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DESTABILIZING DIGITAL "BANK WALKS"

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ABSTRACT

We study the impact of digital banking on the value of the deposit franchise and the stability of the banking sector. Using the classification of digital banking in Koont (2023), we find that when the Fed funds rate increases, deposits flow out faster, and the cost of deposits increases more in banks that offer a mobile app and brokerage services. Using the model of Drechsler et al. (2023b), we find that correcting for digital betas and deposit outflows results in a deposit franchise value that is 14-22% lower for digital-broker banks relative to traditional banks. Moreover, we find that digital-broker banks' deposit franchise values increase by less when interest rates rise, serving as less of a hedge. We apply this analysis to the case of Silicon Valley Bank (SVB) and find that the reduced value of the deposit franchise can explain why SVB was insolvent in early March 2023, even before the bank run occurred.

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1 Introduction

Banks are in the business of maturity transformation (Diamond and Dybvig, 1983; Kashyap et al., 2002; Hanson et al., 2015), which exposes them to liquidity and interest rate risk. One of the main reasons why banks can bear this risk is that deposits are “sticky”, i.e. they are not very sensitive to movements in interest rates (Drechsler et al., 2021). This stickiness of deposits gives rise to what is referred to as a bank’s deposit franchise value, the value of the “intangible asset that arises from the bank’s ability to pay below-market rates on deposits” (Drechsler et al., 2023b). The deposit franchise value of a bank increases with interest rates. Thus, it serves as a hedge against drops in the bank’s asset values that are the result of those increases in interest rates. This has important implications for bank valuation and stability.

The value of the deposit franchise is a function of the stickiness of deposits: how much (and for how long) depositors are willing to tolerate a remuneration of deposits much below the policy rate. This stickiness is in turn driven by many factors, such as what the deposits are used for or how sophisticated the depositors are. *Ceteris paribus*, however, technology is an important factor. A mobile app makes it easier for depositors to walk away when the rate on deposits is too low since they can move their money to a money market fund without leaving their sofa, just by using their smartphone. Since the Great Financial Crisis, more than half of all commercial banks have introduced a mobile application (Koont, 2023). As a result, it is reasonable to expect that the demand for bank deposits has become much more sensitive to the interest rates offered by alternative forms of liquidity storage (like money market funds), especially in banks with well-functioning digital platforms.

In this paper, we study how the introduction of digital banking has changed depositors’ propensity to walk away and how this reduced stickiness has impacted the franchise value of deposits and, consequently, the stability of the banking sector.

We start by documenting that, on average, deposits have become more sensitive to changes in the Fed funds rate in the last decade. While the time series evidence is consistent with the digitalization hypothesis, it is difficult to link it to one particular channel. To shed more light on the effects of digitalization, we turn to the cross section of banks. We find that this deposit sensitivity is particularly pronounced for the deposits of banks with a digital platform and the deposits of banks which offer brokerage services, which facilitate customers’ reallocation of savings from low interest paying deposits to more remunerative investments without the need to switch insti-

tutions. Depending on our definition of digital banks, we find that a 425bps increase in the Fed funds rate, roughly what the Fed increased rates in 2022, leads to a differential drop in deposit growth of 7.2% for non-digital banks without a brokerage, which we refer to as “traditional” banks, but between 11.05% and 18.7% for digital banks with a brokerage.

Banks’ decisions to offer a digital application or brokerage services may correlate with other characteristics that lead to differential deposit outflows. To provide evidence that our observed effects operate through digitalization, we consider deposit flows within-bank-year, looking at variation across their branch networks. Specifically, for a given bank, we look at whether deposit flows are more sensitive in counties that have higher internet usage, depending on whether the bank is digital or not. Internet usage proxies for the extent to which local customers make use of digital banking. We find that banks’ deposit outflows and rate increases are more pronounced in markets with higher internet usage, but that this is only the case for digital banks. This finding supports the interpretation that it is digital banking that has led banks’ deposits to become more sensitive to shocks in the Fed funds rate, rather than some unobserved characteristic of these digital banks.

Digital banks’ greater deposit outflows in response to increases in the Fed funds rate may arise for two very different reasons: flightier depositors prefer digital banks, or digital banks make depositors flightier by reducing the costs of moving deposits around. Identifying the true channel has important financial stability implications. In the first case, digitalization concentrates flightier depositors in digital banks, increasing the risk to the stability of these banks but not that of the overall banking system. In the second case, digitalization increases the overall financial stability risk by increasing the number of flightier depositors. To shed light on which of these two channels is driving our results, we study how county-level aggregate deposit outflows are affected by the diffusion of digital banks, measured as the proportion of digital banks operating in a county. Since digital banks may strategically enter markets where depositors are flightier, we proxy the presence of a digital bank in a county with the presence of the same bank in that county in 2009 before the proliferation of mobile banking. We show that there is a greater deposit outflow at the county level when there are more digital banks, suggesting that the differential deposit outflow of digital banks is not all due to re-sorting among depositors but that digitalization makes depositors flightier.

Having established that digital banks experience greater deposit outflows in response to increases in the Fed funds rate, we move to analyze how digitalization affects the response of

deposit rates to changes in Fed funds rate, also known as deposit beta. We find that the beta of digital-broker banks is significantly higher, between 0.44 and 0.46, compared to the beta of an average bank of 0.39.

The interest-sensitivity of banks' deposit flows along with banks' deposit betas are key determinants of the value of banks' deposit franchise, and indeed are two of the key parameters in Drechsler et al. (2023b). Having obtained estimates for both of these parameters, we can evaluate how digitalization affects the value of banks' deposit franchises. We first consider the value of deposit franchise after an increase in the Fed funds rate of 425bps. We find that correcting for the different betas and deposit outflows of digital banks results in a deposit franchise value that is 14-22% lower for digital-broker banks relative to a traditional bank. Then, we estimate the cyclicity of banks' deposit franchise value by calculating the change in deposit value following an increase in the Fed funds rate. We find that in the presence of positive interest rate shocks, digital-broker banks experience lower increases in their deposit franchise values when compared to traditional banks. Not only is the deposit franchise less valuable in digital banks, it is also less of a natural hedge against interest rate fluctuations.

Going forward, it is possible that digitalization will alter not only deposit outflows and betas, but also the costs of servicing these deposits. Accordingly, we assess the robustness of our findings as we vary the differential cost of servicing deposits in traditional and digital-broker banks. We find that as costs decrease toward zero, digital brokers' deposit franchise value increases and can rise above that of traditional banks if the benefit-to-cost ratio is large enough. If the level of deposit franchise in digital-broker banks can be higher, its procyclicality is always lower: in digital-broker banks the deposit franchise value increases less than in traditional banks when the Fed funds rate rises for any level of costs. Thus, an important result of this paper is that future digitalization will reduce the natural hedge that banks' deposits provide against rate increases, reducing the ability of the banking sector to engage in maturity transformation.

Finally, we compute the solvency of SVB in 2022, prior to the deposit runs. We evaluate the deposit franchise value of SVB with both digital-broker parameters as well as traditional parameters, constructing thus a fictitious "traditional SVB". We allow both the costs of servicing deposits and the natural decay of deposits to vary, as we do not have estimates for these parameters. We find that there is a region of parameter values for which SVB would remain solvent if it were a traditional bank but is insolvent once we recognize that it is a digital broker bank. In the presence of the aggressive interest rate hikes observed in 2022, SVB's digital nature made it

cross the solvency line sooner through the destabilizing “walk” of digital deposits seeking higher rates elsewhere. This example illustrates how much more fragile the banking system has become and the additional challenges to monetary policy that digitalization brings.

Related Literature.

Our work builds on a recent set of influential papers by Drechsler et al. (2017, 2021) and Drechsler et al. (2023b). In Drechsler et al. (2017), these authors show that as monetary policy tightens and interest rates increase, banks increase spreads, and deposits flow out of the banking system. They show that the limited passthrough of Fed funds rate to deposit rates is more pronounced in more concentrated banking markets.¹ In Drechsler et al. (2021) and Drechsler et al. (2023b), they explore the implications of this finding for financial stability. In particular, they argue that maturity transformation serves as a hedge to banks’ interest rate risk: “The reason is the deposit franchise, which allows banks to pay deposit rates that are low and insensitive to market interest rates. Hedging the deposit franchise requires banks to earn income that is also insensitive, that is, to lend long term at fixed rates.” The key parameter is then the “deposit beta”, which determines how much deposit rates, r_d , fluctuate with policy rates, as in $r_d = \beta r$, where r is the policy rate and $\beta \in (0, 1)$ is the deposit beta. As mentioned, they attribute this limited passthrough to imperfect competition.² We show a different determinant of limited passthrough: technology. We also explore the corresponding financial stability implications of this channel.

Digitalization increases the willingness of depositors to walk away when the Fed funds rate increases and banks pass through only a limited increase to their deposit rates. We build on Koont (2023), who documents that banks’ digital platform adoption leads to compositional changes in funding towards less stable deposits that require higher interest rates and are more sensitive to bank risk. We follow Drechsler et al. (2021)’s empirical methodology closely and re-estimate the sensitivity of deposit rates to shocks in the Fed funds rate depending on whether banks have digital platforms and offer their customers brokerage services.

¹See also Berger and Hannan (1989), Diebold and Sharpe (1990), Hannan and Berger (1991), Neumark and Sharpe (1992) and Driscoll and Judson (2013). For an early review of the empirical literature on competition in banking, see Degryse and Ongena (2008).

²Hutchison (1995) is, to our knowledge, the first one to propose a formal equilibrium model of imperfect competition in deposit markets in which a constant deposit beta arises out of bank profit maximization; he also shows how this deposit beta depends on the actual number of banks present in the market. See in particular equation (35) in that paper and the discussion around it.

The stickiness of deposits is an important source of value for banks: The ability of the bank to retain deposits at rates below those depositors could, in principle, obtain elsewhere is potentially a significant component of its equity market value, as we document below. Hutchison and Pennacchi (1996) were the first to write a model to estimate what they referred to as "a bank's monopoly rent from issuing retail deposits." More recently, Drechsler et al. (2023b, p. 9) have referred to the difference between the book and market value of deposits as the deposit franchise value of the bank. This value is, of course, directly related to the sensitivity of deposit rates to other rates available to depositors. Our paper is the first to use this framework to assess the effect of digitalization on the value of the deposit franchise. We argue that digitalization lowers this value and that this has important consequences for financial stability as it lowers the countercyclicality of the deposit franchise value: The deposit franchise value increases by less for digital-broker banks than for traditional banks when interest rates rise.

More broadly, all these findings are important because they speak to the sensitivity of bank profitability to interest rate changes and overall financial stability.³ In particular, our work connects to Egan et al. (2017) and Jiang et al. (2023). Egan et al. (2017) explore the financial stability consequences of uninsured depositors sensitivity to bank distress. Uninsured depositors are more likely to withdraw in the presence of an increase in the CDS spreads, for instance; the more sensitive uninsured depositors are to distress, the higher the interest rates that banks have to offer depositors, which lowers profitability and makes the existence of a run equilibrium more likely. Jiang et al. (2023) explore the financial stability consequences associated with the losses in the banks' hold-to-maturity portfolios. These losses are the result of the unprecedented speed of interest rate rises by the Federal Reserve throughout 2022 (see also Drechsler et al. (2023a)). If interest rate increases are small, so are the losses and a run equilibrium does not exist, whereas it does if the rate hike is large enough. Acharya et al. (2023) are concerned with the instability of deposit funding associated with the expansion and contraction of the Fed's balance sheet during

³Samuelson (1945) is an early reference in the literature; see also Hancock (1985). Flannery (1981, 1983) finds that bank profitability have a low exposure to interest rate changes, the reason being that "large banks have effectively hedged themselves against market rate risk by assembling asset and liability portfolios with similar average maturities." English (2002) presents some international evidence consistent with this lack of exposure of bank profitability to interest rates. A more recent literature explores banks' exposure, or the lack thereof, to interest rates shocks using balance sheet data; see for instance Begenau et al. (2015), amongst others. Finally, another literature looks at changes in bank equity valuation due to shocks in interest rates. See, for example, English et al. (2018), who use high frequency data to assess the effect of FOMC announcements on bank stock valuation.

QE and QT (quantitative tightening) episodes: Banks finance reserve holdings with deposits but do not shrink them when they lose them as the Fed pivots away from QE to QT. Financial market integration is another channel that can affect deposit stability. D’Amico and Alekseev (2024) study the dynamics of US financial markets integration between 1953 and 1983. They argue that the increase in nominal interest rates reduced the dispersion of lending rates across states significantly, as households substituted low paying local deposits with national instruments marketed precisely to facilitate the reallocation of funds across state lines, such as negotiable CDs.

Our paper is also closely related to Haddad et al. (2023). These authors propose a model in which depositors face a cost when switching from one bank to another. They investigate the depositor incentives to switch even when fully insured. In their model, depositors value the stream of services banks offer in addition to the interest in deposits. Banks can still fail, which occurs when all depositors withdraw their deposits. In this case the depositor loses the present value of the stream of services associated with her deposit account. This makes her more likely to switch, and these switching incentives are more pronounced when interest rates are high. The usual complementarity obtains across depositors, which results in a run equilibrium even when depositors are fully insured: Depositors run not because that allows redemption in full ahead of others, but simply because when failure is anticipated the present value of the stream of banking services is lower, justifying bearing the costs of switching. We provide evidence that one effect of digitalization and brokerage services is to lower the cost of reallocating funds across more remunerative alternatives, either across banks or other vehicles such as mutual money market funds offering higher rates or within banks offering brokerage services. Digital-brokerage banks increase their betas, offering a higher interest rate to depositors to compensate for these lower switching costs, and in doing so lower their franchise value.

Finally, there is a small but rapidly growing literature on the effect of digitalization on banks.⁴ In a contemporaneous piece Erel et al. (2023) study online banks’ deposit flow sensitivity to changes in the Fed funds rate. Their focus is on banks that interact with customers mostly or entirely online, and their sample comprises seventeen banks that represent about 5% of total system deposits. They find that online banks increase interest rates significantly more than traditional banks and do not experience deposit outflows. We focus on banks that have branches and digital platforms, not online-only banks, and find that they increase rates more than banks with no digital platforms, but likely less than these online-only banks, and that in addition they

⁴See Stulz (2019) for a discussion of how digitalization and FinTech threaten banks’ business models.

experience greater deposit outflows than traditional banks. In subsequent work to the present piece, Benmelech et al. (2023) study the relation between branch density, bank branches divided by deposits, and deposit inflows and outflows. They show that banks with low branch density experienced larger deposit outflows during the banking crisis in the first quarter of 2023. They suggest that digital banking allows banks to grow their (uninsured) deposit base fast, but that these inflows are fickle and ready to leave at the first sign of bank trouble. We instead use a direct measure of digitalization and estimate the deposit beta, as well as the deposit outflow sensitivity of these banks, which allows us to estimate the deposit franchise value for them and study banking stability in a world of digital banking and interest rate shocks. Lu et al. (2024) find that customers shift deposits across bank accounts more actively as payment technologies become more efficient, which provides complementary evidence in a different context to our findings that digitalization leads to a more interest-sensitive deposit base. Related to the recent banking crisis, Cookson et al. (2023) document the role of social media, specifically Twitter, in fueling the bank run at SVB. In the broader literature on bank digitalization, Jiang et al. (2022) explores the effects of bank competition in the era of digital banking on financial inclusion. Haendler (2022) documents the effects of mobile banking competition on the business models of small community banks. Hong et al. (2019) show that the digitalization of asset management can lead to highly synchronized investor behavior. Curi et al. (2023) show that the digitalization of banking has been a significant factor in market valuation, especially during the Covid-19 shock. Our work is most closely related to Koont (2023), who traces out the effects of endogenous adoption of digital platforms on the industrial organization of the banking sector and the effects on financial stability through changes in banks' balance sheet composition. We focus on the effect of digitalization on the stickiness of the deposits and the value of the deposit franchise.

2 Data and Definitions

Digital Banks. Our data on banks' digital platforms comes from Koont (2023), who constructs a data set related to the introduction of digital banking platforms for the universe of US banks. Specifically, our measure of banks' digital presence is based on the release dates of banks' earliest mobile applications on either the Apple or Android App Store. In order to focus our analysis on banks with significant usage of digital platforms, we leverage information on the number of reviews that these applications have received on the iTunes app store up to 2022, and we take a

higher number of reviews to correlate with significant use of the digital platform.

We consider two classifications of *Digital* banks. Our first classification is binary, $\text{Digital}_{b,t}^B$ in which we define a bank to be digital in a given year t if it has a mobile banking application in year t with at least 300 reviews. This measure is attractive in that it provides a simple classification, however it misses banks with fewer than 300 application reviews, and may correlate with bank size due to a lack of normalization of the review count. Accordingly, our second classification is continuous, $\text{Digital}_{b,t}^C$, in which we define the digital services offered by a bank in a given year t to be,

$$\text{Digital}_{b,t}^C = \frac{\text{Number of mobile application reviews}}{\text{Average number of deposit accounts 2010–2022}}, \quad (1)$$

if the bank has a mobile banking app in year t . We winsorize this measure at 1% and normalize it to range from 0 to 1 across the sample for interpretability. Table 1 panel A provides summary statistics related to these classifications for the universe of commercial banks in 2022, and Table 1 panel B repeats the analysis focusing only on banks with between \$1 and \$250 billion in asset size.⁵

Brokers. In addition to identifying digital banks, we categorize banks depending on whether or not they have a brokerage. In order to do so, we collect banks’ income in fees and commissions from securities brokerage from the FFIEC Consolidated Reports of Condition and Income, generally referred to as Bank Call Reports. These regulatory filings provide quarterly bank-level information for every U.S. commercial bank. We find that 8% of banks report non-zero brokerage income in 2022. Throughout the paper, we define a bank to be a *Broker* if it reports non-zero brokerage income. Table 1 panel A tabulates the number of banks that are brokers and that are digital in 2022, and Table 1 panel B repeats the tabulation focusing only on banks with between \$1 and \$250 billion in asset size. We winsorize constructed deposit growth variables at 1%.

Traditional Banks. To simplify our terminology, we refer throughout as banks that are neither digital nor brokers as “traditional banks”.

Bank Deposits. We construct various categories of bank deposits, as following. First, we con-

⁵From Table 1, it is clear that banks with larger asset size tend to adopt digital platforms. For more on banks’ endogenous digital platform adoption decisions, see Koont (2023).

sider bank-level deposits, which we take to be the sum of savings deposits, demand deposits, and time deposits from banks' Call Reports. Second, we consider bank-level estimated insured deposits from the FDIC SDI. Both of these deposit categories are reported quarterly. Finally, at the bank-branch level, we obtain annual deposits from the FDIC Survey of Deposits (SOD).

Additional Data Sources. We thank Jiang et al. (2023) for providing data and measures on banks' marked-to-market securities losses in 2022. We further collect additional bank balance sheet quantities from banks' Call Reports, and hand-collect information from SVB's consolidated quarterly reports. Table 1 panel C provides summary statistics on balance sheet quantities and deposit rates.

For our within-bank analysis, we obtain annual branch locations from the FDIC Survey of Deposits. We collect the proportion of households in a county that have internet subscriptions from the 2019 Census American Community Survey, using the 5-year estimates. For our aggregate county-level analysis, we obtain annual county-level median income from the Census Small Area Income and Poverty Estimates (SAIPE). We obtain annual county-level number of establishments, employees, and payroll from the Census County Business Patterns (CBP).

Aggregate time-series data on nominal commercial bank deposits, GDP, and the effective federal funds rate come from Federal Reserve Economic Data (FRED). Throughout the paper we refer to the effective federal funds rate as the "Fed funds" rate.

3 Deposit walks and interest expense betas

3.1 Deposits and interest rates: Time series evidence

The stability of deposits plays a central role in the banking literature. Other than their payment needs, depositors may withdraw funds either because they are concerned about the health of the bank and they hold uninsured deposits, or because they hope to obtain higher interest rates on their funds than those paid by the bank on their deposits. Our focus is on this second source of deposit sensitivity. In particular, it is the stickiness of deposits that is the source of the banks' deposit franchise value: The component of bank value that is due to the fact that deposits remain with the bank even when interest rates go up by more than the interest paid on deposits. Increases in interest rates may result in higher net interest margins if banks have a sizable portfolio of

adjustable interest rate loans or are able to originate new loans at high rates, and rates on deposits increase by less. These gains partially compensate for the losses borne by banks on their assets as interest rates increase, such on their holdings of securities and fixed rate loans. The value of banks' deposit franchise falls if deposits become less sticky, which has implications for bank solvency.

To begin exploring whether bank deposits have become more sensitive to interest rate shocks, we estimate a simple time series regression of changes in normalized deposits to changes in the Fed funds rate. Specifically, for each decade in the sample we run the following time series regression with quarterly data from 1973 to 2023,

$$\Delta (\text{Deposits/GDP})_{t,t-1} = \beta_0 + \beta_1 \times \Delta FFR_{t,t-1} \times \text{Decade}_t + \varepsilon_t, \quad (2)$$

where $\Delta (\text{Deposits/GDP})_{t,t-1}$ is the difference in the ratio of nominal deposits to nominal GDP from quarter $t - 1$ to quarter t , $\Delta FFR_{t,t-1}$ is the difference in the Fed funds rate between quarter $t - 1$ and t in percentage points, and Decade_t is an indicator variable for each decade.⁶

Table 2 reports the results. Figure 1 Panel B suggests that the elasticity of deposits as a share of GDP with respect to increases in Fed funds rate is much higher in recent years. Table 2 shows time series evidence that is consistent with this hypothesis: Deposit outflows in the presence of interest rate increases were more pronounced starting in the first two decades of the 21st century than in the last third of the 20th. In the 2000s, a 100 bps increase in the Fed funds rate was associated with a 0.5% decrease in deposits to GDP, which is statistically significant, but not economically large. In the 2010s and onward, however, a 100 bps increase in the Fed funds rate is associated with a 2.7% decrease in the deposit-to-GDP ratio. In the second column of Table 2, we include an indicator variable for the spike of deposits in the second quarter of 2022 related to the Covid-19 pandemic stimulus, and find that this event does not fully explain the increased elasticity in recent years.

In general, there are several reasons why the sensitivity of deposits to the Fed funds rate might be greater in the last 25 years. First, money market funds were created only in 1971 and started to be massively diffused only at the end of the 1990s. Second, the 1999 repeal of Glass Steagall allowed banks to own brokerage accounts and integrate them in their services. Last but not least, Koont (2023) documents that since the Great Financial Crisis, there has been signif-

⁶Given data availability, the 1970 decade ranges from 1973 through 1979, and the 2010+ decade includes 2010 through 2023.

icant adoption of mobile applications by commercial banks, further facilitating moving funds from bank deposits to money markets. As a result, moving money from a deposit to a money market fund can be done with a single mouse click without leaving the living room sofa. Thus, it is reasonable to expect that the demand for bank deposits has become much more sensitive to the interest rates offered by alternative forms of liquidity storage (like money market funds), especially in banks with well-functioning digital platforms. In order to disentangle the effects of technological changes on deposit sensitivity, we turn next to the cross-section of banks.

3.2 Digital Banking and the sensitivity of deposits to interest rates

3.2.1 Digital banking, brokerage and deposit outflows in 2022 and 2023

We are interested in analyzing whether digital banks see greater deposit outflows when there are increases in the Fed funds rate. As a starting point, we look at deposit flows during the rate hikes of 2022. Figure 2 Panel A plots the quarterly growth rate in deposits (the sum of demand, savings, and time deposits) averaged across banks for digital and non-digital banks, using our binary classification of digital banks.⁷ We focus on mid-sized banks, those between \$1B and \$250B in assets, as they have been at the center of much of the turmoil in early 2023. Table 1 panel B documents that 50% of these mid-sized banks are digital.

The analysis is restricted to the period of monetary tightening and thus we start the plot in the third quarter of 2021. In the third quarter of 2022, the rate of growth of deposits for digital and non-digital banks diverges as the pace of Fed funds rate increases accelerates. In fact, digital banks start experiencing deposit outflows in the fourth quarter of 2022. In the debate following the collapse of SVB, much has been made of the differential behavior of insured versus uninsured deposits. In panel B we restrict our attention to banks' insured deposits. While the overall growth trends are more muted, the divergence in rates of growth for digital and non-digital banks is even larger at the end of 2022. Whatever happened in the banking system in late 2022 and early 2023

⁷This figure differs slightly from Figure 1 in our blog post in the Promarket website. In this paper our binary definition of digital banks are those that have greater than 300 reviews on their mobile application. In the blog post, we had excluded banks below \$5B in asset size, and given the sample of larger banks, had used a stricter definition of digital banks to be those that had (in logs) a number of reviews to deposits in the top quartile of the distribution and greater than 300 reviews. See <https://www.promarket.org/2023/04/04/destabilizing-digital-bank-walks/>

was not just about the flight of uninsured deposits.

In addition, banks that supply brokerage services facilitate transferring deposits to other accounts, such as money market mutual funds. To explore this channel, we further split banks depending on whether they are brokers, as described in Section 2. There are thus four types of banks, traditional banks that have neither a digital platform nor report brokerage fees, banks that have no digital platform but offer brokerage services, banks that have digital platforms but no brokerage services and finally digital-brokers, those banks that offer both digital banking as well as brokerage. Figure 2 Panel C shows that brokerage makes a difference: Banks with brokerage services experienced lower deposit growth than traditional banks in the second half of 2022. Finally, in Figure 2 panel D we consider insured deposits, we find that traditional banks maintain stable insured deposit growth through the end of 2022 while digital-broker banks experience nearly a 2% decline in their insured deposit growth throughout 2022.

3.2.2 Bank-level panel regressions

To formalize the findings in Figure 2 that digital banks see greater outflows when there are increases in the Fed funds rate, we next estimate a panel regression of the form,

$$\begin{aligned} \frac{Y_{b,t} - Y_{b,t-1}}{Y_{b,t-1}} = & \alpha_b + \beta_1 \Delta FFR_{t,t-1} + \beta_2 \Delta FFR_{t,t-1} \times \text{Digital}_{b,t} + \beta_3 \Delta FFR_{t,t-1} \times \text{Broker}_{b,t} \\ & + \beta_4 \Delta FFR_{t,t-1} \times \text{Digital}_{b,t} \times \text{Broker}_{b,t} + \beta_5 \text{Digital}_{b,t} + \beta_6 \text{Broker}_{b,t} \\ & + \text{Controls}_{b,t} + \varepsilon_{b,t} \end{aligned} \quad (3)$$

where $Y_{b,t}$ is the outcome variable of interest in each specification. We expand our analysis to the universe of banks annually between 2010 and 2022. The main explanatory variables are $\Delta FFR_{t,t-1}$, the difference in the Fed funds rate between years $t - 1$ and year t , in percentage points, interacted with the corresponding indicator variables. $\text{Digital}_{b,t}$ is a variable which tracks bank b 's digital classification in year t , and we consider both our binary and continuous measures in turn. $\text{Broker}_{b,t}$ is an indicator variable that takes the value one if bank b has a brokerage in year t . We include in the specification the level terms of $\text{Digital}_{b,t}$ and $\text{Broker}_{b,t}$ to capture the average effects of these characteristics on banks' deposit growth. In $\text{Controls}_{b,t}$ we also include the log assets of the bank (lagged one period) and its interaction with differences of the Fed funds rate. Finally, we include a bank fixed effect, α_b , to absorb out time invariant bank characteristics such as the average size of each bank. In Appendix Table A.1 we also show the robustness of our

results to including a year fixed effect.

Tables 3 and 4 reports the estimates for different outcome variables of interest, using the binary and continuous classification, respectively, of banks' digital services. We consider two deposit categories: in both tables, columns (1) and (2) consider all deposits, and columns (3) and (4) consider insured deposits, as defined in Section 2.

Beginning with our binary classification of digital banks, Table 3 column (1) reports that a 100bps increase in the Fed funds rate decreases the rate of growth of all deposits in a digital bank by 2.6%, compared to 1.7% for traditional banks. This specification includes level controls for Digital and Broker, which enter positively and negatively, respectively: Digitalization increases the rate of growth of deposits in the cross section, whereas the existence of a brokerage decreases them, presumably because of the reallocation away from deposits and into brokerage accounts when that option is available. Thus, digitalization helps banks grow their deposits faster, but renders them more sensitive to interest rate shocks, highlighting the double edged sword nature of digitalization for banking stability.⁸ In column (2) we find that the results are robust to the inclusion of size effects (as measured by the Lag Log Assets) even when interacted with the shocks to the Fed funds rate.

In columns (3) and (4) of Table 3, we next consider the growth of insured deposits. We find that a 100bps increase in the Fed funds rate reduces the growth of insured deposits in a digital bank by 1.9%, compared to 1.4% for traditional banks. In column (4) when we additionally include size controls, the reduction in growth becomes 4.6% for digital banks relative to 3.8% for traditional banks. The level controls for Digital and Broker remain strongly significant throughout both specifications.

In Table 4 we report the same regressions but now using the continuous digital classification defined in expression (1). We find that the results remain very similar. Throughout specifications and definitions of deposits, a positive shock to the Fed funds rate results in an additional drop in the rate of growth of deposits for digital banks relative to traditional banks. For instance, in column 1 we find that a 100bps positive increase in the Fed funds rate results in a 2.9% slowdown in growth of all deposits for digital banks, relative to 1.7% for traditional banks. As before, the slowdown in deposit growth is robust to the inclusion of size controls.

With the continuous measure of digital banks, we find that the slowdown in deposit growth

⁸We thank our discussant Marianne Farboodi for encouraging us to highlight this specification and suggesting this interpretation.

is even stronger for digital banks that additionally offer brokerage services, our “digital-broker” banks. For instance, in column 1 we find that digital-broker banks see an additional 1.5% slowdown in the growth of all deposits, resulting in an overall slowdown of 4.4% ($= 2.9 + 1.5$) in the growth of all deposits for these banks, relative to the 1.7% at traditional banks.

In sum then, digital-broker banks grow their deposit faster, but experience large deposit outflows in response to increases in the Fed funds rate, relative to traditional banks that do not offer these services.

3.2.3 Within-bank-year panel regression

The fact that a bank has a digital platform or offers its clients brokerage services may correlate with other characteristics that make deposits behave differently in response to changes in the Fed funds rate. To provide evidence that our observed effects operate through digitalization, we next estimate the following within-bank regression,

$$\frac{D_{b,c,t} - D_{b,c,t-1}}{D_{b,c,t-1}} = \alpha_{bt} + \gamma \Delta FFR_{t,t-1} \times \text{Internet}_c + \beta \Delta FFR_{t,t-1} \times \text{Internet}_c \times \text{Digital}_{b,t} + \varepsilon_{b,c,t}. \quad (4)$$

The dependent variable is the deposit growth of bank b in county c across year t . Bank b ’s deposits in a given county c are calculated as the sum of all deposits accruing to branches of bank b within the county c . We estimate this bank-county-year panel between 2010 and 2022. The inclusion of a bank-year fixed effect α_{bt} restricts variation to be across different counties that a bank operates in when it faces a shock to the Fed funds rate, where the “treatment intensity” is determined by each county’s internet usage, Internet_c . The main explanatory variable now is thus $\Delta FFR_{t,t-1} \times \text{Internet}_c \times \text{Digital}_{b,t}$, which is the difference in the Fed funds rate in percentage points, interacted with the county-level proportion of households that have internet subscriptions, and additionally by a variable which tracks whether the bank offers digital services. Specifically, Internet_c is a variable that ranges from 0 to 1, and $\text{Digital}_{b,t}$ is the binary or continuous classification of digital in turn, as defined in Section 2.

Table 5 Columns (1) and (4) reports the results for the binary and continuous classification of digital banks, respectively. We find that for a given 100 bps increase in the Fed funds rate, banks with digital platforms face more pronounced outflows in markets with high internet usage. For a 10% increase in county-level internet usage, digital banks’ deposit growth is 1.1% lower according to the binary classification, or 0.8% lower according to the continuous classification.

In general, counties with high internet usage may differ in deposit flows than those with low internet usage. This granular specification allows us to consider a specification with a county fixed effect α_c , absorbing out average differences across counties,

$$\begin{aligned} \frac{D_{b,c,t} - D_{b,c,t-1}}{D_{b,c,t-1}} = & \alpha_{bt} + \alpha_c + \gamma \Delta FFR_{t,t-1} \times \text{Internet}_c \\ & + \beta \Delta FFR_{t,t-1} \times \text{Internet}_c \times \text{Digital}_{b,t} + \varepsilon_{b,c,t}. \end{aligned} \quad (5)$$

Table 5 Columns (2) and (5) reports the results for the binary and continuous classification of digital banks, respectively, and the results remain very similar. We find that for a given 100 bps increase in the Fed funds rate, banks with digital platforms face more pronounced outflows in markets with high internet usage, even after controlling for county level differences. For a 10% increase in county-level internet usage, digital banks' deposit growth is 1.0% lower according to the binary classification, or 0.8% lower according to the continuous classification.

Finally, for the most restrictive specification in this setting we can further include county-year α_{ct} and bank-county α_{bc} fixed effects. The county-year fixed effect α_{ct} takes out the county-level average effect in a given year and looking at variation across types of banks, depending on whether or not they are digital. The county-bank fixed effect α_{bc} controls for persistent differences in banks' deposit growth across counties.

$$\frac{D_{b,c,t} - D_{b,c,t-1}}{D_{b,c,t-1}} = \alpha_{bt} + \alpha_{ct} + \alpha_{bc} + \beta_1 \Delta FFR_{t,t-1} \times \text{Internet}_c \times \text{Digital}_{b,t} + \varepsilon_{b,c,t}. \quad (6)$$

Table 5 Columns (3) and (6) reports the results for the binary and continuous classification of digital banks, respectively. Even with this most stringent specification, we find that for a given 100 bps increase in the Fed funds rate, banks with digital platforms face more pronounced outflows in markets with high internet usage. For a 10% increase in county-level internet usage, their differential deposit growth is 0.6% lower according to the binary classification, after controlling for the average yearly growth rate of each county with the county-year fixed effect, and persistent differences in banks' deposit growth across counties with the bank-county fixed effect. The magnitude of the estimate for the continuous digital classification is also 0.6%, but is marginally insignificant.

Notice that this analysis allows us to address two key identification concerns. First, a worry may be that depositors of digital banks are flighty for a reason orthogonal to the existence of a digital platform. By comparing the local deposits of banks that operate within the same county,

we are able to tighten our identification by comparing depositors that are more homogeneous and that face a similar economic environment. Relative to our bank-level analysis, we are able to rule out that digital banks' depositors react differently to monetary policy shocks due to living in disparate regions of the country.

Second, the bank-year and county-year fixed effects together controls for time-varying differences in banks' investment opportunities and overall depositor clientele. For instance, it may be that the investment opportunities of banks with digital platforms deteriorate when the Fed funds rate increases by more than those of banks with no digital platform. As a result, banks with digital platform may underwrite a lower amount of loans and create less deposits. However, deposits are fungible across counties and can be invested at the bank-level, thus this alternative story does not explain why digital banks would suffer larger deposit outflows in counties with greater internet usage. If local loan growth varies across counties, leading to differential deposit growth, it should not vary differently for digital banks relative to non-digital banks within the same county.

In sum, we find that banks' deposit outflows are more pronounced in markets with higher internet usage, but that this is only the case for digital banks. Thus, through the inclusion of bank-year and county-year fixed effects, we are able to cleanly identify that digital platforms do indeed lead to greater deposit outflows in response to changes in the Fed funds rate. This finding supports the interpretation that it is digital banking that has led banks' deposits to become more sensitive to shocks in the Fed funds rate, rather than some unobserved characteristic of these digital banks.

3.2.4 County-level panel regression

Thus far, we have shown that digital banks experience greater deposit outflows in response to increases in the Fed funds rate. This may arise through two channels: flightier depositors prefer digital banks, or digital banks make depositors flightier by reducing the costs of moving deposits around. While both channels have implications for financial stability, it is particularly important to determine whether digitalization is simply leading to a reallocation of depositors or if it changes depositors' behavior.

The time-series evidence in Table 2 documents that the behavior of deposits has been changing in recent decades, becoming more sensitive to changes in the Fed funds rate. How-

ever, it is difficult to link this time-series trend to one particular channel such as digitalization. Moreover, teasing out whether differential deposit outflows are due to re-sorting or changes in deposit behavior is challenging given the lack of data on deposit account level information in the U.S. banking sector. However, county-level deposit data can provide some evidence on whether the observed differential behavior of digital deposits has aggregate implications beyond simply re-sorting depositors. In particular we assess next how positive shocks to the Fed funds rate increases county-level aggregate deposit outflows, depending on the digitalization of local banks.

Specifically, we calculate the proportion of banks that operate in the county that are digital, according to either our binary or continuous classification. Bank presence in a county though is endogenous: digital banks may enter certain counties exactly because of differential depositor behavior. In order to account for this, we use historical bank presence, prior to the adoption of mobile banking services, using the branches that banks had in 2009 to determine bank presence in each county. The set of banks present in a given county are thus the set of banks that operate at least one branch in the county in 2009. The proportion of banks that are digital in a given county in year t , $\text{Proportion Digital}_{c,t}$, then ranges from 0 to 1 and is the proportion of banks among this set that are digital in year t , according to either our binary or continuous specification. We consider the following annual county-level specification from 2010 through 2022,

$$\begin{aligned} \frac{D_{c,t} - D_{c,t-1}}{D_{c,t-1}} = & \alpha_t + \alpha_c + \beta \Delta FFR_{t,t-1} \times \text{Proportion Digital}_{c,t} \\ & + \gamma \text{Proportion Digital}_{c,t} + \text{Controls}_{c,t} + \varepsilon_{c,t}, \end{aligned} \quad (7)$$

where the outcome variable is the annual county-level deposit growth. We include year and county fixed effects, absorbing out the overall effect of changes in the Fed funds rate as well as time-invariant differences across counties. Finally, we include a variety of time-varying demographic characteristics at the county-level in the controls.

The results are reported in Table 6. Columns (1) through (3) consider our binary classification of digital banks, whereas columns (4) through (6) consider our continuous classification. We find that β is consistently negative, ranging from between -.008 to -.002, and is significant in 5 out of 6 specifications: County-level aggregate deposit outflows are larger when there are a higher proportion of digital banks present. This heightened aggregate deposit outflow at the county level strongly suggests that the differential deposit outflows of digital banks are not all due to re-sorting among depositors.

3.3 Deposit rates, interest expense betas, and digital banking

So far, the focus has been on how deposits react to increases in the Fed funds rate. In Tables 3 and 4, we document that digital banks experience greater deposit outflows in the cross-section of banks, in Table 5, we show that within-bank, digital banks face greater deposit outflows in counties with greater internet usage in the presence of increases in the Fed funds rate, and in Table 6 we document that digitalization has an effect on the aggregate county-level deposit growth. The question is, of course, whether digital banks try to resist deposit flight through increases in deposit rates.

To explore this, we next calculate a measure of banks' sensitivity of deposit interest rates to changes in the Fed funds rate. Drechsler et al. (2021) suggest an estimation technique for what they refer to as banks' deposit beta.⁹ Specifically they suggest the following specification

$$\Delta Deposit Expense_{b,t} = \alpha_b + \sum_{\tau=0}^3 \beta_{b,\tau}^{Dep} \Delta FFR_{t-\tau} + \varepsilon_{b,t}, \quad (8)$$

where $Deposit Expense_{bt}$ is the change in bank b 's deposit expenses scaled by bank b 's deposits. They define the bank-specific deposit beta as $\sum_{\tau=0}^3 \beta_{b,\tau}^{Exp}$ "to capture the cumulative effect of Fed funds rate changes over a full year".¹⁰ We follow this methodology, but estimate a single average deposit beta for each category of bank we consider, such as traditional and digital banks, rather than bank-specific betas. In this section we follow the convention in Drechsler et al. (2023b) of reporting the Fed funds rate, FFR , in decimal points so that .01 is 1 percentage point.

In order to estimate average deposit betas for traditional and digital or digital-broker banks,

⁹In the Appendix we also consider the general beta for all interest expenses in Table A.3. Additionally, in Table A.2 we calculate average deposit and interest expense betas in our full sample of banks. Notably, in column (2) of this table we reproduce the average interest expense beta found by Drechsler et al. (2021), using their time sample of 1983 through 2017. We find an average expense beta of 0.363, which is very close to their estimate of 0.345. See also Kang-Landsberg et al. (2023), who also calculate the cumulative change in deposit rates relative to the cumulative change in the Fed funds rate over several tightening cycles.

¹⁰See Drechsler et al. (2021, p. 1112) equation (9) and the discussion around it.

we estimate the following regression specification,

$$\begin{aligned} \Delta IntExp_{b,t} = & \alpha_b + \sum_{\tau=0}^3 \beta_{\tau}^{\text{Exp}} \Delta FFR_{t-\tau} + \sum_{\tau=0}^3 \beta_{\tau}^{\text{Digi Exp}} \Delta FFR_{t-\tau} \times \text{Bank Type}_{b,t} \\ & + \gamma \text{Bank Type}_{b,t} + \varepsilon_{b,t}, \end{aligned} \tag{9}$$

where $\text{Bank Type}_{b,t}$ varies depending on whether we are estimating differential betas for digital banks or digital-broker banks. When estimating differential betas for digital banks, $\text{Bank Type}_{b,t}$ is simply equal to the digital classification (either binary or continuous). When estimating differential betas for digital-broker banks, $\text{Bank Type}_{b,t}$ is equal to the product of our digital classification and our broker indicator variable. We calculate the differential deposit betas to be the sum of statistically significant coefficients $\sum_{\tau=0}^3 \beta_{b,\tau}^{\text{Exp}} + \beta_{b,\tau}^{\text{Digi Exp}}$, whereas the deposit beta for banks not of the given bank type remains the sum of statistically significant coefficients $\sum_{\tau=0}^3 \beta_{b,\tau}^{\text{Exp}}$.

Table 7 reports the results for digital and digital-broker banks, using both the binary and continuous classification of digital. In column (1) and (2), we consider the differential deposit beta of digital banks using the binary and continuous classification of digital in turn. We find that the deposit beta for digital banks is significantly higher than that of non-digital banks, at between 0.42 and 0.45 relative to between 0.37 and 0.38. The F-statistic associated with a test of statistical difference across these betas is reported at the bottom of the tables. In columns (3) and (4), we consider the differential deposit beta of digital-broker banks for the binary and continuous classification of digital in turn. Again, we find that the interest expense beta for digital-brokers is significantly higher, at between 0.44 and 0.44 compared to an average beta of 0.39. The F-statistic associated with a test of statistical difference across these betas is reported at the bottom of the tables.

Overall, the evidence in this section is consistent with the hypothesis that digital banks do indeed try to slow their “deposit walk” through increasing the rates that they offer to their depositors, resulting in higher deposit betas relative to the average bank.

4 The banking crisis of 2023

We have established that digital banking increases the sensitivity of deposits to interest rate shocks, and that banks increase their deposit rates, consistent with an attempt to stem this “deposit

walk”. What are the implications of this decreased deposit stickiness for financial stability? In Section 4.1, we first demonstrate that there are limits to the extent that banks can increase the interest that they offer to depositors without impairing their profitability. Second, in Section 4.2 we combine the evidence on deposit sensitivity and deposit betas to provide a simple estimate of the effect that digital banking has on banks’ deposit franchise value. In Section 4.3 we conclude by zeroing on Silicon Valley Bank, which is perhaps the most salient of the episodes in the banking crisis of 2023, and highlighting the lessons of our analysis for individual bank performance.

4.1 Constraints on the ability to raise interest rates

We have already demonstrated in Section 3.3 that digital banks do raise their interest rates by more as is reflected in their deposit betas; nevertheless they lose more deposits. We take this as evidence of the mobility of deposits in digital banks. Yet, digital banks do not have to lose deposits: they can match, one-to-one, any increase in the Fed funds rate. This resistance, however, would come at the expense of their profitability.

Consider as an example SVB. On March 8th, 2023, SVB gave a mid quarter presentation¹¹ in which they updated their expectations regarding deposits for the quarter, which stood in the \$167bn-\$169bn range (news accounts suggest that the drop in deposits was much higher than anticipated). In 2022 SVB had \$173.1 billion in deposits and reports \$2.2 billion in pre-tax income in its consolidated statements of income. Thus, if the bank had paid 125 bps more on its deposits, its net profits would have gone to zero.¹² The ability of SVB to raise interest rates on deposits without suffering operating income losses was not that large.

Figure 3 Panel A repeats this logic for the universe of banks in 2022. Specifically, for each bank we compute the increase in the deposit rate, expressed in basis points, which when applied to all the deposits would eliminate the bank’s 2022 operating income. As we can see from the figure, over 40% of banks would become unprofitable if they had raised the interest on deposits by 150 bps or more. In Figure 3 Panel B we repeat the same exercise restricting our attention to the banks that have losses in their held-to-maturity assets that exceed their book value of equity. For the estimate of the losses in the HTM portfolio, we rely on Jiang et al. (2023). As Jiang et al.

¹¹This presentation can be found at https://s201.q4cdn.com/589201576/files/doc_downloads/2023/03/Q1-2023-Mid-Quarter-Update-vFINAL3-030823.pdf

¹²SVB’s interest on deposits jumped from \$ 62 million in 2021 to \$862 million in 2022.

(2023) shows, there are roughly 2,300 banks that are technically insolvent if the franchise value of their deposits is zero. Of these banks, 248 cannot raise their deposits rate by more than 75 bps, otherwise they will become unprofitable. Note that since the beginning of December 2022, the Fed Funds rate has increased by 100 bps.

It is useful to put these number in perspective. As shown by Kang-Landsberg and Plosser (2022), in the first figure of their note, the spread between the Fed funds rate and interest-bearing deposit rates is not large by historical standards. Our point is that the presence of digital platforms and the bundling of brokerage services have made deposits more sensitive to increases in the deposit spread than before.

Obviously, the Fed Funds rate increases will over time increase the return on bank assets as well. Thus, the shortfall in profitability is only temporary. Nevertheless, these calculations suggest that increased sensitivity of deposits to the Fed Funds rate places banks in a difficult position: If they do not increase rates, they run the risk of losing so many deposits that they have to realize large losses. If they do not want to lose deposits, they need to increase the deposit rate, undermining, at least in the short run, their profitability and showing to the market the reduced value of their deposit franchise, precisely when the rate hikes have weakened their balance sheet.

4.2 Digital banking and deposit franchise values

Banks have the ability to pay below-market rates on their deposits due to their market power or the convenience for customers of holding these deposits for payment services. This ability is an asset, one that is not recognized in the balance sheet but that contributes to the market equity of the bank. The value of this intangible asset is referred to as the deposit franchise. How does the transformation of traditional to digital banking affect the deposit franchise value? How does it affect the sensitivity to shocks in the Fed funds rate and financial stability? How did these effects play out in the Silicon Valley Bank case? We answer the first two of these questions in this section, and the third in the next section.

We draw from the recent piece by Drechsler et al. (2023b) who propose a simple model that neatly captures the effect of a one time shock in the Fed funds rate,¹³ $\Delta f = f_1 - f_0$, on the

¹³Another formal model of the deposit franchise value can be found in Hutchison and Pennacchi (1996, Sections II and III).

value of the deposit franchise, which is given by

$$DF(f_1, \theta) = D (1 - w(\Delta f, \theta)) \left[\frac{(1 - \beta(\theta)) f_1 - c}{f_1 + \delta} \right]. \quad (10)$$

In (10), D is the initial level of deposits, before the one-time shock that takes the Fed funds rate from f_0 to f_1 is realized, and $w(\Delta f, \theta)$ is a *walk* function, the deposit outflow that occurs as a result of that interest rate shock.¹⁴ Thus the amount of deposits after the shock on the Fed funds rate is $D (1 - w(\Delta f, \theta))$. The term in brackets is simply the discounted cash-flow associated with one dollar of deposits. The bank captures the spread $(1 - \beta(\theta)) f_1$ and pays a marginal cost c per dollar of deposits every period. These cash-flows are discounted at the new prevailing rate f_1 and there is an amortization adjustment as deposits are assumed to decay at the rate δ . In expression (10), $\theta \in \{t, d\}$ is an indicator variable that takes the value d if the bank is a digital-broker one and t if it is a traditional bank.¹⁵

Drechsler et al. (2023b) use expression (10) to evaluate the cyclical properties of the deposit franchise value.¹⁶ We are instead interested in the cross sectional properties of the deposit franchise as a function of θ and how shocks to the Fed funds rate affect differentially traditional and digital-broker banks.

Consider first the level. Our results show that digital-broker banks have higher deposit betas, so that $\beta(d) > \beta(t)$, and that digital-broker banks experience larger outflows in the presence of positive interest rate shocks, so that $w(\Delta f, d) > w(\Delta f, t)$. As a result, for given δ and c , the deposit franchise value is higher for traditional than for digital-broker banks:

$$DF(f_1, d) < DF(f_1, t). \quad (11)$$

To have a sense of the drop in franchise value of deposits associated with the digitalization of banking, Table 8 reports the deposit franchise value as a percentage of deposits for both traditional and digital broker banks. We do this for the case of an increase in rates as the one we observed

¹⁴Drechsler et al. (2023b) write the outflow rate as a function of the deposit spread, $s_d \equiv (1 - \beta) f$ and the rate itself, f , $w(s, f)$. Because the deposit beta is assumed to be a constant, and the initial rate f_0 is a parameter of the model, the outflow rate can be written simply as a function of the new rate itself, f_1 .

¹⁵Notice that, as Drechsler et al. (2023b) themselves note, for f near 0, the deposit franchise value in equation (10) can even be negative.

¹⁶More specifically they evaluate the duration properties of the deposit franchise value, defined as $T_{DF}(f) = -\frac{DF'(f)}{DF(f)}$, where $DF'(f)$ is the derivative of the deposit franchise value with respect to f . See their Proposition 1 and the discussion around it.

in 2022, which was $\Delta f = .0425$.¹⁷ The deposit betas for traditional and digital banks are $\beta(t) = .387$ and $\beta(d) = .436$, respectively, and are based on the estimates in Table 7 for digital-broker banks using the binary classification of digital. The estimates for the deposit outflows are .072 for traditional banks and .1105 for digital-brokers, derived from the results in Table 3.¹⁸ Finally, for the marginal cost of servicing deposits, c , and the amortization rate δ Drechsler et al. (2023b) use $c = .015$ and $\delta = .1$, which is these authors preferred specification.¹⁹ Because there is considerable uncertainty over these estimates and because digitalization itself may affect for instance the marginal cost of servicing deposits, we consider the value of the deposit franchise for $\delta \in \{0, .05, .1, .15\}$ and $c \in \{.005, .01, .015\}$.

First, and as shown in (11), the value of the deposit franchise is higher for traditional than for digital banks: For each combination of c and δ the value of the deposit franchise as a percentage of deposits is higher for traditional banks than for digital banks. In particular for $c = .015$ and $\delta = .1$ the value of the deposit franchise is 5.6% of deposits for digital-broker banks and 7.2% for traditional ones. The last column reports the percentage drop in value when banks “go digital”. As can be seen by inspection of expression (10), this measure is independent of the amortization rate δ and thus we report the drop for each value of the marginal cost, c . For Drechsler et al. (2023b)’s preferred specification, with $c = .015$, the drop is large, about 22%.

Second, the value of the deposit franchise is also large in terms of the value of a bank’s equity. Consider again the case in which $c = .015$ and $\delta = .1$. For a digital midsize bank such as Capital One with deposits of \$333bn in fiscal year 2022,²⁰ the deposit franchise value was

¹⁷The (effective) federal funds rate at the end of 2022 was 4.33% whereas it was .08% in March 2022; these numbers are obtained from Fred at the Federal Reserve Bank of Saint Louis.

¹⁸Ideally, when estimating $w(\Delta f, \theta)$ we would like to do so non-parametrically but data is imply not available. Instead we consider a linear approximation as in $w(\Delta f, \theta) \approx w'(\Delta f = 0, \theta) \times \Delta f$ for $f_0 \approx 0$ and where we have assumed that $w(0, \theta) = 0$. Our deposit outflow estimation reported in Table 3 provides an estimate of $w'(\Delta f, t) = 1.7\%$ for traditional banks, and 2.6% for digital-broker banks, $w'(\Delta f, d) = 2.6\%$. This reduced-form estimation of $w'(\Delta f, \theta)$ accounts for both the different betas across traditional and digital-broker banks, as well as the different sensitivity of depositors to these betas resulting from the differing ease of moving traditional vs. digital deposits.

¹⁹Drechsler et al. (2023b, footnote 12) take their estimate for δ from a study of the Federal Deposit Insurance Corporation prepared for Congress during the Dodd-Frank deliberations, FDIC (2011). They argue that this estimate, $\delta = .1$, is in fact in the low range for this parameter. For that reason in the Table below we have added the estimation of the deposit franchise value when $\delta = .15$. Obviously, the higher the amortization rate the lower the deposit franchise value.

²⁰We take 2022 because we want to assess the state of banking stability *prior* to the interest rate increases in 2022.

about \$18.6bn, or 35.4% of the book value of the equity, which was \$52.6n. If it were instead evaluated as a traditional bank, the deposit franchise would have been \$24.0bn or 45.6% of the book value of the equity. For a large bank such as JP Morgan with \$2.3tr in deposits at the time, the deposit franchise value was \$131.0bn or 44.8% of the \$293bn of book equity. At that time JP Morgan's price to book was about 1.6, so the deposit franchise would have been about 28.0% of market equity. For JP Morgan, the deposit franchise value would have been \$168.4bn in a world without digital banking, which is 57.5% and 36.0% of book and market equity, respectively. That is, digitalization has lowered the value of the deposit franchise for JP Morgan by about \$37bn. In sum, the value of the deposit franchise is big relative to the book and market value of the equity and digitalization results in a significant drop in this value.

Clearly digitalization may actually lead to lower marginal costs of servicing deposits. Koont (2023) estimates the cost functions of digital banks in detail and provides evidence that service provision via digital platforms reduces bank costs relative to services provided via brick-and-mortar branches, particularly by increasing the economies of scale. Thus, as digital services become even more ubiquitous going forward, it is likely that c will tend to a lower value, which will increase the deposit franchise value per equation (10). Indeed it might be the case that, perhaps paradoxically, the drop in the marginal cost c may more than compensate for the increase in deposit betas and outflows that results in the transition from traditional to digital banks, yielding, in net, a higher deposit franchise value.²¹ For instance, in the case $\delta = .1$, if mobile banking results in a reduction in marginal costs from $c = .015$ to $c = .01$ the deposit franchise value of digital banks would raise to 8.7% of deposits, higher than the deposit franchise value of a traditional banks with higher marginal costs which is 7.2%. Still in what concerns the banking episode in 2022, given that banks are only in a state of transition towards digital service provision, and continue to operate large branch networks, it is a reasonable approximation that the value of c has not yet decreased significantly. Further, as interest rates increase, the present value of the future reduction in costs is lower and thus present costs loom larger, as we illustrate next.

Consider next the effect of an increase in the Fed funds rates on the change in the value of the deposit franchise. This of interest because, the argument goes, the deposit franchise value is a hedge against the losses in the securities and loan portfolio that are the result of positive shocks to interest rates. To analyze this, we differentiate the deposit franchise value in (10) with respect

²¹We thank Thomas Philippon for pointing this to us.

to the rate and evaluate it at $\Delta f = 0$ or $f_1 = f_0$ (with $w(0, \theta) = 0$):

$$DF'(0, \theta) \propto -w'(0, \theta) ((1 - \beta(\theta)) f_0 - c) + \frac{(1 - \beta(\theta)) + c}{f_0 + \delta}. \quad (12)$$

The first term captures the fact that, say, positive shocks to interest rates result in deposit outflows (as $w'(0, \theta) > 0$). The second captures the fact that the bank earns a higher spread on the remaining deposits and the stream of marginal costs to be paid on those deposits get discounted at a higher rate. Drechsler et al. (2023b) argue that for reasonable parameter values the second effect dominates, so that the deposit franchise value increases as rates increase. This is the key point in their paper, that deposits are a hedge against shocks in rates. Our point is that they are less of a hedge for digital broker banks.

To see this, Figure 4 plots the increase in the value of the deposit franchise, ΔDF , as a fraction of deposits against the increase in the Fed funds rate, where

$$\begin{aligned} \frac{\Delta DF}{D} &= \frac{DF(\Delta f, \theta) - DF(0, \theta)}{D} \\ &= (1 - w(\Delta f, \theta)) \left[\frac{(1 - \beta(\theta)) f_1 - c}{f_1 + \delta} \right] - \frac{(1 - \beta(\theta)) f_0 - c}{f_0 + \delta} \end{aligned} \quad (13)$$

We plot this for both traditional and digital banks. For the latter though we also consider the possibility that digitalization lowers the marginal cost associated with servicing deposits, so that c goes from $c_H = .015$ to $c_L = .005$. For traditional banks we assume the marginal cost remains pegged at $c_H = .015$. Notice that if $f \approx 0$, as it was at the beginning of 2022,²² the x -axis can be read simply as the policy rate itself, after successive increases. First, as in Drechsler et al. (2023b) the deposit franchise value is indeed a hedge against positive interest rate shocks: It increases in value with Δf . Second, it increases less for digital-broker banks. Consider first the case for which the marginal cost is unchanged by digitalization. An increase of $\Delta f = .0425$, which is the actual change observed in 2022, results in an increase in the value of the deposit franchise for traditional banks of 22.2%, which is about two percentage points more than for a digital-broker bank. That is, for JP Morgan, a digital bank which recall had about \$2.3 trillion in deposits at the beginning of 2022, the increase in the value of the deposit franchise is \$37.4bn ($= (.222 - .206) \times \$2,340bn$). Or, to put it differently, JP Morgan's equity would have increased by an additional 12.8% of book equity value in the absence of digitalization. Thus, in a world

²²Notice that this means that the deposit franchise value was negative at that time!

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