, minority status, and being low income status (below $30,000 household income). APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an indicator for if institution i is an online bank and $1[PostMarch2022]_t$ is an indicator for time period t being after the rate increases in March of 2022. α_i and α_t are institution and time fixed effects. Standard errors are in parentheses and are clustered at the institution level. $*p < .1$, $**\ p < .05$, $***\ p < .01$

Table C.2: Balance Sheet Summary Statistics - Online Banks

	Mean	SD	Max	Min	Median	Obs
Panel A: Liabilities						
Deposits	0.77	0.11	0.91	0.43	0.79	16
Equity	0.11	0.03	0.16	0.06	0.10	16
Panel B: Assets						
Loans	0.69	0.18	0.91	0.23	0.74	16
Cash	0.13	0.08	0.35	0.03	0.12	16
Securities	0.14	0.15	0.66	0.00	0.09	16
Panel C: Loans						
Consumer Loans	0.49	0.29	0.98	0.07	0.46	16
Commercial Loans	0.26	0.24	0.71	0.00	0.19	16
Bank Loans	0.06	0.23	0.93	0.00	0.00	16
Commercial Real Estate Loans	0.11	0.12	0.38	0.00	0.09	16

Notes: This table displays summary statistics on bank balance sheets. Panel A presents values as a share of total liabilities. Panel B presents values as a share of total assets. Panel C presents values as a share of total loans. Statistics are calculated as of April 2021. Alliant Credit Union, who does not file with the FFIEC has not been included. Source: FFIEC

Table C.3: Balance Sheet Summary Statistics - B&M Banks

	Mean	SD	Max	Min	Median	Obs
Panel A: Liabilities						
Deposits	0.85	0.07	0.97	0.00	0.87	4005
Equity	0.11	0.03	0.93	0.00	0.10	4005
Panel B: Assets						
Loans	0.60	0.15	0.94	0.00	0.61	4005
Cash	0.13	0.10	0.74	0.00	0.11	4005
Securities	0.21	0.15	0.87	0.00	0.18	4005
Panel C: Loans						
Consumer Loans	0.29	0.20	1.00	0.00	0.25	4005
Commercial Loans	0.20	0.16	1.74	0.00	0.16	4005
Bank Loans	0.00	0.01	0.20	0.00	0.00	4005
Commercial Real Estate Loans	0.25	0.15	0.96	0.00	0.24	4005

Notes: This table displays statistics on bank balance sheets. Panel A presents values as a share of total liabilities. Panel B presents values as a share of total assets. Panel C presents values as a share of total loans. Statistics are calculated as of April 2021. Source: FFIEC

Table C.4: Hand Collected Online Banks

Bank	**Website**	**Internet Archive Coverage**
Affirm	www.affirm.com	Yes
Bask Bank	www.baskbank.com	Yes
Barclays	www.banking.barclaysus.com	Yes
Bread Financial	savings.breadfinancial.com	Yes
Charles Schwab Bank	www.schwab.com	Yes
Chime	www.chime.com	Yes
Ever Bank	www.everbank.com	No
Go2bank	www.go2bank.com	Yes
Marcus by Goldman Sachs	www.marcus.com	Yes
One United Bank	www.oneunited.com	Yes
Popular Direct	www.populardirect.com	Yes
Revolut	www.revolut.com	No
Scarlet	www.getscarlet.com	No
SoFi	www.sofi.com	No
Tab Bank	www.tabbank.com	Yes
UFB Direct	www.ufbdirect.com	No
Varo	www.varomoney.com	Yes
Vio Bank	www.viobank.com	No
Upgrade	www.upgrade.com	No
Zynlo	www.zynlobank.com	No

Notes: This table displays the online banks that do not have sufficient RateWatch coverage but are reviewed by NerdWallet. Banks flagged 'Yes' in the third column are those that have Internet Archive coverage prior to April 2022 and no gaps in coverage longer than 6 months after April 2022. These banks are included in the extended online bank sample. Source: nerdwallet.com & archive.org