INTERNET APPENDIX

FINANCIAL SOPHISTICATION AND BANK MARKET POWER

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INTERNET APPENDIX

A.1 Data Sources

Table A1 provides a description of all the data and variables used in the study along with their definitions and corresponding sources.

A.1.1 CD Rates

We gather data on interest rates for certificates of deposit (CDs) from S&P RateWatch for the period from January 5, 2001 to June 30, 2023. RateWatch collects weekly branch-level data for interest rates from over 96,000 branch locations in the U.S. for a wide variety of products, such as checking, savings, and money market accounts, and CDs for different account sizes and tenors.[1] The data cover branch-level rates for over 75% of banks and credit unions in the U.S. and represent more than 90% of deposits in commercial banking (Yankow (2023)). For expositional simplicity, we refer to these rate-setting bank branches and banks generically as banks. Following Drechsler, Savov, and Schnabl (2021), we require banks to be located in the 50 U.S. states plus the District of Columbia.

Our analysis focuses on CDs with six-month, one-year, two-year, three-year, four-year, and five-year tenors and principal amounts of less than or equal to $100,000. Specifically, for each week in the sample period, we collect all CD rates and the corresponding annual percentage yields (APYs) from banks in the RateWatch dataset for principal amounts of up to and including $100,000, and calculate their arithmetic averages by tenor for each bank.[2] To ensure that the CDs are insured by the Federal Deposit Insurance Corporation (FDIC), we require that CD rates are from banks with a valid FDIC certificate number. Furthermore, we use the following algorithm to ensure the integrity of the data. First, we exclude CD rates designated as promotional rates, as well as negative rates and negative APYs. We then make use of the fact that CD rates and APYs should differ only by a small amount, with the APY being weakly larger due to the effect of compounding. Second, we exclude observations where the difference between the CD rate and the APY is greater than five basis points. Third, for the remaining observations, we test whether the absolute difference between the APY and the CD rate exceeds 10 basis points. From this subset, we exclude

[1] See https://www.spglobal.com/marketintelligence/en/campaigns/ratewatch.

[2] In robustness tests, we also calculate weekly averages of CD rates by tenor for CDs with principal amounts of $10,000 which is the most-frequently quoted principal amount in the RateWatch dataset.

observations where the absolute difference between the CD rate and the APY is greater than the square of the CD rate.[3]

A.1.2 Early Withdrawal Penalties

We collect data on early withdrawal penalties for CDs from two sources. First, we collect quarterly interest rate risk exposure reports from the Office of Thrift Supervision (now merged with the Comptroller of the Currency) for the period from Q1 2001 to Q4 2011.[4] These reports provide early withdrawal penalties measured in terms of months of foregone interest for CDs with original maturity T for the categories $T \leq 12$ months, $12 < T \leq 36$ months, and $T > 36$ months. Since the OTS presents early withdrawal penalties in terms of months of foregone interest, we translate them into days of foregone interest by multiplying the numbers by $365.25/12 = 30.4375$. Next, we calculate annual averages of the quarterly early withdrawal penalties for each tenor to obtain an annual time series for the period from 2001 to 2011.[5]

Second, we collect early withdrawal penalties from the RateWatch database for the period from January 2, 2012 to June 30, 2023. In the RateWatch data, early withdrawal penalties are available for CDs with tenors of three months, and one, two, three, four, and five years. These penalties are measured in terms of days of foregone interest.[6] Since there are few observations in the RateWatch data for some tenors in 2012, 2013, and 2014, we use RateWatch data beginning in 2015. For the period from 2015 to 2023, we calculate annual averages across all withdrawal penalty observations for the aforementioned tenors. To obtain withdrawal penalties for 2012, 2013, and 2014, we linearly interpolate between the annual averages for 2011 and 2015.

[3]The idea behind this criterion is straightforward. To illustrate, let r denote the CD rate. Since the APY is bounded from above by the continuously compounded CD rate $\exp(r)$, we can approximate the difference between the CD rate and the corresponding APY using a simple Taylor expansion giving the expression $\exp(r) - (1 + r) \approx (1 + r + \frac{r^2}{2}) - (1 + r) < r^2$.

[4]See https://www.occ.gov/news-events/newsroom/news-issuances-by-year/ots-issuances/ots-aggregate-irr-exposure-and-cmr-reports.html.

[5]To map the tenors available in the OTS reports to the six CD tenors, we use the $T \leq 12$-months category for six-month and one-year CDs, the $12 < T \leq 36$-months category for two-year and three-year CDs, and the $T > 36$-months category for four-year and five-year CDs.

[6]To obtain early withdrawal penalties for six-month CDs, we use the simple average of the penalties for three-month and one-year CDs.

By combining the OTS and RateWatch series, we obtain an annual time series of early withdrawal penalties measured in terms of days of foregone interest for the period from 2001 to 2023 for CDs with six-month, one-year, two-year, three-year, four-year, and five-year tenors. Table A2 presents the resulting time series.

A.1.3 Bank Call Report Data

For each bank in the RateWatch dataset described in Section A.1.1, we collect several bank-specific variables from bank balance sheets and income statements that are widely used in the banking literature (e.g., Drechsler, Savov, and Schnabl (2017), Ben-David, Palvia, and Spatt (2017) and others). We obtain this data by matching each bank to Federal Financial Institutions Examination Council (FFIEC) Consolidated Reports of Condition and Income (Call Reports), which we access through Wharton Research Data Services (WRDS).[7]

Call Reports are filed at the quarterly frequency and offer information on balance sheet and income statement items for U.S. banks.[8] To form consistent time-series for the bank-specific variables, we follow Drechsler, Savov, and Schnabl (2017, 2021).[9] First, we collect total assets as a measure of bank size. As a measure of the size of a bank's deposit business, we use the ratio of demand and savings deposits to total assets (Demand/Savings Deposit Ratio).[10] We also calculate the ratio of deposits in excess of the FDIC insurance limit to total assets (Uninsured Deposit Ratio), and the ratio of fed funds purchased and securities sold under agreements to repurchase to total assets (Wholesale Ratio).

Next, we calculate the repricing maturity of bank liabilities (Liability Duration) using the approach in English, Van den Heuvel, and Zakrajšek (2018) and

[7]Every National Bank, State Member Bank, and insured Nonmember Bank is required by the FFIEC to file Call Reports as of the close of business on the last day of each calendar quarter using forms FFIEC 031, 041, or 051. The FFIEC is a formal U.S. government interagency body composed of the Federal Reserve Board of Governors (FRB), the Federal Deposit Insurance Corporation (FDIC), the National Credit Union Administration (NCUA), the Office of the Comptroller of the Currency (OCC) and the Consumer Financial Protection Bureau (CFPB).

[8]The data in the Call Reports is subject to regulatory oversight by the Federal Reserve System, FDIC, and the Comptroller of the Currency.

[9]We follow the data dictionary and code provided at https://pages.stern.nyu.edu/∼pschnabl/data/data_callreport.htm.

[10]We define demand and savings deposits as the difference between total deposits and time deposits.

Drechsler, Savov, and Schnabl (2021).[11] Specifically, during the 2001 to 2023 sample period, banks report the repricing maturity t of their small and large time deposits for four categories: $0 \leq t < 0.25$, $0.25 < t \leq 0.75$, $1 < t \leq 3$, and $t > 3$ years. We assign the midpoint to each interval and five years to the $t > 3$-years categogry. Demandable deposits such as transaction and savings deposits are assigned a repricing maturity of zero. Likewise, wholesale funding such as repo and fed funds purchased are assigned a repricing maturity of zero. Subordinated debt is assigned a repricing maturity of five years. We compute the repricing maturity of liabilities as the weighted average of the repricing maturities of all of these categories, using their dollar amounts as weights. We also calculate the ratio of loans and leases net of unearned income and allowance for loan and lease losses to total assets (Loan Ratio), the ratio of total securities to total assets (Securities Ratio), and ratio of book equity to total assets (Equity Ratio).

From bank income statements, we use the return on assets, calculated as the ratio of net income to quarterly average assets. As proxies for interest expenses on deposits, we calculate the ratio of interest expense on total deposits to total deposits (Total Deposit Expense Rate), the ratio of interest expense on demand and savings deposits to total demand and savings deposits (Demand/Savings Deposit Expense Rate), and the ratio of interest expense on time deposits to time deposits (Time Deposit Expense Rate). To minimize the impact of outliers in these variables, we filter out the 1st and the 99th percentile of total deposits, time deposits, and demand/savings deposits, and winsorize the aforementioned deposit expense rates at the one percent level. We also require that these interest expense and interest income variables be positive.

The resulting dataset has weekly data on CD rates and early withdrawal penalties for six-month, one-year, two-year, three-year, four-year, and five-year tenors from 16,891 rate-setting branches and banks, as well as the aforementioned balance sheet and income statement variables for the period from January 5, 2001 to June 30, 2023.

A.1.4 Demographic Data

We collect several demographic measures that are commonly used in the literature to analyze characteristics of a bank's depositors (see Drechsler, Savov, and Schnabl (2017), d'Avernas, Eisfeldt, Huang, Stanton, and Wallace (2023), and others). These include the median income, median age, and percentage of the population with a college degree or higher. We obtain this data for each year

[11]The description of this approach mirrors Drechsler, Savov, and Schnabl (2021), Internet Appendix, Section III.

and each U.S. state (plus D.C.) from the American Community Survey (ACS).[12] We merge these state-level demographic variables with the bank-level dataset described in Section A.1.3 at the bank-state level.

A.2 Bank CDs

In this section we provide an overview of certificate of deposits (CDs). We begin by describing their characteristics and conclude with a discussion of Federal Deposit Insurance Corporation (FDIC) insurance.

A.2.1 Certificate of Deposits

Bank CDs are part of the M2 monetary aggregate measure which includes currency, checkable deposits, savings deposits (including money market deposit accounts), and shares in retail money market mutual funds.[13] CDs are an important asset class for households in the United States. The total amount of CDs (with notional amounts of $100,000 or less) was more than $885 billion as of the end of the sample period in June 2023.[14] Results from the 2022 Survey of Consumer Finances show that the average household held roughly $100,000 in CDs, representing 6.5% of the value of financial assets held by the average U.S. household.[15]

CDs are savings certificates where the principal amount invested is held in a bank account for a set period of time (referred to as term or tenor), which typically ranges between one month and five years. CDs have little or no risk of default by the issuing bank since they are backed by the full faith and credit of the United States government.[16]

The holder of a CD accrues interest and receives a single cash flow in the

[12]The ACS is an annual survey conducted by the U.S. Census Bureau on a wide range of demographic, social, economic, and housing characteristics of the U.S. population covering topics such as age, race, income, education, employment, and housing conditions.

[13]See https://www.federalreserve.gov/releases/h6/current/default.htm.

[14]See the Financial Accounts of the United States, Balance Sheet of Households Table B.101.H.

[15]See the 2022 Survey of Consumer Finances, available at https://www.federalreserve.gov/econres/scfindex.htm.

[16]See https://www.fdic.gov/resources/deposit-insurance/brochures/insured-deposits/. We discuss FDIC insurance in Section A.2.2 below.

amount of the principal plus accrued interest at maturity. The Truth in Savings Act (12 CFR Part 1030) requires interest rates on CDs to be quoted in terms of APY. To illustrate, suppose an investor invests in a $10,000 CD with a one-year term and an APY of 4%. After one year, this investor receives one (final) cash flow of $10,000 + $400 = $10,400.[17]

While a CD is intended to be held until maturity, investors have the option to withdraw a partial amount or the full principal prior to the maturity date.[18] We refer to this feature as the early withdrawal option because it is similar in nature to a put option on a bond investment (see Fleckenstein and Longstaff (2024)). To see this, note that the investor in a putable bond has the option to sell back the bond to the issuer during some pre-specified period of time. Likewise, the holder of CD has the option to "put back" the CD to the bank at any point in time prior to the CD's maturity date.

While the holder of a putable bond typically has the option to sell the bond back to the issuer at par value, the holder of a CD incurs a penalty for doing so. Typically, this penalty is assessed in terms of a certain number of days of interest. To illustrate, suppose an investor owns a $10,000 CD with a one-year term and an APY of 4% (annually compounded). Assume that the early withdrawal penalty on this CD is 90 days of interest. This means that if the investor redeems the $10,000 any time before the one-year term is over, the penalty amounts to $(\frac{90}{365} \times 4\%) \times \$10,000 = \$98.63$. If the investor were to redeem the CD early any time during the first 90 days of the one-year term, the investor would actually incur a loss of principal.

When a CD reaches its maturity date, many banks automatically renew or roll over the CD into a new one with similar terms, unless the depositor actively communicates to the bank the decision to opt-out of this automatic renewal feature. In many cases, this actually entails the depositor having to call the

[17] CDs can accrue interest at different periodicities such as daily, weekly, monthly, quarterly, etc. However, interest is paid out in a single cash flow at the maturity date of the CD.

[18] Investors can redeem a CD any day without prior notice. Federal regulations require a minimum withdrawal penalty of seven days of simple interest on early withdrawals during the first six days after investing in a CD. However, there is no rule limiting the maximum withdrawal penalties banks can charge on early withdrawals (see 12 CFR 1030 "Truth in Savings Act (Regulation DD)"). At maturity of the CD, investors have a grace period, typically between one to two weeks, during which they may redeem the CD without penalty before the CD renews for a time period equal to the original term at the interest rate offered on the maturity date.

bank and give clear instructions to either withdraw the funds or transfer them to a different account. Most banks offer a grace period, typically lasting about seven to ten days after the maturity date, during which depositors can still withdraw or transfer funds without penalty. Failure to act during this time period may result in the funds being locked into a new CD term, potentially at less favorable interest rates, or early withdrawal penalties, if the depositor decides to terminate the CD after the grace period has expired.

Lastly, it is important to note that while we focus on this type of plain-vanilla CD described above, there are other investments oftentimes referred to as "CDs" but with fundamentally different properties. The first example is a negotiable CD (NCD). First, NCDs may be traded in secondary markets.[19] Second, NCDs have no early redemption feature (holders can sell in the secondary market). Third, some NCDs may be callable by the issuing bank. Fourth, some NCDs pay interest cash flows at regular intervals prior to the maturity date. The second example is a brokered CD (BCD) which is a type of CD that investors purchase through a brokerage firm or broker. Like NCDs, BCDs trade in the secondary market. BCDs may also be callable and pay regular interest cash flows until maturity. Unlike NCDs, however, BCDs may not be covered by FDIC insurance.

A.2.2 FDIC Insurance

In the United States, CDs are insured up to a certain dollar amount called the deposit insurance limit, if the issuing bank is a member of the Federal Deposit Insurance Corporation (FDIC).[20] This limit was raised several times since the FDIC was first established in 1933.[21] Specifically, at the beginning of our sample period in January 2001, the FDIC insurance limit was $100,000 (see FDIC (1998)). It was raised to $250,000 on October 3, 2008, and has remained at that level since then.[22]

[19]By contrast, there is no secondary market for plain-vanilla CDs. Accordingly, they are also referred to as "non-negotiable CDs."

[20]See, https://www.fdic.gov/resources/deposit-insurance/brochures/insured-deposits/. The FDIC maintains a database of FDIC-insured banks at https://banks.data.fdic.gov/bankfind-suite/bankfind.

[21]Some states in the U.S. adopted a form of deposit insurance as early as 1829. For instance, New York was the first state that adopted plans, over a period from 1829 to 1917, to guarantee bank deposits or other obligations that served as currency (FDIC (1984)).

[22]The increase on October 3, 2008 initially was a temporary measure enacted with the Emergency Economic Stabilization Act (EESA). However, on July 21, 2010 this increase was made permanent by the Dodd-Frank Wall Street Reform

It is important to note that FDIC insurance applies to an amount of $250,000 per depositor, per insured bank, for each account ownership category.[23] This means that the FDIC insures CDs that an investor owns in one insured bank separately from any other CD that the investor owns in another separately chartered insured bank.[24] Moreover, the FDIC provides separate insurance coverage for CDs held in different categories of legal ownership (ownership categories). To give one example, suppose investors A and B equally share an investment in a $500,000 CD in a joint account. In that case, A and B are each insured up to $250,000 resulting in the full $500,000 CD receiving FDIC insurance.[25] FDIC insurance includes principal plus any interest accrued or due to the CD holder. For example, if an investor owns a CD with a principal balance of $247,000 and $3,000 in accrued interest, the full $250,000 is insured by the FDIC.

A.3. Robustness

Table A3 reports the frequency of inconsistent term structures resulting from setting the term structure of CD rates equal to the term structure of Treasury rates minus the average spread between Treasury rates and CD rates.[26] As shown, 55.34 percent (or 648) of the 1,171 weekly CD term structures are internally inconsistent. Furthermore, the average size of the pricing inconsistency is 35.40 basis points (conditional on the term structure being internally inconsistent). These results are very similar to those shown in Table 7 in the paper. Specifically, in Table 7 in the paper, 55.85 percent (or 654) of the 1,171 weekly CD term structures are internally and the average size of the pricing inconsistency is 36.64 basis points (conditional on the term structure being internally inconsistent).

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and Consumer Protection Act. See https://americandeposits.com/history-and-timeline-of-changes-to-fdic-coverage-limits/.

[23]To streamline the discussion, we focus on the $250,000 insurance limit, which has been in place since October 2008.

[24]For example, if an investor owns a $250,000 CD at Bank A and another $250,000 CD at Bank B, the CDs are insured separately for the full $250,000. However, CDs held in separate branches of the same insured bank are not separately insured.

[25]This assumes that investors A and B do not also individually hold CDs. For other examples, see https://www.fdic.gov/resources/deposit-insurance/brochures/insured-deposits/.

[26]This results in just one term structure observation per week.

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Table A1

Data Definitions and Sources. This table summarizes the datasets used in this study. Frequency shows at what intervals the data are available. Description and Source show the data source and its definition.

	Data	Frequency	Description and Source
1	CD Rates	Weekly	Interest rates on certificates of deposit (CDs) quoted by banks for principal amounts of less than or equal to $100,000 and with initial maturities of six months, and one, two, three, four, and five years. Data furnished by S&P RateWatch for the period from January 5, 2001 to June 30, 2023.
2	Early Withdrawal Penalties	Weekly	Data on early withdrawal penalties measured in terms of days of foregone interest for CDs with initial maturities of three months, and one, two, three, four, and five years. Data furnished by S&P RateWatch for the period from January 2, 2012 to June 30, 2023.
3	Early Withdrawal Penalties	Quarterly	Data on early withdrawal penalties measured in terms of months of foregone interest for CDs with initial maturities of 12 months or less, 13 to 36 months, and 37 or more months. Data published by the Office of Thrift Supervision (OTS) for the period from Q1 2001 to Q4 2011 and available at https://www.occ.gov/news-events/newsroom/news-issuances-by-year/ots-issuances/ots-aggregate-irr-exposure-and-cmr-reports.html.
4	Treasury CMT Rates	Daily	Treasury constant maturity (CMT) rates from the Federal Reserve H.15 Selected Interest Rates Release. Data retrieved from the Bloomberg system.
5	Bank Call Reports	Quarterly	Bank balance sheets and income statements from the Federal Financial Institutions Examination Council (FFIEC) Consolidated Reports of Condition and Income (Call Reports) for the period from Q4 2000 to Q2 2023. Data obtained from Wharton Research Data Services (WRDS).
5	Demographic Variables	Annual	The median income, median age, and percentage of the population with a college degree (or higher) for each U.S. state (plus D.C.) for the period from 2000 to 2023. Data furnished by the Bureau of Labor Statistics (BLS) and available via the American Community Survey (ACS).

Table A2

Summary Statistics for CD Early Withdrawal Penalties. This table presents early withdrawal penalties for CDs with the indicated initial tenors. Early withdrawal penalties are expressed in terms of days of foregone interest for the indicated tenors. The data on early withdrawal penalties are furnished by the Office of Thrift Supervision for the period from 2001 to 2012 and by S&P RateWatch for the period from 2013 to 2023. Tenors are expressed in months. The numbers presented are the average withdrawal penalty for the indicated tenors and years, where the average is taken across all observations for a given tenor and year. Withdrawal penalties for 2012, 2013, and 2014, are linearly interpolated between the annual averages for 2011 and 2015.

	CD Tenor					
Year	Six-Month	One-Year	Two-Year	Three-Year	Four-Year	Five-Year
2001	94.20	94.20	162.31	162.31	225.09	225.09
2002	95.02	95.02	170.66	170.66	231.54	231.54
2003	94.13	94.13	172.58	172.58	234.37	234.37
2004	88.64	88.64	173.16	173.16	240.41	240.41
2005	86.29	86.29	171.13	171.13	244.03	244.03
2006	87.20	87.20	169.12	169.12	237.87	237.87
2007	93.75	93.75	176.92	176.92	247.38	247.38
2008	92.98	92.98	182.97	182.97	243.52	243.52
2009	97.62	97.62	179.16	179.16	247.68	247.68
2010	99.45	99.45	180.34	180.34	234.06	234.06
2011	99.76	99.76	182.17	182.17	239.77	239.77
2012	94.24	103.41	181.75	191.27	240.08	247.70
2013	88.71	107.07	181.33	200.37	240.39	255.62
2014	83.19	110.72	180.91	209.47	240.70	263.55
2015	77.66	114.37	180.49	218.58	241.00	271.48
2016	74.97	112.67	181.72	220.65	246.42	274.17
2017	73.30	112.53	185.59	226.14	251.60	279.58
2018	76.76	114.20	189.99	232.79	257.96	290.10
2019	74.24	113.08	188.23	229.53	254.72	283.37
2020	74.54	113.75	189.81	227.23	252.24	282.21
2021	77.14	116.14	191.93	230.17	254.99	283.71
2022	78.54	116.20	192.81	235.49	256.04	283.53
2023	77.98	113.63	191.54	234.69	252.56	281.72

Table A3

Summary Statistics for the Frequency and Size of Inconsistent Pricing When CD Rates are Set Equal to Treasury Rates Less the Average Treasury/CD Spread. This table presents summary statistics for the frequency and average size of inconsistent pricing for the indicated years, resulting from setting the term structure of CD rates equal to the term structure of Treasury rates minus the average spread between Treasury rates and CD rates. Frequency is expressed as a percentage. Size presents the average size of the pricing inconsistency for the inconsistent term structures. The size of the pricing inconsistency for any inconsistent term structure is the maximum pricing inconsistency taken over all pairwise comparisons of CD tenors in the same term structure, and is expressed in basis points. N denotes the number of weekly term structures for the indicated years. The row labeled All presents summary statistics for the frequency and average size of inconsistent pricing for all years. The sample period is weekly from January 5, 2001 to June 30, 2023.

Year	Frequency	Size	*N*
2001	23.08	7.38	52
2002	65.38	14.66	52
2003	100.00	41.97	52
2004	43.40	29.48	53
2005	0.00	–	52
2006	0.00	–	52
2007	0.00	–	52
2008	44.23	20.86	52
2009	100.00	52.19	52
2010	100.00	63.53	53
2011	100.00	57.95	52
2012	100.00	21.42	52
2013	100.00	46.09	52
2014	100.00	60.33	52
2015	100.00	28.71	52
2016	77.36	3.69	53
2017	5.77	1.07	52
2018	0.00	–	52
2019	0.00	–	52
2020	77.55	4.86	49
2021	100.00	26.46	53
2022	7.69	9.03	52
2023	0.00	–	26
All	55.34	35.40	1,171