WORKING PAPER · NO. 2023-87

Monetary Policy Transmission Through Online Banks

Isil Erel, Jack Liebersohn, Constantine Yannelis, and Samuel Earnest

JUNE 2023

Becker Friedman Institute
FOR ECONOMICS AT UCHICAGO

5757 S. University Ave.
Chicago, IL 60637
Main: 773.702.5599
bfi.uchicago.edu

MONETARY POLICY TRANSMISSION THROUGH ONLINE BANKS

Isil Erel
Jack Liebersohn
Constantine Yannelis
Samuel Earnest

June 2023

Erel is with the Ohio State University, NBER, and ECGI; Liebersohn is with the University of California Irvine; Yannelis is with the University of Chicago Booth School of Business and NBER; Earnest is with the University of Chicago Booth School of Business. We are thankful to Eduard Inozemtsev, Rene Stulz, Quentin Vandeweyer, Anne Villamil, Michael Weber and Yufeng Wu for helpful comments. Yannelis gratefully acknowledges financial support from the Booth School of Business and the Fama Miller Center at the University of Chicago.

Monetary Policy Transmission Through Online Banks
Isil Erel, Jack Liebersohn, Constantine Yannelis, and Samuel Earnest
June 2023
JEL No. E52,E58,G21,G23,G28

ABSTRACT

Financial technology has reshaped commercial banking. It has the potential to radically alter the transmission of monetary policy by lowering search costs and expanding bank markets. This paper studies the reaction of online banks to changes in federal fund rates. We find that these banks increase rates that they offer on deposits significantly more than traditional banks do. A 100 basis points increase in the federal fund rate leads to a 30 basis points larger increase in rates of online banks. Consistent with the rate movements, online bank deposits experience inflows, while traditional banks experience outflows during monetary tightening in 2022. The findings are consistent across banking markets of different competitiveness and demographics. Our findings shed new light on the role of online banks in interest rate pass-through and deposit channel of monetary policy.

Isil Erel
Fisher College of Business
The Ohio State University
2100 Neil Avenue
Columbus, OH 43210
and NBER
erel@fisher.osu.edu

Jack Liebersohn
University of California Irvine
cjlieber@uci.edu

Constantine Yannelis
Booth School of Business
University of Chicago
5807 S. Woodlawn Avenue
Chicago, IL 60637
and NBER
constantine.yannelis@chicagobooth.edu

Samuel Earnest
Booth School of Business
University of Chicago
Samuel.Earnest@chicagobooth.edu

1 Introduction

A large number of studies have found that monetary policy transmission is imperfect. In particular, market concentration (Drechsler et al., 2017), search costs (Duffie and Krishnamurthy, 2016), lender market power (Scharfstein and Sunderam, 2016), and human frictions (D'Acunto et al., 2021) have all been shown to affect how monetary policy is passed through to the economy. Recent technological advances have the potential to radically alter this process. Individuals can now transfer funds via mobile devices and compare investments online, which dramatically lowers search costs and increases geographic scope and financial market competitiveness. How does the unprecedented growth in financial technology (FinTech) 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.

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. Our empirical strategy exploits the rapid rise in the FFR of 2022-2023 and

[1] By 2022, online bank deposits constituted about 5 percent of the total deposits held by the U.S commercial banks. While many regulated commercial banks 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.

compares rates at online banks to those at traditional banks. We see parallel trends in rates prior to the rate hikes, with significant divergence following the increase in the FFR. Consistent with the deposit channel, we find that monetary policy transmission is significantly larger for online banks. Using a difference-in-differences empirical design, we show a 23 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.

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 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.

We address several potential threats to our empirical analysis. First, we 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. We find no evidence that their investment opportunities improved disproportionately. Second, 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 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. Our findings on significantly larger transmission of policy through online banks hold, with similar economic magnitudes, even when we exclude concentrated banking markets. This finding provides evidence that greater transmission of monetary policy through online banks on deposit rates operates differently than brick-and-mortar banking markets, even compared to ones in competitive areas.

Our model's main assumption is that customers of brick-and-mortar banks are stickier than online banking customers. A natural reason for this is that funds in online accounts are easier to move, but another possible reason is that online banks serve different customers. For example, their customers may be younger and more educated and therefore engage in more search. We repeat our main regressions first with the addition of ZIP code level demographic controls and then using only traditional banks that reside in ZIP codes with demographics similar to users of online banking. Our estimates remain remarkably similar when controlling for demographics. We find that demographics do not explain our main findings on relative rate sensitivities of online banks, suggesting that our results are indeed driven by differences in technology.

Our paper mainly contributes to the extensive literature on monetary policy transmission. The existing literature has documented several channels of the pass-through of monetary policy to the supply of bank loans, namely, the bank lending channel (Bernanke and Blinder 1988, Kashyap and Stein 1994, Kashyap and Stein 1995),[2] 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.[3] The authors show that the deposit market power channel is the most powerful one, explaining much of the transmission to bank borrowers. A related literature (e.g., Hannan and Berger 1991 and Neumark and Sharp 1992) studies the rigidity of the banks' deposit rates against regulatory rate changes, especially in concentrated banking markets. Some recent papers, on the other hand, provide strong evidence on uniform deposit

[2]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.

[3]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.

pricing across banking markets of especially large banks (e.g., Begenau and Stafford 2022 and Granja and Paixao 2023). 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. In particular, policy transmission on rates may be more effective in the future, necessitating updating models and policy guidance.

We also contribute to the literature on the growing role of FinTech in banking. A large and growing literature focuses on the rise of financial technology. The majority of this literature focus on the increasing role of unregulated financial institutions in direct lending to small and medium-sized businesses, especially after the 2008 Financial Crisis (see, e.g., Buchak et al. (2018); Fuster et al. (2019); Stulz (2019); Chernenko et al. (2022); DeFusco et al. (2022); Gopal and Schnabl (2022)) and how they expand the pie of access to finance (see, e.g., 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). 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 more rate hikes to depositors. 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 pass-through. 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 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.[4] 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 the 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 and robustness analysis. Section 6 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.[5] In response to growing comfort with mobile and internet banking, a growing number of online banks have

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

[5]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.

begun to compete with traditional brick-and-mortar banks. A major advantage of purely-online internet banks is that they do not have to maintain branches, lowering the cost of providing banking services. We study online banks because this market segment is fast growing and it will be even more important in the future.

Figure 1 shows nominal deposit growth in online and brick-and-mortar banks indexed to 2001. Online banks are still a small share of total bank deposits; the banks we identify as purely online represent about 5% of total system deposits as of March 2023.[6] At the same time, the combined effects of rising mobile usage, new entry into the field of online banking, and the disruptions of the COVID-19 pandemic have led to a dramatic increase since even ten years ago. Deposits in online banks have increased by a factor of thirty since 2001, over triple deposit growth in brick-and-mortar banks. 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 tradtional banks. The COVID-19 pandemic 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.[7]

Online banks differ from brick-and-mortar banks in several ways that affect their competitive landscape. An important difference is their technology. 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. In the next section, we provide a theoretical framework which formalizes this intuition. A second reason is that the consumers of online banks may be different 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. Finally,

[6]See Appendix FigureA.2.

[7]https://www.americanbanker.com/news/digital-banking-is-surging-during-the-pandemic-will-it-last

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.

2.2 Theoretical Framework

We present a stylized theoretical framework providing intuition for why we might expect a difference in rates for traditional and online banks. The key insight is that users of online banks adjust their asset holdings in response to changes in interest rates, while users of traditional brick-and-mortar institutions do not. This leads to a difference between rate adjustments at online and traditional brick-and-mortar institutions.

Following Drechsler et al. (2017),[8] the spread s_{trad} between deposit rates and the FFR f 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 ρ, the elasticity of substitution between wealth and liquidity.[9] This is because, for users of online banks, it is frictionless to withdraw and transfer funds using apps.

Users of online banks adjust their illiquid asset holdings as rates change. The spread s_{online}

[8]Note that Drechsler et al. (2017) is not the only framework that would predict a spread between deposit rates for online and traditional institutions. Xiao (2020) proposes a new pass-through channel, namely the shadow banking channel. Contrary to traditional banks, the clientele of shadow banks is more sophisticated and, as a result, 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 pass-through of the interest rate shock to the deposit rates, leading to deposit outflow (Xiao (2020)). In contrast, shadow banks increase deposit rates to keep their clientele from switching to other markets.

[9]Increasing the share of traditional banks is equivalent to reducing the elasticity of substitution between liquid and illiquid assets. This makes deposit spreads more sensitive to the fed funds rate.

between deposit rates and the fed funds rate f at online banks is thus insensitive to ρ and given by

$$s_{online} = \delta^{\frac{\varepsilon}{\varepsilon-1}} \left[\frac{\mathscr{M}}{\varepsilon - \mathscr{M}} \right]^{\frac{1}{\varepsilon-1}} f \tag{2}$$

It is immediately evident that an increase in the fed funds rate f leads to a larger change in s_{online} relative to s_{trad}. The spread Δs between online and traditional brick-and-mortar banks is thus given by

$$\Delta s = \delta^{\frac{\varepsilon}{\varepsilon-1}} \left[\frac{\rho}{\varepsilon - \mathscr{M}} \right]^{\frac{1}{\varepsilon-1}} f \tag{3}$$

In the remainder of the paper, we test for differential pass-through of the fed funds rate in rates for online and traditional banks. Note that we will use the deposit rates rather than the spreads, fed fund rate minus deposit rate like in Drechsler et al. (2017), in the rest of the paper, as we would like to present statistics on raw rates first.[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 pass-through 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.

3 Empirical Strategy

We compare how interest rates evolve, comparing rates at online with brick-and-mortar banks following response to federal funds rate increases. We exploit the difference in rates between online and brick-and-mortar banks following the increase in the FFR beginning in March 2022.

[10]With time fixed effects, any coefficient presented from our multivariate estimations would be equal to the negative of the same coefficient for the spreads.

On March 1, 2022 the FFR was zero, and on March 17 the Federal Reserve raised the benchmark rate by 25 basis points. This 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%. 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:

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

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 follwing the increase in interest rates. We include institution and time 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 betters 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 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:

[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)).

$$APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \nu_{it} \tag{5}$$

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.

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 two large online credit unions, Alliant Credit Union and Discovery Federal Credit Union, which we identify as FinTechs and have deposit rate data available. Using the call reports data, we measure banks' total assets, total deposits, interest-bearing deposits and noninterest-bearing deposits by quarter. We collect similar data on Alliant and Discovery Federal using data from the National Credit Union Administration.

We match the Call reports data at the institution level to interest rate data from Ratewatch, which is 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 used by banks to stay informed about their competitors' rates.[12] In recent years, their coverage has expanded to include rates from online products (e.g., E-checking) and online banks. 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 collapse this

[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.

to the month-by-institution level, taking the simple average of rates across each institution's branches. In robustness checks, we consider different averages, 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 landscape of consumer deposits.[13]

We further use data from the FDIC Summary of Deposits (SOD) database to calculate the location and deposits of brick-and-mortar banks. 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 2015-2019 American Community Survey. We match this by ZIP code to the ZIP code of each bank branch.

4.2 Classifying of Online Banks

In order to identify online banks, we begin with a sample of 15 online banks identified by Abrams (2019) and supplement this 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. In the Appendix, we show that our results for deposit quantities are very similar when

[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. We are currently working to correct these errors and in future versions of this paper we hope to have expanded data availability.

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

we also include data on banks which do not have Ratewatch data. We also show that our results are robust to excluding any particular online bank.

Table A.2 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 "Internet Bank." A few are classified as "Bank" or "Credit Union" and one (Quontic Bank) is classified as a Savings & Loan. With one exception — Capital One — the online banks have few branches. Two of the online banks (CIT and E*Trade) were acquired in January, 2022, so we do not have deposit data from them in the year 2023.

Table 1 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 be much larger with an order of magnitude higher deposits and assets.

5 Main Results

5.1 Rates for Online and Traditional Banks

We begin by showing raw means over time in Figure 3. The top left panel shows the FFR over time. There is a sharp increase in the FFR March, 2022, as was discussed in section 3. 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). 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. 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. 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)).

Table 2 makes this graphical evidence more explicit. The top panel of the table shows estimates of equation 4, 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 2 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 pass-through of the FFR for online relative to traditional banks. Across various products, we see an approximate 23 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 5, 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.

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.[15] The dashed vertical line in the figure indicates March of 2022, that is when the Federal Reserve began the rate hikes to tighten its monetary policy. There are two important facts we learn from this figure. First is that online banks' deposits grow at a much faster rate than that of traditional banks over the last decade. Second and 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 till the first quarter of 2022, which totaled over \$15 trillion dollars, almost \$1 trillion of which ran away by the third quarter of 2023. For online banks, though, the change in deposit quantities over this one year, which is about \$200 billion of an increase, is similar in magnitude to the change of the previous decade.

We run the following difference-in-differences specification to show the effect on deposit levels more formally. For a given financial product let i index banking institution and t index month-year, $Deposits_{it}$ equals:

$$Deposits_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \varepsilon_{it}, \tag{6}$$

where $1[Online]_i$ is an indicator for if institution i is classified as an online bank and $1[FFR]_t$ 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 for total deposits first and present the results in Column 1 of Table 3. The coefficient on the interaction of the online and post dummy is positive and significant, showing about \$6.4 billion of larger net deposit inflows to online banks.

In columns (2) and (3) of Table 3, we present results of the same difference-in-differences

[15] As our deposit quantities data source is the Summary of Deposits (SOD), we provide quarter-over-quarter changes in the figure.

estimation for interest-bearing and non-interest bearing deposits separately. 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 is 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 inflow of interest bearing ones happen at a much larger scale for online banks.[16]

5.3 Tests of Alternative Explanations

We show that interest passthrough through online banks is larger. We argue that this finding is due to online banks' being different in terms of operations –i.e., relying on FinTech rather than brick-and-mortar branching– reducing search costs and the clientele that they attract. These depositors are more sensitive to interest rate movements. In this section, we discuss some alternative explanations for our findings.

5.3.1 Passthrough and Competition

One potential explanation for the difference in passthrough by online banks would be the competitiveness of the banking markets of online banks. Hence, we repeat our tests using subsamples of bank branches in countries with high versus low banking competition using the median Hirfindahl-Hirschman Index (HHI). Table 4 presents results, where we create subsamples first based on the HHI at the branch level and then at the bank level. Our findings on significantly larger transmission of policy on rates through online banks hold, with similar economic magnitudes, even when we exclude concentrated banking markets. This finding provides strong

[16]Note that interest bearing deposits were 92.69% of total deposits for traditional while it was 67.05% for online banks, as of 2001Q4.

evidence that greater transmission of monetary policy through online banks is qualitatively different than brick-and-mortar banking markets, even relatively competitive ones.

5.3.2 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 than the types of people who use brick-and-mortar banks. Anenberg et al. (2018) show that younger and higher-income people do 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, similar to the way technology does.

The model in Section 2.2 is designed to capture either demographic or technological reasons that lead online banking customers to act differently than the customers of brick-and-mortar banks. While our results are consistent with both stories, these two 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.

We explore the role of demographics in Appendix B. Using data from the Survey of Consumer Finances, we show that individuals who do online banking are more likely to be young, high-income and educated, and less likely to be members of a racial minority. We then explore how these variables, as well as variables related to computer use, are associated with monetary policy passthrough. We first repeat our main regression with the addition of ZIP code level demographic controls and then run our main regression using only traditional banks that reside in ZIP codes with demographics similar to users of online banking. In both cases the effect of being an online bank remains large and significant. Therefore we do not think that the differences between online and brick-and-mortar branches are mostly due to demographics. However, regional data is an imperfect proxy for the characteristics of individual bank customers. Therefore we think that the role of demographics for interest pass-through is a fruitful area for future research.

5.3.3 Lending Opportunities

Our model assumes that the loan opportunities available to 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' lending opportunities improved relative to brick-and-mortar banks after the federal funds rate increased, it could explain why they raised rates to attract deposits.[17]

We explore the role of time-varying loan and 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 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.

5.4 Robustness Tests

Online banks are yet small in number but not in size. As presented in Table 1, 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 5, we use only large traditional banks with total assets of $40 billion or over in our sample. The findings remain

[17]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.

similar in terms of both economic and statistical significance. Moreover, in Panel B of Table 5, we alternatively run our main tests using deposits of banks to weigh our unit of observations. Results stay similar.

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.3. Presented in this 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.

6 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 massively alter the transmission of monetary policy on deposit rates, as bank 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 23 and 35 basis point larger increase in 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 provide strong evidence on increased interest rate passtrough with increasing share of 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. 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.

References

Abrams, Eliot, "Assessing Bank Deposit Market Power Given Limited Consumer Consideration," 2019. University of Chicago Working Paper.

Anenberg, Elliot, Andrew C Chang, Serafin Grundl, Kevin B Moore, and Richard Windle, "The Branch Puzzle: Why Are There Still Bank Branches?," 2018.

Bartlett, Robert, Adair Morse, Richard Stanton, and Nancy Wallace, "Consumer Lending Discrimination in the FinTech Era," *Journal of Financial Economics*, 2022, *143*, 30–56.

Bauer, Michael D, Carolin Pflueger, and Adi Sunderam, "Perceptions About Monetary Policy," Technical Report, National Bureau of Economic Research 2022.

Begenau, Juliane and Erik Stafford, "Uniform Rate Setting and the Deposit Channel," 2022. HBS Working Paper.

Bernanke, B. and A. Blinder, "Credit, Money, and Aggregate Demand," *American Economic Review*, 1988, *78*, 435—439.

Bhutta, Neil, Jesse Bricker, Andrew C Chang, Lisa J Dettling, Sarena Goodman, Joanne W Hsu, Kevin B Moore, Sarah Reber, Alice Henriques Volz, and Richard Windle, "Changes in US Family Finances from 2016 to 2019: Evidence from the Survey of Consumer Finances," *Federal Reserve Bulletin*, 2020, *106* (5).

Bolton, Patrick and Xavier Freixas, "Equity, Bonds, and Bank Debt: Capital Structure and Financial Market Equilibrium Under Asymmetric Information," *Journal of Political Economy*, 2000, *108* (2), 324–351.

Brunnermeier, Markus K and Yuliy Sannikov, "The I theory of money," Technical Report, National Bureau of Economic Research 2016.

Buchak, Greg and Adam Jørring, "Does Competition Reduce Racial Discrimination in Lending?," *Unpublished Working Paper*, 2016.

__ , **Gregor Matvos, Tomasz Piskorski, and Amit Seru**, "Fintech, Regulatory Arbitrage, and the Rise of Shadow Banks," *Journal of Financial Economics*, 2018, *130*, 453–483.

Chernenko, Sergey, Isil Erel, and Robert Prilmeier, "Why do Firms Borrow Directly from Nonbanks?," *The Review of Financial Studies*, 2022, *35*, 4902–4947.

Cieslak, Anna, "Short-rate Expectations and Unexpected Returns in Treasury Bonds," *The Review of Financial Studies*, 2018, *31* (9), 3265–3306.

__ **and Andreas Schrimpf**, "Non-monetary News in Central Bank Communication," *Journal of International Economics*, 2019, *118*, 293–315.

__ **and Carolin Pflueger**, "Inflation and Asset Returns," *Annual Review of Financial Economics*, 2023.

Coibion, Olivier, Yuriy Gorodnichenko, and Michael Weber, "Monetary Policy Communications and Their Effects on Household Inflation Expectations," *Journal of Political Economy*, 2022, *130* (6), 1537–1584.

Cookson, Anthony, Javier Gil-Bazo Corbin Fox, Juan Felipe Imbet, and Cristoph Schiller, "Social Media as a Bank Run Catalyst," 2023. Working Paper.

de Chaisemartin, Clement and Xavier D'Haultfoeuille, "Two-way Fixed Effects Estimators with Heterogeneous Treatment Effects," *American Economic Review*, 2020, *110*, 2964–2996.

DeFusco, Anthony A, Huan Tang, and Constantine Yannelis, "Measuring the Welfare Cost of Asymmetric Information in Consumer Credit Markets," *Journal of Financial Economics*, 2022, *146* (3), 821–840.

den Heuvel, Skander J Van et al., "The Bank Capital Channel of Monetary Policy," *The Wharton School, University of Pennsylvania, mimeo*, 2002, pp. 2013–14.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl, "The Deposits Channel of Monetary Policy," *The Quarterly Journal of Economics*, 2017, *132* (4), 1819–1876.

__ , **Schnabl Philipp Savov Alexi, and Olivier Wang**, "Banking on Uninsured Deposits,," 2023. NBER Working Paper.

Duffie, Darrell and Arvind Krishnamurthy, "Passthrough Efficiency in the Fed's New Monetary Policy Setting," in "Designing Resilient Monetary Policy Frameworks for the Future. Federal Reserve Bank of Kansas City, Jackson Hole Symposium" 2016, pp. 1815–1847.

D'Acunto, Francesco and Alberto G Rossi, "Robo-advising," *Annual Review of Financial Economics*, 2023.

__ , **Daniel Hoang, Maritta Paloviita, and Michael Weber**, "Human Frictions in the Transmission of Economic Policies," Technical Report, National Bureau of Economic Research 2021.

__ , **Nagpurnanand Prabhala, and Alberto G Rossi**, "The Promises and Pitfalls of Robo-advising," *The Review of Financial Studies*, 2019, *32* (5), 1983–2020.

d'Avernas, Adrien and Quentin Vandeweyer, "Treasury Bill Shortages and the Pricing of Short-term Assets," *Journal of Finance*, 2023.

Erel, Isil and Jack Liebersohn, "Can FinTech Reduce Disparities in Access to Finance? Evidence from the Paycheck Protection Program," *Journal of Financial Economics*, 2022, *146*, 90–118.

Fuster, A., M. Plosser, P. Schnabl, and J. Vickery, "The Role of Technology in Mortgage Lending," *Review of Financial Studies*, 2019, *32*, 1854–1899.

Fuster, Andreas, Paul Goldsmith-Pinkham, Tarun Ramadorai, and Ansgar Walther, "Predictably Unequal? The Effects of Machine Learning on Credit Markets," *Journal of Finance*, 2021, *77*, 5–47.

Gopal, Manasa and Philipp Schnabl, "The Rise of Finance Companies and FinTech Lenders in Small Business Lending," *The Review of Financial Studies*, 2022, *35*, 4859–4901.

Granja, Joao and Nuno Paixao, "Bank Consolidation and Uniform Pricing," 2023. University of Chicago Working Paper.

Granja, João, Christos Makridis, Constantine Yannelis, and Eric Zwick, "Did the Paycheck Protection Program Hit the Target?," *Journal of Financial Economics*, 2022, *145* (3), 725–761.

Haendler, Charlotte, "Keeping Up in the Digital Era: How Mobile Technology Is Reshaping the Banking Sector," 2023. Boston College Working Paper.

Hannan, Timothy H. and Allen N. Berger, "The Rigidity of Prices: Evidence from the Banking Industry," *American Economic Review*, 1991, *81*, 938–945.

Jiang, Erica, Gregor Matvos, Tomasz Piskorski, and Amit Seru, "Monetary Tightening and US Bank Fragility in 2023: Mark-to-Market Losses and Uninsured Depositor Runs?," 2023. NBER Working Paper.

Kang-Landsberg, Alena, Stephan Luck, and Matthew Plosser, "Deposit Betas: Up, Up, and Away?," 2023. Federal Reserve Bank of New York Liberty Street Economics, April 11.

Kashyap, Anil and Jeremy Stein, "Monetary Policy and Bank Lending," *NBER Studies in Business Cycles*, 1994, *29*, 221–256.

_ and _ , "The Impact of Monetary Policy on Bank Balance Sheets," in "Carnegie-Rochester conference series on public policy," Vol. 42 Elsevier 1995, pp. 151–195.

Koont, Naz, "The Risks of Digital Banking," Working Paper," 2023. Columbia University Working Paper.

_ , Tano Santos, and Luigi Zingales, "Destabilizing Digital "Bank Walks"," 2023. University of Chicago Working Paper.

Neuhierl, Andreas and Michael Weber, "Monetary Policy Communication, Policy Slope, and the Stock Market," *Journal of Monetary Economics*, 2019, *108*, 140–155.

Neumark, David and Steve Sharp, "Market Structure and the Nature of Price Rigidity: Evidence from the Market for Consumer Deposits," *The Quarterly Journal of Economics*, 1992, *107*, 657–680.

Pflueger, Carolin and Gianluca Rinaldi, "Why Does the Fed Move Markets So Much? A Model of Monetary Policy and Time-varying Risk Aversion," *Journal of Financial Economics*, 2022, *146* (1), 71–89.

Scharfstein, David and Adi Sunderam, "Market Power in Mortgage Lending and the Transmission of Monetary Policy," *Unpublished working paper. Harvard University*, 2016, *2*.

Stein, Luke CD and Constantine Yannelis, "Financial Inclusion, Human Capital, and Wealth Accumulation: Evidence from the Freedman's Savings Bank," *The Review of Financial Studies*, 2020, *33* (11), 5333–5377.

Stulz, Rene, "FinTech, BigTech, and the Future of Banks," *Journal of Applied Corporate Finance*, 2019, *31*, 86–97.

Wang, Yifei, Toni M Whited, Yufeng Wu, and Kairong Xiao, "Bank Market Power and Monetary Policy Transmission: Evidence from a Structural Estimation," *The Journal of Finance*, 2022, *77* (4), 2093–2141.

Xiao, Kairong, "Monetary Transmission Through Shadow Banks," *The Review of Financial Studies*, 2020, *33* (6), 2379–2420.

Table 1: 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	3001
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	3679
2.5K Savings	0.09	0.08	0.75	0.00	0.07	3918
Total Deposits	4.10	52.84	1986.41	0.00	0.30	4003
Total Assets	5.43	76.45	3207.52	0.05	0.35	4003
Bank Type: Online						
6 Month CD	0.29	0.15	0.60	0.10	0.25	13
12 Month Fixed IRA, 10K	0.40	0.18	0.65	0.15	0.50	11
24 Month CD	0.47	0.17	0.70	0.20	0.50	16
10K MM	0.34	0.16	0.60	0.04	0.35	11
2.5K Savings	0.34	0.20	0.61	0.01	0.40	16
Total Deposits	52.57	77.22	306.69	0.15	27.48	17
Total Assets	66.35	94.52	369.91	0.16	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 2: 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	0.845***	0.686***	0.615***	1.101***	0.702**
	(0.199)	(0.207)	(0.221)	(0.240)	(0.303)
Panel B: FFR Interaction					
Online × FFR	0.325***	0.265***	0.233***	0.343***	0.230**
	(0.077)	(0.080)	(0.086)	(0.079)	(0.109)
Observations	98375	92437	96724	95707	75392
Bank FE	✓	✓	✓	✓	✓
Time Year 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 3: Deposits

	(1) Total Deposits	(2) Interest Deposits	(3) Non-Interest Deposits
Panel A: Post Interaction			
Online × Post March 2022	6.440**	6.500**	-0.060
	(2.511)	(2.577)	(0.141)
Panel B: FFR Interaction			
Online × FFR	2.404**	2.472**	-0.068
	(0.938)	(0.986)	(0.072)
Observations	34703	34703	34703
Bank FE	✓	✓	✓
Time 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 $1[FFR]_t$ 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 4: Pass-through 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	0.842***	0.690***	0.595***	1.086***	0.701**
	(0.199)	(0.207)	(0.221)	(0.241)	(0.303)
Observations	54291	50285	53354	52880	40827
Panel B: High Competition Branches					
Online × Post March 2022	0.852***	0.683***	0.643***	1.131***	0.709**
	(0.199)	(0.207)	(0.221)	(0.241)	(0.303)
Observations	45847	43664	45067	44456	36238
Panel C: Avg Low Competition Banks					
Online × Post March 2022	0.839***	0.683***	0.584***	1.074***	0.697**
	(0.199)	(0.207)	(0.221)	(0.241)	(0.303)
Observations	49460	46437	48612	48145	37896
Panel D: Avg High Competition Banks					
Online × Post March 2022	0.855***	0.690***	0.647***	1.132***	0.706**
	(0.199)	(0.207)	(0.221)	(0.241)	(0.303)
Observations	49215	46225	48338	47862	37746
Bank FE	✓	✓	✓	✓	✓
Time Year FE	✓	✓	✓	✓	✓

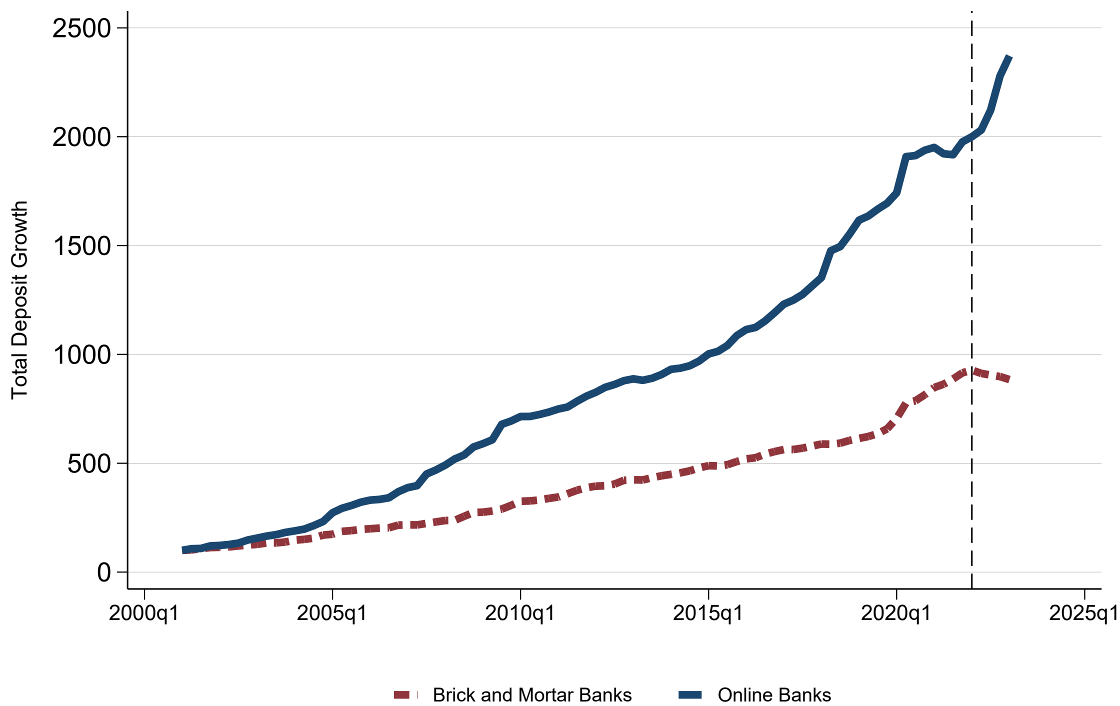
Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an 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.$^{*} p < .1$, $^{**} p < .05$, $^{***} p < .01$

Table 5: 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: Large Banks Only					
Online × Post March 2022	0.844***	0.753***	0.694***	1.223***	0.911***
	(0.205)	(0.212)	(0.239)	(0.269)	(0.324)
Observations	1775	1595	1675	1775	1425
Panel B: Deposit Weighted					
Online × Post March 2022	0.846***	0.686***	0.613***	1.100***	0.701**
	(0.199)	(0.207)	(0.221)	(0.240)	(0.303)
Observations	97645	91729	95972	94868	74853
Bank FE	✓	✓	✓	✓	✓
Time Year FE	✓	✓	✓	✓	✓

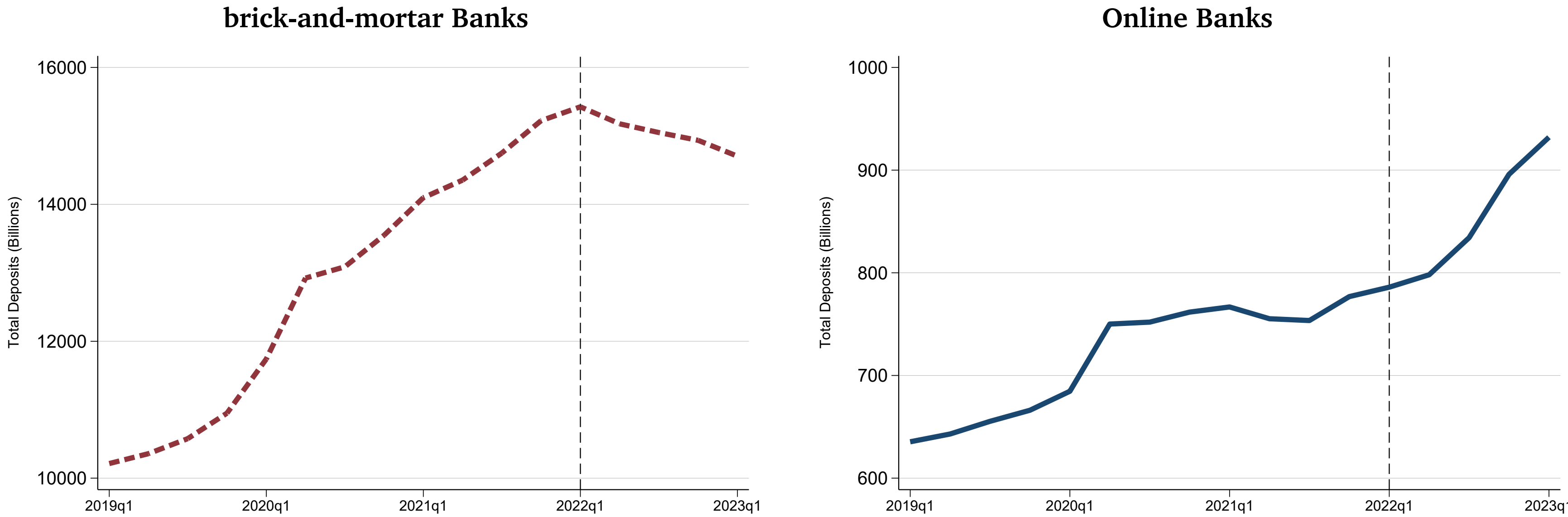
Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \epsilon_{it}$ for the six products listed in each column. APY_{it} is the annual percentage yield offered by institution i at time t. $1[Online]_i$ is an 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 excludes brick-and-mortar banks with total assets worth less than 40 billion. Panel B weights average bank rates by the total deposits under each rate setting branch.* $p < .1$, ** $p < .05$, *** $p < .01$

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 A.2. 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 OTS prior to 2011 have been linearly interpolated from annual Summary of Deposits data. Source: FFIEC & FDIC

Figure 2: Total Deposit Levels

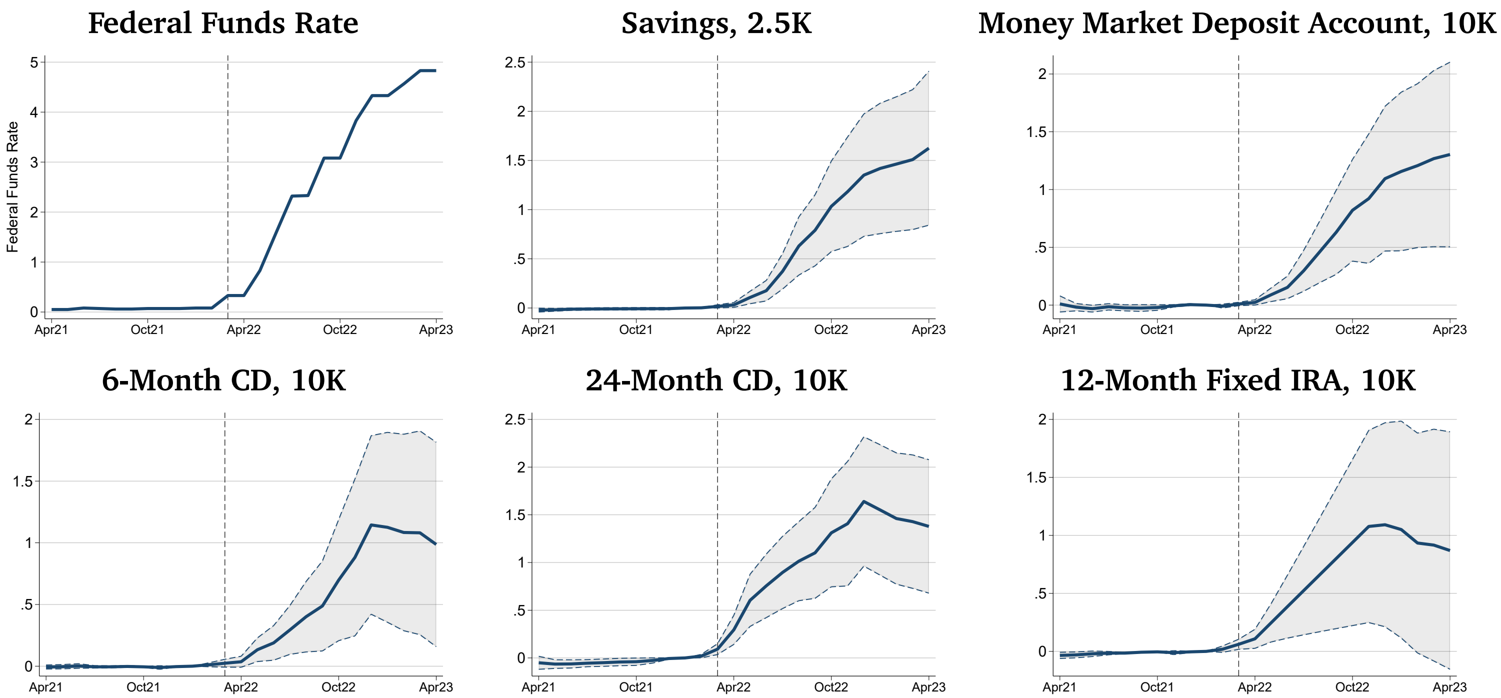


Notes: This figure shows total deposits by bank type. The dashed vertical line indicates when the federal reserve began increasing rates in March of 2022. The online banks that are included are listed in Table A.2. CIT Bank and E*Trade were both acquired in 2022 and have been excluded. Source: FFIEC

Figure 3: Levels for Rates (Raw Means)

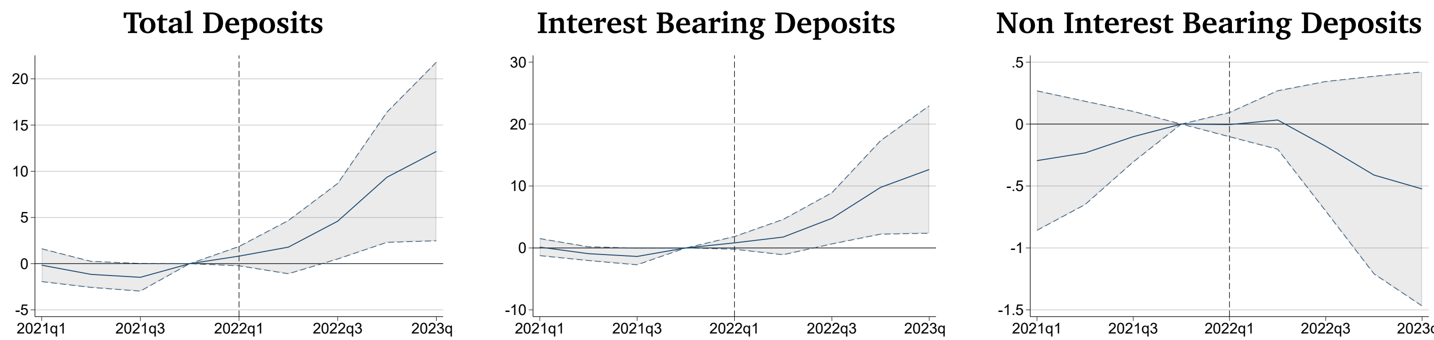
Notes: This figure plots the average annual percentage yield for each product broken down by online banks and brick-and-mortar banks. The solid blue lines show the average APY for online banks and the dashed red lines show average APY for brick-and-mortar banks. The dashed vertical line indicates when 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 $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \epsilon_{it}$ 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 $Deposits_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \epsilon_{it}$ 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: April 2023 Summary Statistics

	Mean	SD	Max	Min	Median	Obs
Bank Type: Brick and Mortar						
6 Month CD	1.28	1.15	5.20	0.01	1.00	3824
12 Month Fixed IRA, 10K	1.60	1.30	5.05	0.01	1.26	2989
24 Month CD	1.72	1.19	5.09	0.01	1.59	3789
10K MM	0.50	0.61	5.02	0.01	0.28	3661
2.5K Savings	0.28	0.42	5.00	0.01	0.15	3898
Total Deposits	4.44	54.20	2043.65	0.00	0.34	3975
Total Assets	6.08	79.75	3267.96	0.02	0.39	3975
Bank Type: Online						
6 Month CD	2.37	1.62	4.52	0.10	2.79	13
12 Month Fixed IRA, 10K	2.61	1.92	5.00	0.20	2.88	11
24 Month CD	3.23	1.54	4.70	0.20	3.92	16
10K MM	2.02	1.50	4.00	0.25	2.00	11
2.5K Savings	2.17	1.73	4.25	0.05	2.63	16
Total Deposits	69.62	97.32	371.64	0.47	39.98	15
Total Assets	86.83	122.30	469.43	0.58	47.56	15

Notes: This table presents summary statistics for the main variables of interest in the last month of our sample (April 2023). The variables have been split by bank type as labeled. Total assets and deposits are reported in billions. Source: RateWatch & FFIEC

Table A.2: Online Banks

Institution Name	Type	Abrams 2019	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	X	1		98.64	158.49	August 02, 2004	
American Express National Bank	Internet Bank	X	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	X	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	X	2	14.17	62.94	98.49	January 01, 1934	
Discovery Federal Credit Union	Credit Union		1	0.05	0.12	0.16	January 01, 1959	
E*Trade Bank	Internet Bank	X	1	7.79	43.45		January 01, 1933	January 01, 2022
First Internet Bank of Indiana	Internet Bank	X	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	X	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.
Source: RateWatch & FFIEC

Table A.3: Drop One Robustness Check

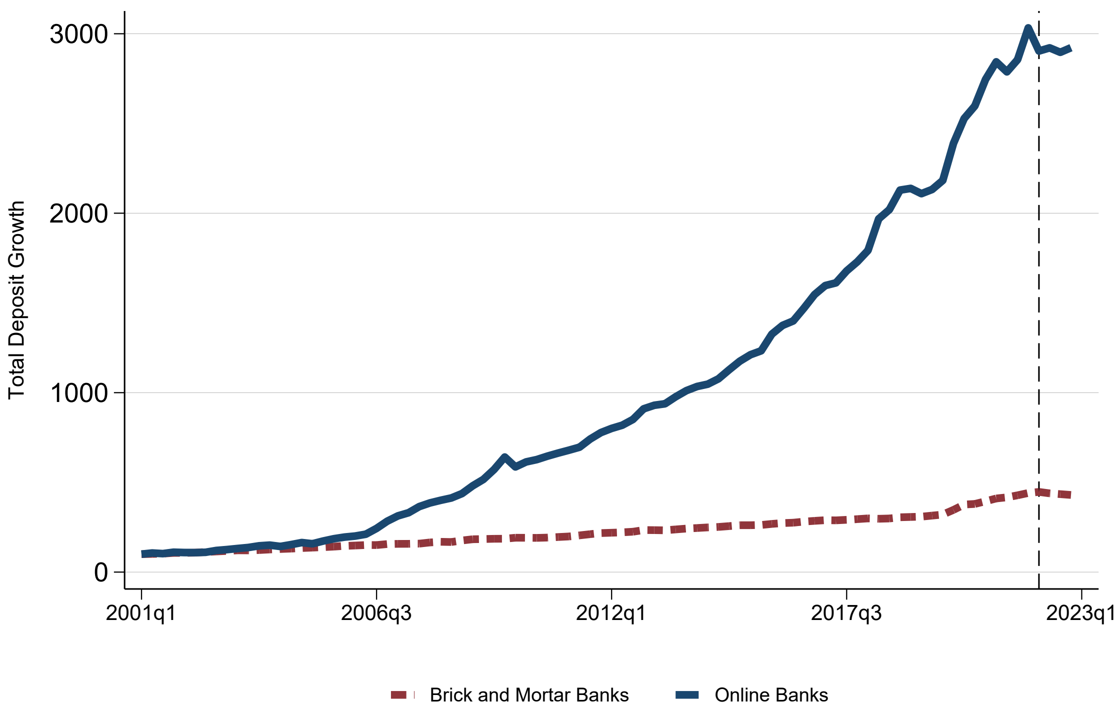
	(1) Savings, 2.5K	(2) Money Market, 10K	(3) 6-Month CD, 10K	(4) 24-Month CD, 10K	(5) 12-Month Fixed IRA, 10K
Alliant Credit Union					
Online × Post March 2022	0.813***	0.686***	0.615***	1.049***	0.583*
	(0.210)	(0.207)	(0.221)	(0.251)	(0.309)
Observations	98350	92437	96724	95682	75367
Ally Bank					
Online × Post March 2022	0.802***	0.610***	0.565**	1.093***	0.602*
	(0.207)	(0.213)	(0.234)	(0.256)	(0.316)
Observations	98350	92412	96699	95682	75367
American Express National Bank					
Online × Post March 2022	0.797***	0.686***	0.615***	1.051***	0.702**
	(0.206)	(0.207)	(0.221)	(0.251)	(0.303)
Observations	98350	92437	96724	95682	75392
Axos Bank					
Online × Post March 2022	0.907***	0.775***	0.703***	1.217***	0.832***
	(0.202)	(0.208)	(0.221)	(0.227)	(0.304)
Observations	98350	92412	96699	95682	75367
Bank5 Connect					
Online × Post March 2022	0.907***	0.686***	0.703***	1.217***	0.702**
	(0.202)	(0.207)	(0.221)	(0.227)	(0.303)
Observations	98350	92437	96699	95682	75392
CIBC Bank USA					
Online × Post March 2022	0.903***	0.767***	0.619***	1.122***	0.656**
	(0.204)	(0.211)	(0.239)	(0.256)	(0.330)
Observations	98350	92412	96699	95682	75367
CIT Bank					
Online × Post March 2022	0.906***	0.771***	0.703***	1.217***	0.702**
	(0.203)	(0.209)	(0.221)	(0.227)	(0.303)
Observations	98350	92412	96699	95682	75392
Capital One, National Association					
Online × Post March 2022	0.798***	0.686***	0.556**	1.039***	0.813***
	(0.207)	(0.207)	(0.231)	(0.248)	(0.312)
Observations	98350	92437	96699	95682	75367
Discover Bank					
Online × Post March 2022	0.795***	0.604***	0.583**	1.051***	0.597*
	(0.206)	(0.210)	(0.237)	(0.251)	(0.314)
Observations	98350	92412	96699	95682	75367
Discovery Federal Credit Union					
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	98350	92412	96699	95682	75367
					Continued on next page

Table A.3: 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
E*Trade Bank					
Online × Post March 2022	0.907***	0.686***	0.615***	1.101***	0.702**
	(0.202)	(0.207)	(0.221)	(0.240)	(0.303)
Observations	98350	92437	96724	95707	75392
First Internet Bank of Indiana					
Online × Post March 2022	0.883***	0.603***	0.524**	1.046***	0.702**
	(0.209)	(0.210)	(0.220)	(0.250)	(0.303)
Observations	98350	92412	96699	95682	75392
LendingClub Bank, National Association					
Online × Post March 2022	0.777***	0.686***	0.615***	1.035***	0.702**
	(0.200)	(0.207)	(0.221)	(0.247)	(0.303)
Observations	98350	92437	96724	95682	75392
NBKC Bank					
Online × Post March 2022	0.845***	0.687***	0.703***	1.120***	0.816***
	(0.199)	(0.228)	(0.221)	(0.256)	(0.311)
Observations	98375	92412	96699	95682	75367
Quontic Bank					
Online × Post March 2022	0.789***	0.610***	0.571**	1.065***	0.832***
	(0.204)	(0.213)	(0.235)	(0.254)	(0.304)
Observations	98350	92412	96699	95682	75367
Synchrony Bank					
Online × Post March 2022	0.784***	0.664***	0.523**	1.049***	0.583*
	(0.203)	(0.226)	(0.219)	(0.251)	(0.309)
Observations	98350	92412	96699	95682	75367
TIAA, FSB					
Online × Post March 2022	0.851***	0.714***	0.634***	1.132***	0.704**
	(0.212)	(0.226)	(0.238)	(0.254)	(0.333)
Observations	98350	92412	96699	95682	75367
Bank FE	✓	✓	✓	✓	✓
Time Year FE	✓	✓	✓	✓	✓

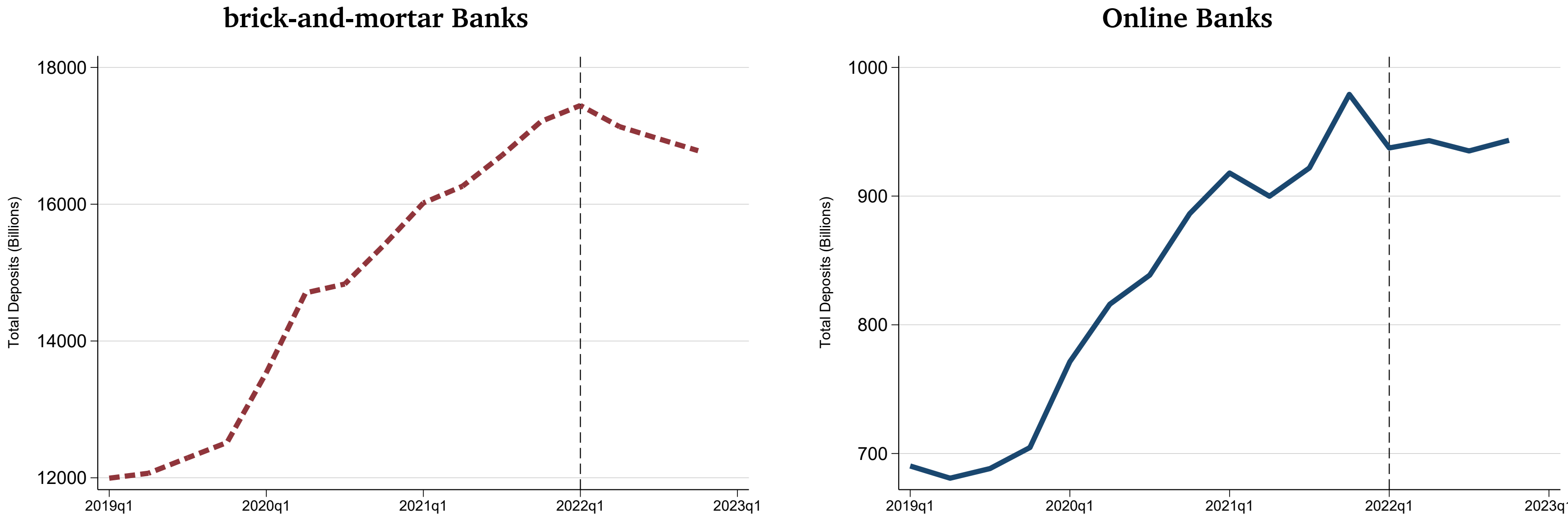
Notes: This table presents estimates of β from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[FFR]_t + \epsilon_{it}$ for the six products listed in each column. In each row one online bank is excluded from the regression as indicated in the top left corner. Standard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

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



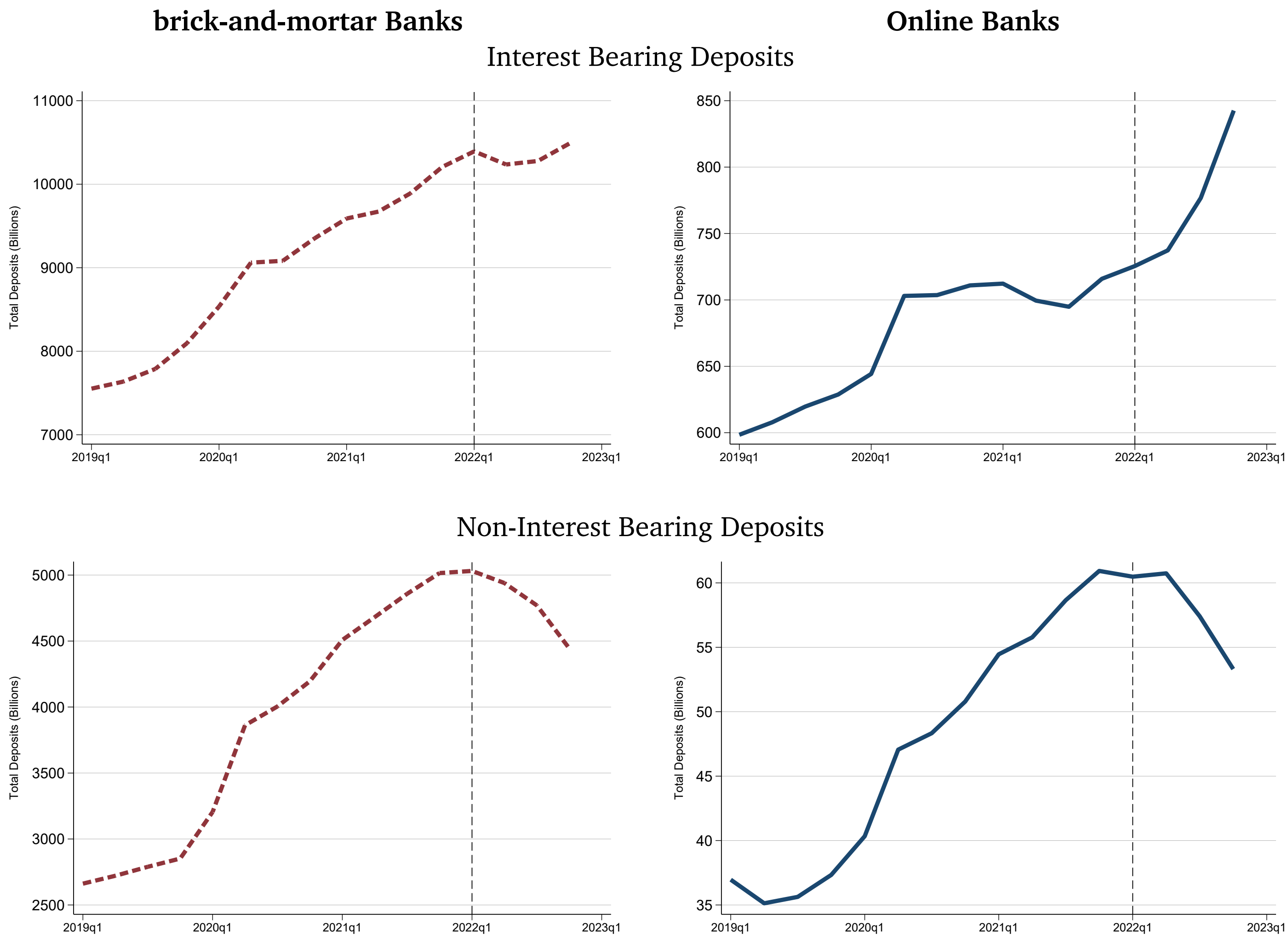
Notes: This figure shows total deposit growth since March 2001 by bank type using all available banks in the FFIEC call reports (not just those with RateWatch coverage). The dashed vertical line indicates when the federal reserve began increasing rates in March of 2022. The online banks that are included are listed in Table A.2. 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)



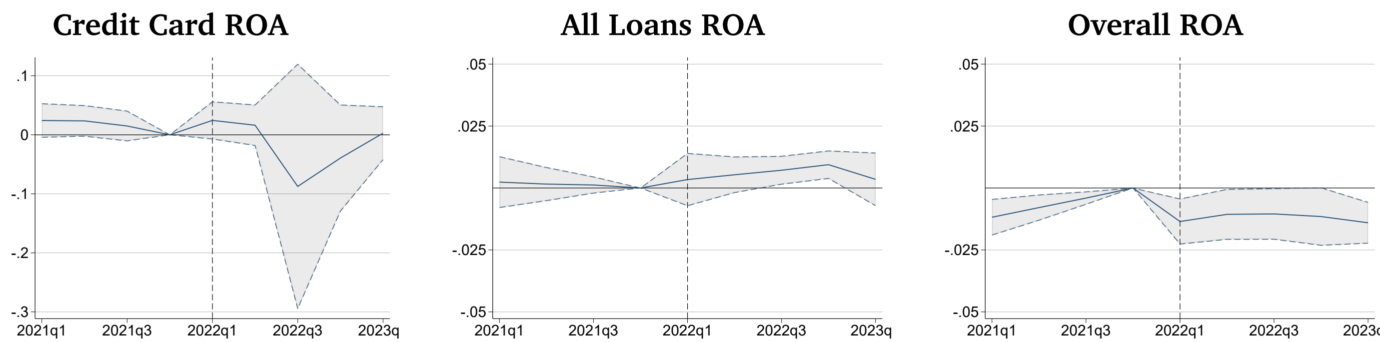
Notes: This figure shows total deposit March 2019 by bank type using all available banks in the FFIEC call reports (not just those with RateWatch coverage). The dashed vertical line indicates when the federal reserve began increasing rates in March of 2022. The online banks that are included are listed in table A.2. 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 deposit 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 A.2. CIT Bank and E*Trade were both acquired in 2022 and have been excluded. Source: FFIEC

Figure A.4: ROA Event Studies

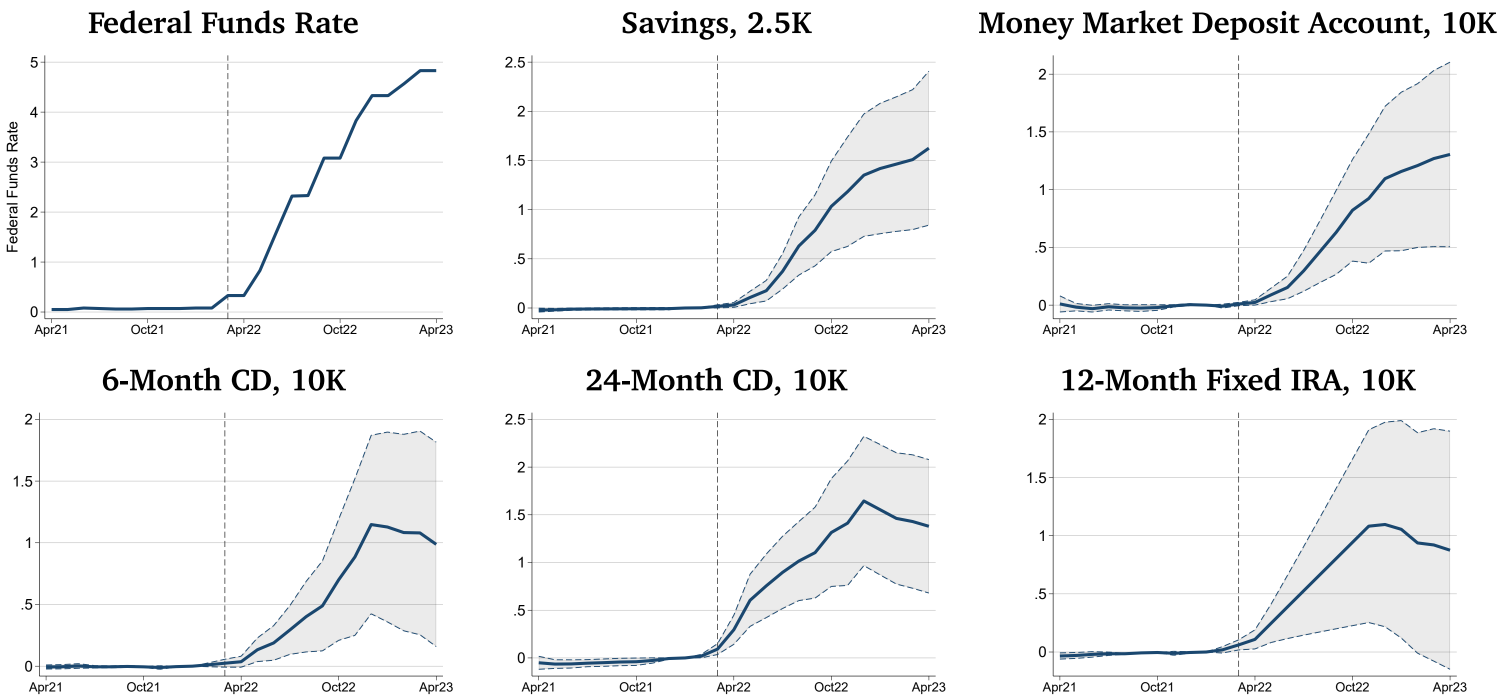


Notes: This figure plots β_t from the OLS regression $ROA_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \epsilon_{it}$ along with a 95% confidence interval. ROA_{it} is the return on assets for institution i at time t. $Online_i$ is an indicator for if institution i is an online bank. α_i and 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: 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.6: Event Studies - No Asset Threshold

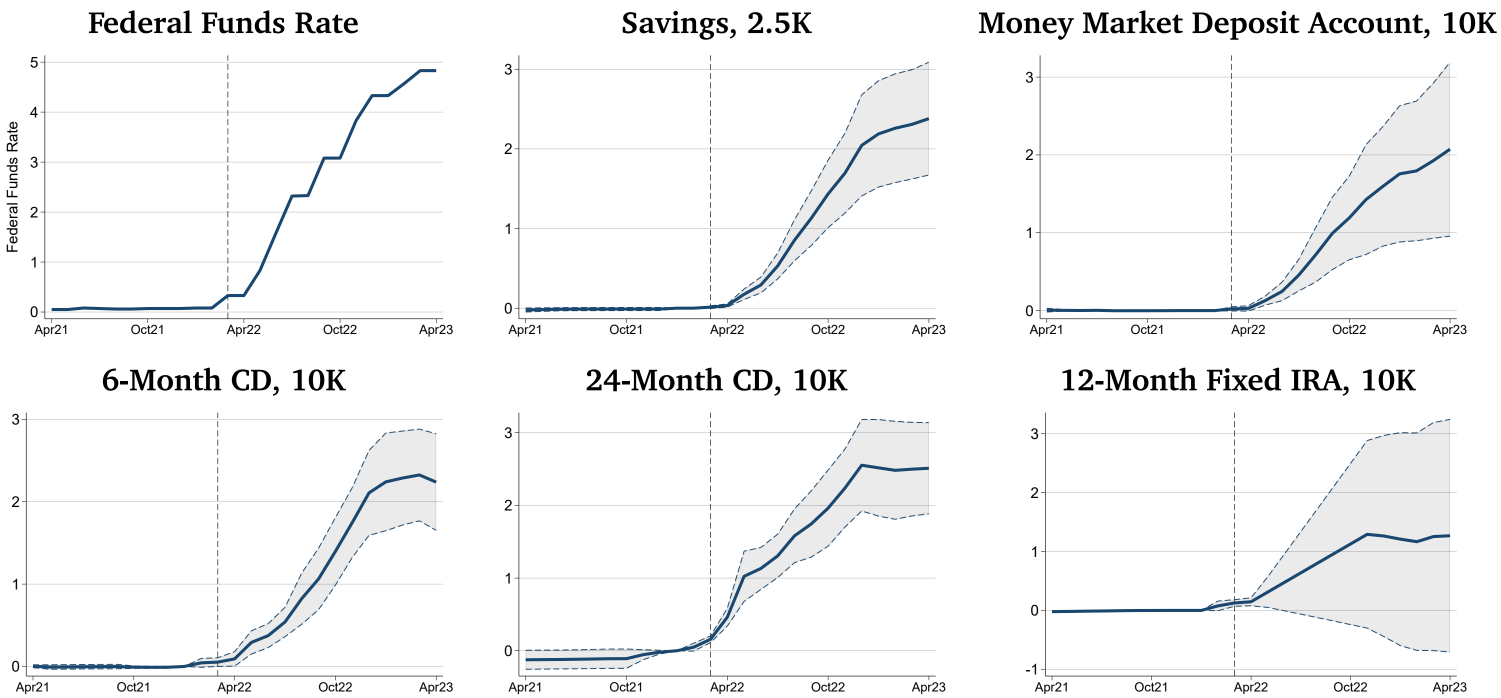


Notes: This figure plots β_t from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \epsilon_{it}$ along with a 95% confidence interval. APY_{it} is the annual percentage yield offered by institution i at time t. $Online_i$ is an indicator for if institution i is an online 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.7: 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.8: Event Studies - Total Deposits Weighted

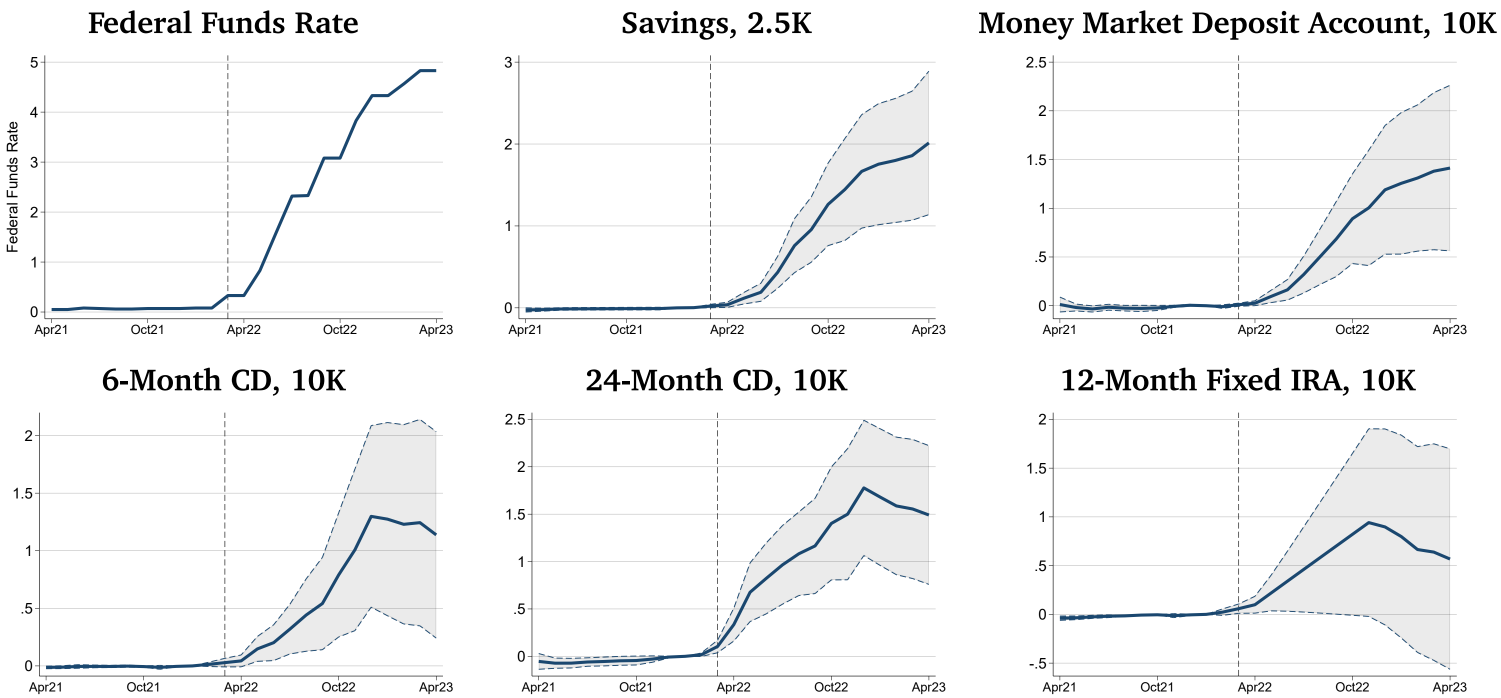


Notes: This figure plots β_t from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \epsilon_{it}$, weighted using the each bank's total deposits, along with a 95% confidence interval. APY_{it} is the annual percentage yield offered by institution i at time t. $Online_i$ 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.9: 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.10: Event Studies for Rates using Online Banks from Abrams (2019) Sample



Notes: This figure plots β_t from the OLS regression $APY_{it} = \alpha_i + \alpha_t + \sum_t \beta_t Online_i + \epsilon_{it}$ 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

B Demographics and Pass-Through

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 we think 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:

$$\text{APY}_{it} = \alpha_i + \alpha_t + \beta 1[Online]_i \times 1[PostMarch2022]_t + \sum_j \delta_j Demographic_{ji} \times 1[PostMarch2022] + \epsilon_{it} \quad (7)$$

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 B.2. If the demographics of users explains online bank's pass-through 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 pass-through. 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 B.3. Estimates again remain large and significant.

Table B.1: Online Banking Demographics

	Mean	SD	Max	Min	Median	Obs
Never Used Online Banking						
Age 65+	0.45	0.50	1.00	0.00	0.00	5352
College Degree	0.14	0.35	1.00	0.00	0.00	5352
Minority	0.42	0.49	1.00	0.00	0.00	5352
Low Income	0.52	0.50	1.00	0.00	1.00	5352
Used Online Banking						
Age 65+	0.19	0.39	1.00	0.00	0.00	23278
College Degree	0.43	0.49	1.00	0.00	0.00	23278
Minority	0.29	0.46	1.00	0.00	0.00	23278
Low Income	0.16	0.37	1.00	0.00	0.00	23278

Notes: This table presents 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. Source: 2019 SCF

Table B.2: 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	1.124***	0.809***	0.944***	1.498***	0.803*
	(0.225)	(0.217)	(0.268)	(0.308)	(0.428)
Observations	101274	93865	99604	98920	71645
Has Computer Control	✓	✓	✓	✓	✓
Internet Access Control	✓	✓	✓	✓	✓
Age 65+ Control	✓	✓	✓	✓	✓
College Degree Control	✓	✓	✓	✓	✓
Minority Control	✓	✓	✓	✓	✓
Low Income Control	✓	✓	✓	✓	✓
Branch FE	✓	✓	✓	✓	✓
Time 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 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. 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 B.3: 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	1.059***	0.743***	0.893***	1.478***	0.738**
	(0.205)	(0.208)	(0.225)	(0.259)	(0.366)
Observations	4012	3691	3842	3963	3490
Branch FE	✓	✓	✓	✓	✓
Time 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. 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. $^*p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$

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.[18] Because of low RateWatch coverage only these 17 banks are used during our analysis.[19]

Aside from Alliant Credit Union and Discovery Federal Credit Union (two large online credit unions), 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.

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

[19]See Table A.2 for a complete list of these 17 banks and their overlap with Abrams (2019).

C.2 Rate Setting Branch Weighting

In Table 5 Panel B, we substitute our main sample of brick-and-mortar annual percentage yields for annual percentage yields weighted by the total number of deposit each rate setting branch governs. This is done using branch level data in the 2020 Summary of Deposits data (SOD) provided by the FDIC. Because some banks book deposits at their headquarters location we exclude branches with deposits above $10 billion. For each rate setting branch we aggregate the total branch deposits of the branches governed by the respective rate setting branch at the product level. We then average annual percentage yields at the bank-month level weighted by the total deposits each branch governs.

C.3 High and Low Competition Branches

In Table 4 Panels A and B, we split bank's branches by HHI. This is done by calculating the county level HHI for each branch using the 2020 Summary of Deposits data. For each product we then calculate the median HHI and classify branches as high or low competition branches based on if their HHI is above or below the median. For each bank's product we average the annual percentage yield of their low competition branches and their high competition branches separately.

C.4 Avg Bank HHI Weighting

In Table 4 panels C and D we split our brick-and-mortar banks by average HHI. This is done by calculating the county level HHI for each branch using Summary of Deposits data. We then average each bank's HHIs weighted by the respective branch's total deposits in 2020. For each product we calculate the median HHI and define low competition banks as those with average HHIs above the median HHI and high competition banks as those with average HHis below the median HHI.