The Spillovers of LSAPs on Banks in the Euro Area*

Marco Graziano[†] Marius Koechlin[‡] Andreas Tischbirek[§]

December 2025

Abstract

We study the spillovers of large-scale asset purchases (LSAPs) in the U.S. on financial intermediation in the euro area using bank-level supervisory data and high-frequency identified policy surprises. Our detailed panel data permit us to trace the impact of LSAPs through bank balance sheets. We find that the Federal Reserve affects credit provision in the euro area through a channel that we refer to as the "international bank capital channel" of unconventional monetary policy. In response to news about LSAPs that lead to a steepening of the U.S. Treasury yield curve, the Treasury positions of euro area banks shrink, capital ratios worsen, and banks that are less well capitalized contract their lending relative to banks that are better capitalized. Our results are consistent with an important role of revaluation effects, imperfect risk hedging, and credit as an adjustment margin for banks in the proximity of regulatory capital constraints.

Keywords: Large-Scale Asset Purchases, International Spillovers, Global Financial Cycle, Credit Channel of Monetary Policy, U.S. Treasury Yield Curve, Exchange Rates

JEL Classification: E52, F42, F44, G21

*We thank Miguel Ampudia, Philippe Bacchetta, Gianluca Benigno, Luigi Bocola, Andrea Ferrero, Jordi Galí, Marek Jarociński, Galo Nuño, Pascal Paul, Alessandro Rebucci, Emiliano Santoro, Jesse Schreger, Emil Verner, and numerous seminar participants for helpful comments and discussions. The analysis and conclusions set forth in this paper are those of the authors and do not indicate concurrence by other members of the research staff or the Board of Governors.

[†]University of Basel (marco.graziano@unibas.ch)

[‡]University of Lausanne (marius.koechlin@unil.ch)

[§]Board of Governors of the Federal Reserve System and CESifo (andreas.j.tischbirek@frb.gov)

1 Introduction

As a result of large-scale asset purchases (LSAPs), the balance sheet of the Federal Reserve more than doubled in size over the course of the years 2020 and 2021. The increase in the volume of securities held outright was larger than during the three Quantitative Easing (QE) programs implemented in the aftermath of the Great Financial Crisis combined. Following the COVID-19 pandemic, the Federal Reserve began to shrink its balance sheet through a process popularly referred to as Quantitative Tightening (QT). In addition, members of the Federal Open Market Committee proposed to shorten the average maturity of Treasuries held to levels closer in line with the average maturity of all Treasuries outstanding. Monetary policy in the U.S. has been identified as a key driver of the Global Financial Cycle, the high degree of comovement observed in financial markets around the world (Miranda-Agrippino and Rey, 2020a,b). Given the central role of the U.S. and the dollar in the international monetary system, the historical magnitude of the Federal Reserve's balance-sheet normalization process may be the cause of severe spillovers to other countries. Nonetheless, many aspects of the international transmission of QE and QT have remained not well understood.

In this paper, we combine high-frequency identified financial market surprises about LSAPs in the U.S. with bank balance sheet data from the euro area to study the mechanics underlying the spillovers of unconventional monetary policy between advanced economies. Our bank-level panel data allow us to track the effects of LSAPs in different parts of the balance sheets of banks located in the euro area. We uncover a transmission channel that we refer to as the "international bank capital channel" of unconventional monetary policy—LSAP shocks that steepen the U.S. Treasury yield curve lower the market value of banks' Treasury holdings, diminish standard regulatory capital ratios, and lead banks in closer proximity to regulatory capital constraints to contract their lending relative to banks that are better capitalized.

Our analysis relies on bank-level supervisory reporting data collected by the European Banking Authority (EBA) in the process of its EU-wide transparency exercises, supplemented with data from bank stress tests. The panel dataset that we construct includes observations on more than 150 banks under the direct supervision of the European Central Bank (ECB) typically sampled twice annually between 2010 and 2024. Our data have two distinct benefits.

First, they provide a wide coverage of one of the world's largest advanced economic areas with the banks in the sample accounting for about 90 percent of the assets held by the entire banking sector in the euro area in 2024. Thus, they allow us to provide a complementary perspective to existing studies of international monetary policy spillovers at the micro level, which rely on loan-level data from emerging market economies including Mexico (Morais et al., 2019) and Turkey (Baskaya et al., 2017; di Giovanni et al., 2022). Second, our panel data include detailed information on a range of balance sheet items and regulatory metrics, permitting us to gain insights into the transmission of LSAPs within the boundaries of a bank.

We first illustrate six facts about euro area banks that have immediate implications for the channel that we describe. Namely, i) banks in the euro area have substantial outright holdings of U.S. Treasuries, ii) Treasury holdings are concentrated among the largest banks, iii) about half of the Treasuries held by the top size quartile have a maturity of more than 5 years, iv) the large majority of Treasury holdings is marked to market, v) larger banks tend to have larger ratios of Treasury holdings to risk-weighted assets, and vi) capital constraints generally do not bind for the banks holding the majority of Treasuries. In short, an economically meaningful volume of Treasuries is held at maturities targeted by LSAPs and listed predominantly at market prices, opening the door to revaluation effects. Treasuries are furthermore concentrated among large banks, which tend to operate at some distance to regulatory capital constraints and can hence afford some fluctuations in their regulatory capital ratios but may also wish to limit them.

Our LSAP shocks are based on surprises extracted from financial market data in a short window around policy announcements using the method pioneered by Gürkaynak et al. (2005). Drawing on a shock series from Swanson (2021), we eliminate residual predictability following the recommendations of Miranda-Agrippino and Ricco (2021) and Bauer and Swanson (2023a). Impulse responses estimated with the help of local projections show that the resulting shocks have intuitive effects. Following an expansionary LSAP shock, the slope of the U.S. Treasury yield curve flattens and the dollar depreciates against the euro.

With these ingredients at hand, we turn to estimations at the bank level. In a first step, we estimate the effect of the slope of the U.S. yield curve, instrumented with the LSAP shocks, on banks' outright holdings of U.S. Treasuries. In response to an increase in the slope of the yield curve, banks' Treasury positions that are marked to market shrink. The steepening of the yield curve affects banks in the euro area through the associated fall in the prices of Treasuries with longer maturities and the ensuing appreciation of the dollar. By extracting the component of the total effect that is linked to the exchange rate, we show that the appreciation of the dollar in isolation puts upward pressure on banks' Treasury holdings. The same pattern emerges for Treasury positions that are listed at historical cost—The exchange rate effect is positive while the total effect is negative, albeit at a much smaller scale. Furthermore, holdings with a maturity between 1 and 10 years are affected, while shorter and longer maturities show no significant response. Effects on securities issued by other countries point to international comovement in sovereign bond yield curves. Taken together, the estimates are consistent with a dominant role of revaluation effects on new and existing positions. Importantly, banks in the euro area do not actively adjust their portfolios to fully stabilize their Treasury positions in response to LSAPs.

Changes in the value of Treasuries on the asset side must result in corresponding changes in capital on the liability side of bank balance sheets, unless banks use instruments that hedge risks to the total value of their assets or unrealized capital gains and losses are permitted to be excluded from reporting. We find that standard regulatory metrics measuring the adequacy of bank capital, the Tier 1 capital ratio and the leverage ratio, respond to LSAPs with the same sign as banks' Treasury positions. A steepening of the yield curve in the U.S. has adverse effects on capital ratios in the euro area, which suggests that banks allow LSAP-induced fluctuations in the value of Treasury holdings to feed into their regulatory capital.

Finally, we inspect the consequences of LSAPs in the U.S. for domestic credit provision in the euro area. The overall effect of a shock that raises the slope of the yield curve is positive in line with increased profitability of maturity transformation resulting from a higher spread between lending and funding rates. Due to the decline in the value of Treasuries and other sovereign debt described above in combination with increased lending, banks' capital ratios fall toward the regulatory limit. Our key result is the coefficient estimate on an interaction term showing that banks that are less well capitalized contract their lending relative to banks that are better capitalized. This negative effect on lending in response to the looming threat of the regulatory capital constraint is the international bank capital channel of LSAPs. Banks in the euro area generally have capital buffers of a substantial size in our sample. Our results show that the distance to prudential limits affects their response to LSAPs nonetheless. Banks with relatively low values of capital expand their lending by less, preventing their capital ratio from falling even closer to the regulatory constraint.

Literature. Our analysis contributes to a growing literature concerned with the origins of the Global Financial Cycle and, more specifically, the channels underlying the international spillovers of monetary policy.

Seminal work by Rey (2013) and Miranda-Agrippino and Rey (2020b) uncovers strong global comovement in financial variables including risky asset prices, capital flows, and credit, pointing to the existence of an international cycle in financial markets with common drivers, the Global Financial Cycle.[1] Based on financial aggregates, Miranda-Agrippino and Rey (2020a,b) demonstrate that U.S. monetary policy lies at the heart of this cycle, consistent with the U.S.'s central position in the global monetary and financial system (Gourinchas et al., 2019).[2] In response to an unexpected tightening of conventional monetary policy in the U.S., major stock price indices fall in the rest of the world, international capital flows subside, and global credit contracts. Miranda-Agrippino and Rey (2020b) show furthermore that U.S. monetary policy affects a measure of aggregate risk aversion extracted from the VIX. They conclude that monetary policy spillovers may be transmitted through an open-economy analogue of the risk-taking channel first described by Borio and Zhu (2012) and Bruno and Shin (2015). We contribute to these insights by focusing on the Federal Reserve's LSAPs and providing evidence for another cross-border transmission channel, the international bank capital channel.

A number of additional studies analyze the spillovers of monetary policy based on financial and macroeconomic aggregates. Maćkowiak (2007) shows that U.S. monetary policy is an important source of macroeconomic fluctuations in a group of emerging-market economies. Using a larger panel of emerging and advanced countries, Dedola et al. (2017) estimate that U.S. monetary policy has similar effects on real variables and inflation across many countries,

[1] See Miranda-Agrippino and Rey (2022) for a detailed review of the literature on the Global Financial Cycle.
[2] Boehm and Kroner (2025) present evidence for spillover effects of U.S. news releases beyond news related to monetary policy.

while the responses of financial variables are heterogeneous. Miranda-Agrippino and Nenova (2022) and Georgiadis and Jarociński (2025) also rely on high-frequency identified surprises to study the global effects of monetary policy. Both find that the Federal Reserve's LSAPs generate sizable spillovers that are largely transmitted through trade and financial channels and that the latter are mediated by shifts in aggregate risk aversion. In contrast to these papers, ours combines high-frequency identified monetary policy shocks with bank-level micro data, permitting us to trace the effects of policy spillovers through bank balance sheets and to shed light on the international transmission of LSAPs working through financial intermediation.

Monetary policy spillovers have been studied based on micro data before, with a focus on emerging-market economies. Morais et al. (2019) inspect the influence of conventional and unconventional monetary policy in the U.S, the U.K., and the euro area on bank lending in Mexico. A characteristic of the Mexican banking sector is that the majority of commercial credit is extended by foreign banks. They find that softer monetary policy in advanced economies leads to an expansion of credit supplied in Mexico, because global banks reach for yield by shifting their lending activities abroad when interest rates fall in their home markets. By contrast, Baskaya et al. (2017) and di Giovanni et al. (2022) conclude that the transmission mainly runs through domestic banks in Turkey, where global banks occupy a smaller share of the market. They further show that banks that rely more on funding from international capital markets increase their credit provision in response to capital inflows relative to banks that resort more to domestic funding sources. While these papers provide valuable case studies of monetary policy spillovers to emerging-market economies, we study spillovers between two regions that both represent a sizable fraction of world GDP, the U.S. and the euro area.

More broadly, our paper is connected to a large body of micro-level evidence on the role of credit for the domestic transmission of conventional monetary policy. In a classic article, Kashyap and Stein (2000) present estimates consistent with the bank lending channel, which posits that monetary policy affects the supply of credit through changes in bank reserves and hence banks' reservable liabilities such as deposits. Jiménez et al. (2014) provide evidence in favor of the risk-taking channel of monetary policy using information on loan applications in Spain. Similar to us, Jiménez et al. (2012) show that the response of credit provision depends on the strength of intermediary balance sheets in accordance with the bank balance-sheet channel of monetary policy. We find that euro area banks let valuation effects of LSAPs feed into their regulatory capital and that banks with less regulatory capital contract their lending relative to banks that are better capitalized. We refer to this mechanism as the "international bank capital channel" in analogy to a related domestic channel described by van den Heuvel (2002). Recent complementary work by Greenwald et al. (2024) and Orame et al. (2025) also highlights the importance of monetary policy transmission through securities that are marked to market.

Overview. The remainder of the paper is organized as follows. Section 2 introduces the bank-level data and characterizes the banks in our sample based on descriptive statistics. Section 3 provides details on the series of high-frequency identified LSAP shocks. Section 4 explains our estimation strategy. Section 5 contains the results. Section 6 collects a large number of robustness exercises. A final section concludes.

2 Bank-Level Data

Our analysis draws on an unbalanced panel of banks located in the euro area that contains detailed information on balance-sheet positions and regulatory metrics.

2.1 Sources

The bank-level data are obtained from the EBA. They are based on information from regulatory reports that are released in the context of the EBA's EU-wide transparency exercises. Releases from the transparency exercises are available between 2013 and 2024 with each of the annual exercises containing bank-level information at two reference dates, the ends of the first half of the current year and the second half of the preceding year. We supplement these data with information from the EBA's EU-wide stress tests containing the corresponding data for the second half of 2010, two years prior to the first observations from the transparency exercises, and the second half of 2013, observations that are missing because 2014 was the only year in which no transparency exercise was carried out after they had been introduced. Our dataset thus includes 24 semesters between the second half of 2010 and the first half of 2024.

We focus our attention on banks that are based in the euro area. Only banks qualifying for direct supervision by the European Central Bank (ECB) fall within the remit of the transparency and stress test exercises and hence into our sample. As a result, they tend to have comparably large balance sheets, as we discuss below in more detail.[3] Our data contain information on a total of 157 banks over the entire sample period. On average, about 60 percent of them are observed per semester. The banks observed in 2024 jointly account for about 90 percent of the assets held by the entire banking sector of the euro area. Figure A.1 in the Appendix shows the number of banks observed over time, and Appendix Figure A.2 provides details on the frequency at which individual banks are contained in the sample.

2.2 Accounting Standards

In accordance with prevailing accounting requirements, banks classify U.S. Treasuries as "held-to-maturity", "trading", or "available-for-sale" securities. Holdings of the first type are intended to be held until they mature. These positions are valued at amortized historical cost in banks' balance sheets. Therefore, we refer to them as the "book value portfolio" of Treasuries. Holdings of the latter two types are, respectively, earmarked for short-term trading or placed in a default category that does not place restrictions on their liquidity. Because they have to be valued at fair market value, we refer to them as the "market value portfolio."[4]

The classification of banks' U.S. Treasury positions is observed in most periods. An exception are the years 2016 and 2017, in which the total amount of each bank's Treasury holdings are disclosed through the EU-wide transparency exercise but not their breakdown into the individual accounting categories. However, our dataset includes the categorization of total sovereign debt holdings for each bank during that period. To impute the market and the book value portfolio of U.S. Treasuries for these two years, we assume that the relative amount of Treasuries listed at market and at book value is equal to the same ratio in the total sovereign portfolio. Robustness exercises show that the imputation procedure has little effect on our results.

[3] The criteria for direct supervision by the ECB are laid out in an article of the EU Regulation known as the "Single Supervisory Mechanism regulation." These criteria pertain to the banks' size, economic importance for their home state, and significance for cross-border activity.

[4] The two categories differ in other ways though. For example, for trading securities, unrealized gains or losses are recorded in the profit and loss statement of banks while, for available-for-sale securities, only realized gains or losses are recorded as net income.

2.3 U.S. Treasury Holdings by Banks in the Euro Area

We highlight six facts about the U.S. Treasury holdings of banks in the euro area before turning to a broader description of the estimation sample. To derive insights about differences in the composition of balance sheets by bank size, we first obtain the percentiles of the total-asset distribution in each period and then compute the relevant statistics pooling all observations in the resulting size groups over time.

Fact 1—Banks in the euro area have substantial outright holdings of U.S. Treasuries.

On aggregate, banks in the euro area hold an economically meaningful amount of U.S. Treasuries. The banks sampled in the first half of 2024, the most recent period covered by our data, held U.S. Treasuries with a total value of about 478 billion euros.

Fact 2—U.S. Treasury holdings are concentrated among the largest euro area banks.

Figure 1 illustrates banks' average U.S. Treasury holdings by bank size, remaining maturity, and valuation method. Banks with total assets below the median and banks with total assets between the 50^{th} and the 75^{th} percentile hold little Treasuries compared to banks above the 75^{th} percentile in our sample. As a result, any changes in the yields of Treasuries likely affect the banking sector of the euro area predominantly through the balance sheets of the largest institutions.

Fact 3—About half of the U.S. Treasuries held by the top quartile have a maturity of more than 5 years.

From the Treasury holdings of the largest 25 percent of banks with an average total value of 10.9 billion euros, 2.1 billion and 3.2 billion euros are held in the form of securities with a maturity of 5 to 10 years and more than 10 years, respectively, as shown in the right panel of Figure 1. LSAPs are equally focused on longer maturities. Between 2009 and 2024, the average maturity of the Federal Reserve's System Open Market (SOMA) Treasury portfolio lay in the range of 6.1 to 10.4 years.[5] Thus, the asset classes that are of most importance for large banks in the euro area are the ones that are directly targeted by LSAPs.

[5] In the aftermath of the Great Financial Crisis, the fraction of securities in the SOMA Treasury portfolio with a maturity above 5 years reached a peak of 77 percent.

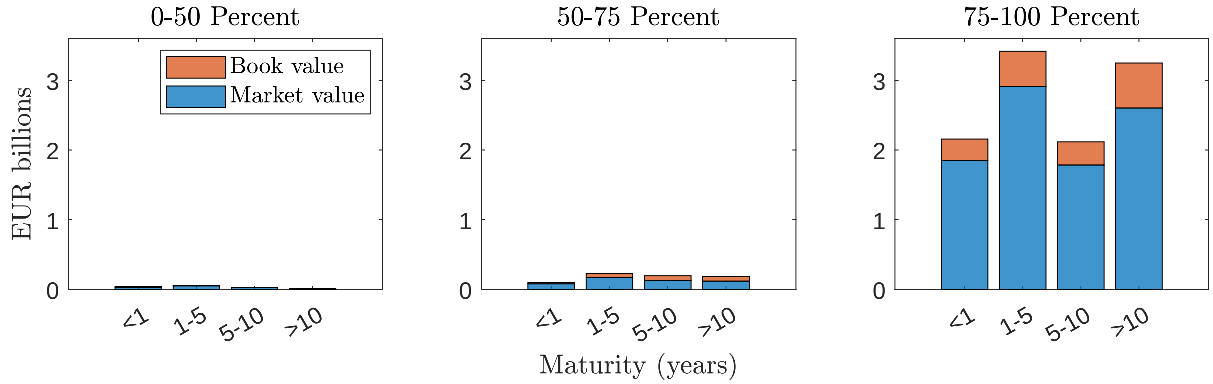

Figure 1: Average U.S. Treasury Holdings by Bank Size, Maturity, and Accounting Method

Notes: The figure shows U.S. Treasury holdings by total bank assets and maturity, divided into positions that are listed at market prices (market value) and at historical cost (book value). Each panel shows averages for the segment of the total asset distribution given in the title.

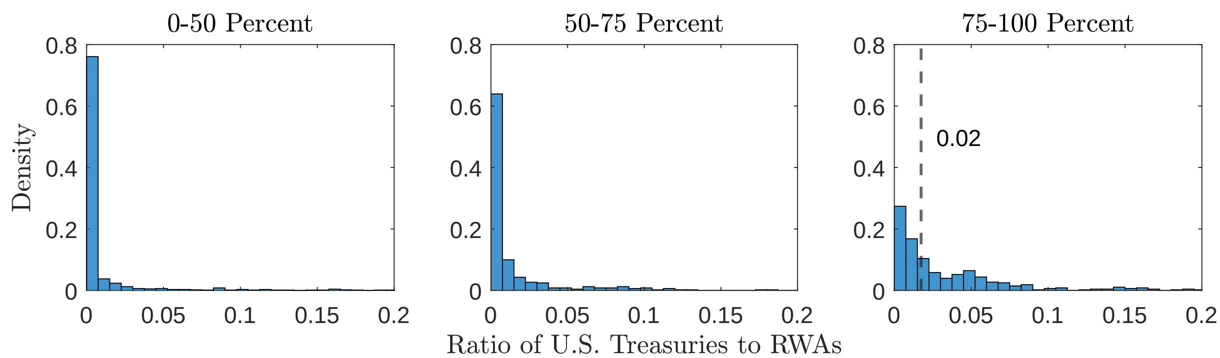

Figure 2: U.S. Treasury Holdings Relative to RWAs by Bank Size

Notes: Each panel of the figure shows the distribution of U.S. Treasury holdings relative to RWAs for the segment of the total asset distribution given in the title. Treasury holdings include the market and the book value portfolio. The dashed vertical line in the right panel marks the group median.

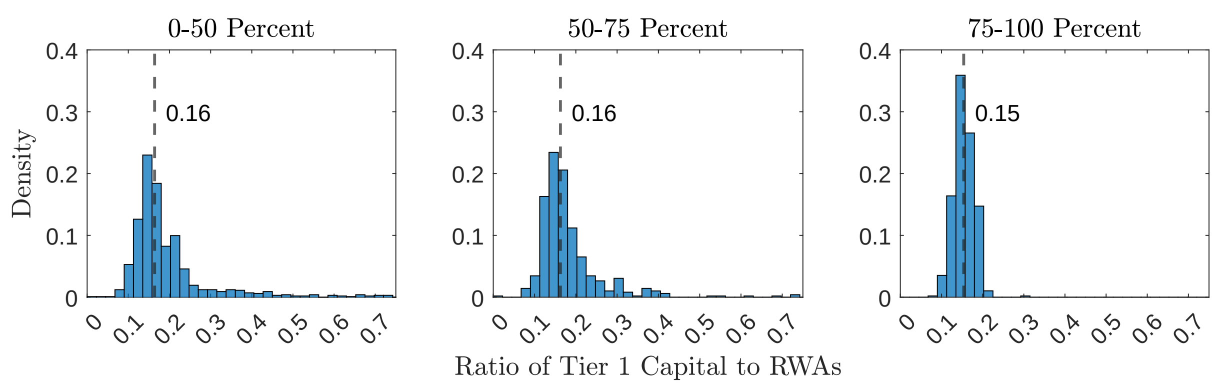

Figure 3: Tier 1 Capital Ratio by Bank Size

Notes: Each panel of the figure shows the distribution of Tier 1 capital relative to RWAs for the segment of the total asset distribution given in the title. The dashed vertical lines mark the respective group median.

Fact 4—The large majority of U.S. Treasury holdings is contained in banks' market value portfolios. The breakdown of average Treasury holdings into market-value and book-value positions is also illustrated in Figure 1. For the top 25 percent of banks, close to 85 percent of the total holdings are contained in the market value portfolio and hence marked to market. Consequently, changes in Treasury prices induced by U.S. monetary policy may have an impact on the balance sheets of euro area banks through both substitution and valuation effects.

Fact 5—Larger banks tend to have larger ratios of U.S. Treasury holdings relative to risk-weighted assets. The ratio of U.S. Treasury holdings to risk-weighted assets (RWAs) by bank size is depicted in Figure 2. The figure illustrates the distribution of the ratio within each bank size group for the pooled sample. Among the euro area banks whose total assets lie in the two bottom quartiles, the median Treasury holdings are close to zero. A ratio of Treasuries to RWAs around 5 percent or higher is rare. For banks in the third quartile of the size distribution, Treasuries play only a marginally larger role. In the top quartile of banks, the majority of banks hold a substantial amount of Treasuries, the median Treasuries-to-RWAs ratio is 2 percent, and values around and above 5 percent are frequently observed, which suggests that Treasury holdings are of disproportionate significance for large banks.[6]

Fact 6—Capital constraints generally do not bind for the banks holding the majority of U.S. Treasuries. Regulatory capital requirements are generally not immediately binding for the banks in the euro area. To illustrate this point, we plot the Tier 1 capital ratio, the ratio of high-quality regulatory capital to RWAs, in Figure 3. The vast majority of Tier 1 capital falls into the Common Equity Tier 1 (CET1) subcategory. Over the sample period, different requirements for Tier 1 and CET1 capital were in place. These bounds, which have a common and an idiosyncratic component, were progressively tightened, reaching an average of about 11 percent in 2024 for the CET1-to-RWAs ratio. The median Tier 1 capital ratio in our sample is about 15.5 percent, and values below 10 percent are rare, especially among the largest 25 percent of banks. However, there is a sizable amount of variation in capital ratios that we exploit in our estimations.

[6] The same qualitative picture arises when the ratio of U.S. Treasury holdings to total assets is considered. See Figure A.3 in the Appendix.

2.4 Estimation Sample

We impose two sample restrictions to improve the efficiency of our estimates. First, we eliminate banks that do not hold U.S. Treasuries at any point over the entire sample period. This restriction reduces the total number of banks in the estimation sample to 102 and the number of bank-semester observations in the pooled sample to 1,654. Second, we limit the influence of outliers by applying a mild amount of trimming. More specifically, we drop observations from the sample that are strictly lower than a variable's 0.5$^{\text{th}}$ and higher than its 99.5$^{\text{th}}$ percentile in each period. The bounds are chosen such that a very small number of observations with negative Treasury holdings are excluded while zero holdings are retained, and extreme outliers at the top are eliminated. Banks were not required to report all variables sampled in every period so that the effective number of observations is lowered somewhat further.

Assets and Capitalization. Table 1 reports summary statistics of key variables based on the pooled estimation sample. Because the banks in our sample fulfill the criteria for ECB supervision, they have sizable balance sheets. The median total asset holdings are 107 billion euros, and there is a strong skew in the distribution of total assets with the mean exceeding the median by a factor of nearly three. Our sample spans a wide variety of bank-semester observations. Total assets range from 21 billion at the 10$^{\text{th}}$ to 955 billion euros at the 90$^{\text{th}}$ percentile. RWAs are smaller in accordance with the appropriate regulatory risk weights. As highlighted above, Treasury holdings are also skewed and of disproportionate significance for large banks. The 90$^{\text{th}}$ percentile of the Treasuries-to-RWAs ratio is a sizable 7.4 percent while the median is only 0.5 percent. The median Tier 1 capital ratio is 15.5 percent, unchanged by the sample restrictions. Credit makes up a significant fraction of total assets. On average, the majority of credit is extended domestically, which opens the possibility for changes in Treasury yields to spill into banks' local lending operations.

Risk Hedging. The strength of potential spillovers of LSAPs depends on the degree to which banks are hedged against balance sheet risks. Two regulatory risk exposure indicators, also shown in Table 1, suggest that banks may not perfectly offset the risks arising from govern-

Table 1: Summary Statistics

Variable	Median	Mean	SD	P10	P90	n
EUR (billions)						
Total assets	106.5	292.5	436.4	20.6	954.8	1,513
RWAs	46.8	106.7	147.9	5.7	347.1	1,606
U.S. Treasuries	0.2	3.8	12.4	0.0	7.6	1,582
Total credit	28.1	67.6	96.3	3.0	214.6	1,602
Tier 1 capital	7.1	16.1	21.6	1.4	50.8	1,606
Debt exposure	0.2	1.0	3.3	0.0	2.1	1,537
Foreign exchange exposure	0.1	0.6	1.3	0.0	1.6	1,537
Ratios (percent)						
U.S. Treasuries / RWAs	0.5	2.9	8.0	0.0	7.4	1,534
Tier 1 capital / RWAs	15.5	18.1	11.7	11.8	23.0	1,606
Total credit / total assets	21.6	23.0	9.1	13.1	35.1	1,485
Domestic credit / total credit	61.1	55.2	26.2	13.8	88.4	1,419

Notes: The table shows summary statistics of the pooled estimation sample.

ment debt holdings denominated in a foreign currency. The first aggregates the interest-rate and credit-spread risk stemming from debt securities and related derivatives, and the second provides a measure of exchange-rate risk.[7] Both take on sizable values in the respective upper tail of their distribution.[8] While they are not specific to U.S. Treasury holdings, these indicators are suggestive for a non-negligible net exposure to Treasuries among banks in the euro area. We return to a detailed assessment of the effects of LSAPs on Treasury positions in Section 5.1.

3 LSAP Shocks

The well-known endogeneity of monetary policy is likely to result in smaller estimation bias in the context of international spillovers than in assessments of domestic policy outcomes. Nonetheless, the Federal Reserve may adjust its policies in response to developments in the euro area that affect inflation or the labor market in the U.S. Our approach to addressing this concern builds on the high-frequency identification procedure of Swanson (2021) coupled with

[7]The two indicators account for correlated and offsetting positions as well as risk hedging through derivative instruments. See the Standards on the Minimum Capital Requirements for Market Risk, published by the Basel Committee on Banking Supervision, for details.

[8]Evidence for heterogeneity in the exposure to exchange rates is also contained in Abbassi and Bräuning (2023).

insights from Bauer and Swanson (2023a,b) and Miranda-Agrippino and Ricco (2021). Local projections estimated using the exogenously-identified LSAP shocks that we obtain yield intuitive impulse responses at the macro level.

3.1 Derivation

We depart from the series of LSAP shocks at Federal Open Market Committee (FOMC) meeting frequency identified by Swanson (2021). We strip these shocks from variation that is predictable based on data releases prior to FOMC announcements and autoregressive terms.

High-Frequency Surprises. The identification procedure of Swanson (2021) proceeds in three steps. First, changes in a 30-minute window around FOMC announcements are obtained for the prices or yields of financial assets following Gürkaynak et al. (2005). Specifically, high-frequency surprises are calculated for the contract rates on federal funds futures for the months of the current and the next FOMC meeting, the contract rates on eurodollar futures for the three subsequent quarters starting with the next, and the Treasury yields at 2-, 5-, and 10-year maturity. Second, the first three principal components are extracted from the resulting series. Third, three latent structural factors corresponding to changes in the federal funds rate, forward guidance, and LSAPs are estimated through a rotation of the matrix of principal components. Importantly, the identification of the latent factors is achieved by imposing the restrictions that the loadings of the forward guidance and the LSAP factor on the surprises in the current-month federal funds futures rate be zero and that the LSAP factor be as small as possible prior to the lower-bound period starting in 2008.[9]

Orthogonalization to Prior Data Releases. Under full information, rational expectations and the absence of arbitrage opportunities, economic theory predicts that high-frequency surprises and hence shock series derived from them in the way outlined above are orthogonal to information available prior to the FOMC announcement at which they are measured. However, a number of articles argue for the presence of information frictions that may result in correlation

[9]We thank Eric Swanson for sharing an extended version of his shock series with us.

between high-frequency surprises and prior data releases.[10] Without orthogonality of the shock series, standard methods used to estimate causal effects of monetary policy may yield biased results (Stock and Watson, 2018). We address this concern by adopting the solution proposed by Bauer and Swanson (2023a,b), which involves regressing the high-frequency identified shocks on time series with predictive power for them and calculating a series of robust shocks as the regression residuals. The time series that we consider in our regressions are i) the three-month change in the slope of the yield curve, ii) the three-month growth rate in the Bloomberg Commodity Spot Price index, iii) the surprise component of the most recent nonfarm employment data release, iv) the one-year growth rate in nonfarm employment, v) the three-month growth rate in the Standard and Poor's 500 stock price index, and vi) the Treasury skewness index from Bauer and Chernov (2024) averaged over the previous month, as proposed by Bauer and Swanson (2023a) in the context of standard monetary policy. All variables are calculated for the day prior to each FOMC meeting or the latest data release that precedes it. The shocks and the controls are available for the FOMC meetings between February 1988 and December 2023.

Table B.1 in the Appendix contains the results for OLS regressions of the LSAP shocks from Swanson (2021) on the variables described above. The change in the yield curve slope and the employment surprises have the strongest predictive power. Using all six variables, we find evidence for mild but statistically significant predictability with an R^2 of 0.04 and joint significance at the 5-percent level.

Autocorrelation. An additional concern highlighted by Miranda-Agrippino and Ricco (2021) is shock predictability resulting from autocorrelation. To address this issue, we first aggregate the orthogonalized shocks to monthly frequency and then eliminate the autocorrelation in the monthly series through a regression of the aggregated shocks on their first 12 lags. The only horizon that is individually significant is the third lag. With an R^2 of 0.03, this regression uncovers further mild predictability that we remove by taking the residuals of the regression forward as our externally-identified LSAP shocks. Figure B.1 in the Appendix plots the shock series before and after the two orthogonalization steps.

[10]See, for example, Romer and Romer (2000), Melosi (2017), Cieslak (2018), Nakamura and Steinsson (2018), Miranda-Agrippino and Ricco (2021), Karnaukh and Vokata (2022), Bauer and Swanson (2023b), and Sastry (2025).

3.2 Impulse Responses

Next, we compute the impulse responses of the slope of the yield curve and the euro-dollar exchange rate using local projections to confirm that the LSAP shocks have the expected effects.

Setup. Following Jordà (2005), we estimate the local projections

$$y_{t+h} - y_{t-1} = \alpha^h + \beta^h s_t + \sum_{l=1}^{L} \boldsymbol{x}'_{t-l}\gamma_l^h + e_{t+h} \,, \tag{1}$$

at monthly frequency, where y_t is some outcome variable of interest, s_t is the monetary policy shock derived as described above, $\boldsymbol{x}_t$ is a vector of controls, and $h = 0, 1, 2 \ldots, H$ is the impulse response horizon. The sequence of estimated coefficients $\{\hat{\beta}^h\}_{h=0}^{H}$ traces out the impulse response function for each outcome variable. Note that we allow the shock to operate through the contemporaneous values of the controls but not their lags (Ramey, 2016; Holm et al., 2021).

The outcomes are the slope of the yield curve, calculated as the difference between the market yield of U.S. Treasuries at 10-year and at 1-year maturity, and the euro-dollar exchange rate, denominated in euros per dollar (i.e., an increase corresponds to a dollar appreciation). Our choice of controls closely follows Miranda-Agrippino and Ricco (2021). It comprises the 1-year Treasury yield, the unemployment rate, the Gilchrist and Zakrajšek (2012) corporate bond credit spread, monthly CPI inflation, and the log of indices for industrial production and commodity prices. The controls also include lags of the shock series to enhance the efficiency of the estimates. We choose $L = 12$ lags in line with the VAR estimated by Miranda-Agrippino and Ricco (2021), and document confidence bands with 68-percent and 90-percent coverage probability calculated based on homoskedasticity- and autocorrelation-robust standard errors.

Estimates. Figure 4 illustrates impulse response estimates that are normalized such that the response of the yield-curve slope reaches 25 basis points in absolute value. Both responses have the expected sign. The yield curve flattens and the dollar depreciates following asset purchases. The effect on the yield curve takes longer to build up than the response of the exchange rate. Figure B.2 in the Appendix shows that LSAPs further have an expansionary effect on inflation, which in turn leads the federal funds rate to gradually rise somewhat. Figure B.3, also shown

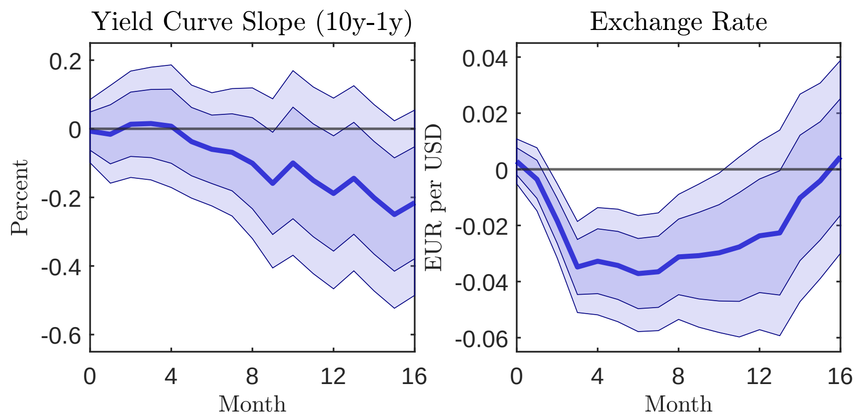

Figure 4: Impulse Responses

Notes: The figure shows impulse responses to an LSAP shock estimated based on equation (1) together with 68-percent and 90-percent confidence bands constructed based on Newey and West (1987) standard errors.

in the Appendix, evaluates the importance of the two orthogonalization steps. The response of the exchange rate that corresponds to a 25-basis-point decline in the slope of the yield curve is of similar shape but somewhat larger without the orthogonalization in line with the small but significant amount of predictability of the uncorrected shock series.

4 Estimation Strategy

We estimate the spillovers of LSAPs in the U.S. on several bank-level outcomes in the euro area using the orthogonalized high-frequency shocks described in the previous section as an instrumental variable (IV).

4.1 Empirical Model

Our baseline specification is of the form

$$y_{i,j,t} = \alpha + \beta \cdot q_t^{LSAP} + \boldsymbol{x}'_{i,j,t}\gamma + \boldsymbol{w}'_{j,t}\delta + u_i + \varepsilon_{i,j,t} \, , \tag{2}$$

where $y_{i,j,t}$ is a balance-sheet position or regulatory metric of bank i located in country j of the euro area at time t, q_t^{LSAP} is a financial-market outcome that is informative for the nature of the spillovers of LSAPs, $\boldsymbol{x}_{i,j,t}$ is a vector of bank-level controls, $\boldsymbol{w}_{j,t}$ is a vector of country-level controls, and u_i is the bank-specific unobserved component of the error term. We consider different bank-level outcomes as the dependent variable in the following section such as the book value and the market value portfolios of U.S. Treasuries as well as the amount of credit extended, all normalized by total assets. We let $q_t^{LSAP} \in \left\{ Slope_t^{10y-1y}, E_t^{\$,€} \right\}$ be either the slope of the nominal Treasury yield curve, defined again as the difference between the 10-year and the 1-year rate, or the spot exchange rate between the euro and the dollar with the euro as the quote currency, as above. More details on the control variables are provided in our discussion of potential identification concerns in Section 4.3. We estimate the above equation using two-stage least squares (2SLS), instrumenting q_t^{LSAP} with the contemporaneous value and lags of the orthogonalized LSAP shocks. The coefficient of interest β gives the effect of LSAPs in the U.S. on bank-level outcomes in the euro area transmitted through changes in the slope of the yield curve or the exchange rate. Note that these effects are not required to be independent.[11] As we discuss below in more detail, changes in the slope of the yield curve are permitted to affect banks in the euro area through an indirect effect on the exchange rate.

4.2 Timing

The micro and the macro data are observed at different frequencies. Recall that our bank-level data are available semiannually with a reference date at the end of each half year. Thus, we let the periods $t = 1, \ldots, T$ correspond to semesters. The slope of the yield curve and the exchange rate are observed more frequently. While bank balance sheets mechanically depend on the prevailing asset valuations on the reference dates, accounting for asset price changes on only those days likely ignores effects of LSAPs that take longer to pass through the entire balance sheet. We therefore aggregate the financial-market outcome q_t^{LSAP}, the slope of the yield curve or the exchange rate, to monthly frequency and assign the value from the last month of each semester to any given period. The respective financial-market outcome is instrumented with 12 successive monthly values of the LSAP shock series beginning with the month of the reference date denoted $\boldsymbol{s}_t = (s_t^0, s_t^{-1}, \ldots, s_t^{-11})'$ to allow the effect of the shocks to build up gradually.[12] For example, if the reference date for the bank-level data in semester t is at the

[11] Greenwood et al. (2023) develop a theory that connects long-term bond demand and supply to exchange rates.

[12] That is, s_t^{-m} is the value of the shock series in the m^{th} month prior to the month containing the reference date, which implies $s_t^{-o} = s_{t+1}^{-o-6}$ for $o = 0, 1, \ldots, 5$.

end of December, then q_t^{LSAP} is the December average of say the slope of the yield curve and the instrument vector $\boldsymbol{s}_t$ includes the monthly LSAP shocks between January and December of that year. Figure 5 illustrates this example.

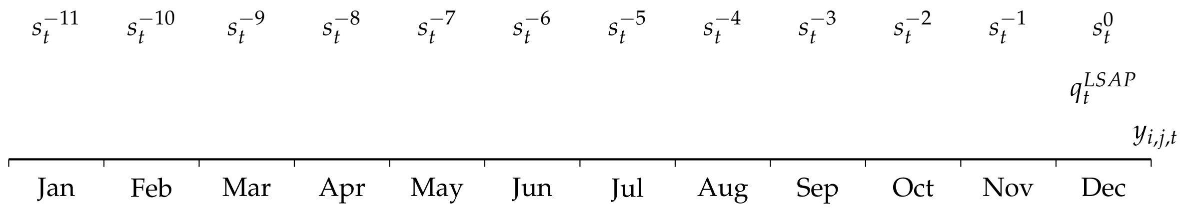

Figure 5: Timing of Empirical Model

Notes: The figure illustrates the timing of the empirical model at the example of bank-level observations with the reference date at the end of December.

4.3 Identification

A naive regression of $y_{i,j,t}$ on q_t^{LSAP} and controls may fail to yield an estimate of the causal effect of LSAPs on bank balance sheets in the euro area for several reasons.

First, there may be unobserved bank-specific factors that are correlated with the regressors, which could result in omitted variable bias. We hence estimate equation (2) with bank-specific fixed effects to allow for arbitrary correlation between $\boldsymbol{X}_{i,j,t} = (1, q_t^{LSAP}, \boldsymbol{x}'_{i,j,t}, \boldsymbol{w}'_{j,t})'$ and u_i.

Second, the causation may run from the banking sector in the euro area to the exchange rate or the slope of the yield curve rather than in the other direction. In addition, shocks that have their origin in the euro area may affect the local banking sector and also spill into the U.S. economy. These shocks may lead to omitted variable bias if they affect the exchange rate or the yield curve. Our 2SLS estimator addresses these concerns provided that the requirements for instrument validity are satisfied. Specifically, let $\boldsymbol{Z}_{i,j,t} = (1, \boldsymbol{s}'_t, \boldsymbol{x}'_{i,j,t}, \boldsymbol{w}'_{j,t})'$ be the regressors presumed to be exogenous. Instrument relevance can then be expresses as a standard rank condition, and exogeneity requires $\mathbb{E}(\varepsilon_{i,j,t} | \boldsymbol{Z}_{i,j,1}, \ldots, \boldsymbol{Z}_{i,j,T}, b_{i,j,1}, \ldots, b_{i,j,T}) = 0$ with $b_{i,j,t} \in \{0, 1\}$ indicating whether a bank is contained in the sample in a given period.[13] Instrument exogeneity is satisfied if the regression errors are mean independent of the instruments and selection

[13]The asymptotic distribution of the panel fixed-effects 2SLS estimator is derived under the assumption that the observations are i.i.d. across individuals, which is violated with country-level regressors. We therefore verify that our results are nearly unchanged if $\boldsymbol{w}_{j,t}$ is eliminated and cluster the standard errors accordingly.

into the sample. The former holds with respect to the setup that includes the slope of the yield curve if LSAPs of Treasuries in the U.S. influence banks in the euro area only through effects set off by changes in the slope of the Treasury yield curve. Exogeneity of this type is plausible, in our view, since longer term yields serve as a target for the Federal Reserve's Treasury purchases similar to the way the federal funds rate serves as a target for the standard tool. We regard changes in the exchange rate as a subcomponent of the transmission mechanism and estimate the setup that includes the exchange rate to gain insights into its importance for the overall effect. The key assumption in this setup is that the slope of the yield curve affects euro area banks through the exchange rate but also through other channels. By instrumenting the exchange rate, we separate the part of the variation in the slope of the yield curve related to LSAPs that works through the exchange rate from the variation that works through the other channels, permitting us to decompose the overall effect. Inspecting the latter mean-independence condition, we found no indication for sample selection based on bank characteristics.

Third, LSAPs may affect banks in the euro area not only directly through changes in bond prices or the exchange rate but also indirectly through an expansionary effect on the economy more broadly. While such an indirect effect does not pose a threat to the identification, it complicates the economic interpretation of the estimation results. To isolate the direct effects, we include country-level variables in the model that control for the state of the business cycle in the country in which a bank is based. These country-level controls $\boldsymbol{w}_{j,t}$ are the growth rate of GDP, core CPI inflation, the change in the unemployment rate, and a diffusion index of loan demand by corporations from the euro area Bank Lending Survey (BLS). We further use the change in the 2-year rate on German sovereign debt as a common control variable to account for spillovers on the ECB's policy stance.

Fourth, additional bank-level controls help assign estimated effects to specific balance-sheet positions and improve their overall efficiency. We return to this point in the following section. Below, we report standard errors that are two-way clustered at the bank level to allow for autocorrelation and heteroskedasticity of the residuals within each bank and at the semester level to allow for arbitrary cross-sectional dependence introduced, for example, by the country-level controls.

5 Results

In this section, we trace the implications of LSAP shocks through bank balance sheets in the euro area by successively turning to different balance-sheet items. Our analysis begins with the effects on the outright holdings of sovereign debt. We then inspect consequences for bank capital and credit provision. For ease of exposition, we consider the effects of a positive change in the slope of the yield curve and hence contractionary policy, or QT, below.

5.1 Sovereign Bond Portfolio

As a starting point, we clarify how banks' outright holdings of U.S. Treasuries are affected by LSAP shocks. To do so, we let the dependent variable in equation (2) be either the market value portfolio or the book value portfolio of Treasuries. We also explore the implications for different bond maturities and for non-U.S. sovereign debt positions. In all cases, the dependent variable is normalized by total bank assets, ratios are expressed as percentages, and two bank-level controls are included in the estimation. These bank-specific controls are the changes in the ratios of RWAs and non-equity liabilities to total assets. Because sovereign bonds carry a risk weight of zero, the former ratio helps control for indirect effects running through asset classes with a positive risk weight, such as loans. The latter ratio helps control for indirect effects stemming from the liability side of the balance sheet.

Reduced Form. Tables C.1 and C.2 in the Appendix show the results of the first-stage regression for the slope of the yield curve and the exchange rate, respectively. The LSAP shocks are jointly highly significant. The F-statistic of the robust weak-instruments test proposed by Kleibergen and Paap (2006) is about 14 in both cases, comfortably exceeding the corresponding critical value from Stock and Yogo (2005) at the standard 10-percent relative bias level. Note that joint significance of the 12 successive values of the shock series is a weaker requirement than significance of the impulse response function to a single such shock illustrated in Figure 4. Furthermore, impulse response functions are estimated using different timing assumptions and with macroeconomic controls, as we describe in detail in Section 3.2. All that is required here is that the instruments plausibly isolate exogenous variation in the slope of the yield curve. The first stage is similar for all outcomes of interest that we consider with the help of the empirical model outline before. Therefore, we only return to it in passing below.

Channels. Changes in the slope of the yield curve induced by Treasury purchases or sales in the U.S. may affect the Treasury holdings of banks in the euro area through three direct channels. First, a steepening of the yield curve, for example, is associated with a decline in the price of long-term bonds, which decreases the value of Treasury positions that are marked to market. Second, in response to an increase in U.S. yields, the dollar appreciates relative to the euro, increasing the euro value of Treasury positions listed at market value. Third, banks may actively rebalance their portfolios in response to a change in the relative prices of financial assets. A rebalancing might be expected to favor positions with temporarily lower relative prices so that a decrease in Treasury prices results in a reallocation toward those positions. More succinctly, the euro value of a bank's Treasury holdings with a given remaining maturity can be expressed as $V^{€}_{i,j,t} = P^{\$}_t \cdot E^{\$,€}_t \cdot Q_{i,j,t}$, where $P^{\$}_t$ is the unit bond price in dollars and $Q_{i,j,t}$ is the quantity held. The three channels outlined above suggest that a steepening in the slope of the yield curve leads to a decline in $P^{\$}_t$, a rise in $E^{\$,€}_t$, and possibly an increase in $Q_{i,j,t}$.

Revaluation and Rebalancing. Table 2 shows the results of the IV regressions for the market and the book value portfolio. The estimated coefficients can be interpreted through the lens of the theoretical channels discussed before. A rise in the slope of the yield curve lowers the size of the market value portfolio, suggesting that the revaluation effect from the decline in the prices of Treasuries dominates the exchange rate and the rebalancing effects. The slope coefficient is statistically significant at the 1 percent level and of meaningful size. Its interpretation is that an unanticipated one-standard deviation increase in the slope of the Treasury yield curve lowers the ratio of the market value portfolio to total assets by 0.135 percentage point. In the setup, in which the exchange rate is used as the independent variable and instrumented with the LSAP shocks, the estimated coefficient turns positive. The coefficient reflects revaluation and rebalancing effects stemming from changes in the exchange rate, while any effects resulting from changes in Treasury prices that do not work through the exchange rate are eliminated, as laid out above. The positive sign of the coefficient is consistent with these predictions if, again,

Table 2: U.S. Treasury Holdings

	Market Value		Book Value	
	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	-0.135***		-0.031**	
	(0.036)		(0.015)	
$E_t^{\$,€}$		0.178*		0.079**
		(0.101)		(0.039)
n	1186	1186	1207	1207
N	94	94	92	92
T	22	22	22	22
KP F-stat.	14.2	14.9	14.1	14.7
SY 10%	11.5	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The respective dependent variable is the market value portfolio (1)-(2) and the book value portfolio (3)-(4), all normalized by total assets and expressed in percent. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls include the bank-level and the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

the revaluation effect dominates. In principle, rebalancing could also run in the same direction as revaluation effects if banks actively adjust security holdings due to a value-at-risk constraint, for example. However, a mechanism of this type would generally result in adjustments of credit rather than safe government bond positions and be associated with changes in non-equity liabilities, on which we condition using our bank-level controls (Adrian and Shin, 2010).

Since the book value portfolio is not listed at market prices, the results of the regressions involving the book value portfolio are free from revaluation effects on preexisting positions. A plausible initial conjecture is that the setup with the slope of the yield curve may yield a positive coefficient estimate, because the decline in the bond price may lead banks to actively scale up their Treasury positions in the book market portfolio. Our estimates uncover an effect of the opposite sign. If the quantity of new Treasuries purchased every period by banks is more or less unaffected by the steepening of the yield curve, the revaluation of new positions rather than a rebalancing determines the size of the estimated coefficient. Thus, the negative

Table 3: Untargeted Sovereign Debt

	U.S. Treasuries						Non-U.S. Debt	
	mat. $\leq$ 1y		1y $<$ mat. $\leq$ 10y		mat. $>$ 10y			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Slope_t^{10y-1y}$	-0.018		-0.111***		-0.021		-4.465***	
	(0.011)		(0.027)		(0.013)		(1.531)	
$E_t^{\$,€}$		0.016		0.186**		0.046		7.276**
		(0.027)		(0.074)		(0.036)		(3.138)
n	1196	1196	1194	1194	1210	1210	1211	1211
N	93	93	93	93	94	94	94	94
T	22	22	22	22	22	22	22	22
KP F-stat.	14.5	14.2	14.4	14.5	14.7	14.5	17.0	14.7
SY 10%	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The dependent variable is Treasury holdings with maturity below 1 year (1)-(2), Treasury holdings with maturity between 1 and 10 years (3)-(4), Treasury holdings with maturity above 10 years (5)-(6), and all non-U.S. sovereign debt (7)-(8), normalized by total assets and expressed in percent. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls include the bank-level and the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

coefficient suggests that active rebalancing plays little role.[14] The size of the effect is much smaller for the book value portfolio than for the market value portfolio, because only newly entered positions are affected. The sign and size of the estimate in the setup that includes the exchange rate support this explanation.

Untargeted Sovereign Bonds. The first six columns of Table 3 display results for regressions in which all outright holdings of U.S. Treasuries are first pooled and then divided into three maturity buckets. In line with the maturities targeted by LSAPs, we obtain significant coefficient estimates for remaining maturities between 1 and 10 years while there are no significant effects on holdings with remaining maturities below 1 year or above 10 years. Thus, we do not find evidence for spillovers into maturity buckets that lie outside of the focus of LSAPs.

[14] A likely explanations is that the Federal Reserve's large-scale asset purchases or sales do not materially alter banks' plans to roll over maturing Treasury positions in the book value portfolio.

By contrast, the columns (7) and (8) show that news about LSAPs have a significant effect on the non-U.S. debt held by euro area banks. The dependent variable in the two specifications shown is the ratio of all non-U.S. sovereign debt holdings to total bank assets. The estimated coefficients are of the same sign as in the regressions for the book and the market value portfolio of U.S. Treasuries. This finding is consistent with the existence of spillovers on the yields of bonds issued by other sovereigns and the finding that the Federal Reserve is an important driver of the "global financial cycle" (Miranda-Agrippino and Rey, 2020a,b). In the presence of such spillovers, LSAP shocks have revaluation effects working through bond prices and exchange rates that are analogous to those described in the context of U.S. Treasuries. The coefficients are larger in absolute value than for U.S. debt in accordance with the substantially bigger volume of the balance sheet items affected by the revaluations.

5.2 Regulatory Capital

Next, we explore whether unconventional monetary policy in the form of asset purchases or sales is associated with changes in standard regulatory capital ratios and hence in the distance of these ratios to bounds imposed by supervisory policy.

Influences on the Tier 1 Capital Ratio. The Tier 1 capital ratio, the ratio of Tier 1 capital to RWAs, may be affected in two ways. First, all else equal, a steepening of the yield curve may lead to a decline in the value of government bond positions, as described in the previous section. The contraction on the asset side may be matched by an adjustment of Tier 1 capital on the liability side of bank balance sheets. This adjustment need not be of equal size though and may even be entirely absent. The reasons are twofold. Banks may hold interest rate swaps or other instruments that allow them to smooth the effect of fluctuations in their sovereign bond portfolio on the total value of their assets. In addition, banks had some discretion over the degree to which unrealized capital gains or losses on securities needed to be reported as a part of Tier 1 capital over most of the sample period.[15] Second, the Tier 1 capital ratio may change in

[15] Banks were given the possibility to exclude capital gains or losses on securities held in the available-for-sale category from their CET1 capital. This option, referred to as a "prudential filter," was phased out toward the end of the sample period.

response to an increase or decrease in RWAs. A decline in the value of sovereign bond holdings brought about by a steepening of the yield curve may feed into Tier 1 capital and induce banks to reduce their RWAs by shrinking their loan portfolio to stabilize the Tier 1 capital ratio.[16] The steepening of the yield curve also raises the profits obtainable from maturity transformation, providing an incentive to scale up lending and hence RWAs. In sum, the response of the Tier 1 capital ratio to a steepening of the Treasury yield curve depends on the extent to which changes in the sovereign portfolio are permitted to feed into Tier 1 capital and the relative strengths of the motives to shrink or expand RWAs by adjusting the loan portfolio.

Spillovers on Bank Capitalization. The columns (1) and (2) of Table 4 contain the results of 2SLS estimations of equation (2), in which the dependent variable is the Tier 1 capital ratio. We now drop the ratios of RWAs and non-equity liabilities to total assets as controls to permit the coefficient of interest to pick up a broad set of influences and avoid reverse-causality concerns. An unanticipated increase in the slope of the U.S. Treasury yield curve of one standard deviation is associated with a statistically significant decline in the Tier 1 capital ratio of about 1.9 percentage points, signifying that banks do not hedge their interest rate risk or adjust their RWAs such that the Tier 1 capital ratio is fully stabilized. The coefficients on the slope of the yield curve and the exchange rate have the same signs as before, consistent with an overall decline in the ratio due to the valuation effects discussed above or an increase in RWAs.

The size of the effect allows drawing conclusions about the underlying mechanism. Because Tier 1 capital is small relative to RWAs, the volatility in RWAs would have to be unrealistically high to bring about an effect on the ratio of the size that we uncover.[17] We conclude therefore that valuation effects on sovereign debt at least contribute to the decline in the Tier 1 capital ratio. The remaining columns repeat the same estimations with the Tier 1 leverage ratio, the ratio of Tier 1 capital to total assets, as dependent variable. The same pattern as with the Tier 1 capital ratio are detectible in this setup.

[16] Sovereign debt holdings have no mechanical effect on RWAs, because their risk weight is zero.

[17] Consider the following back-of-the-envelope calculation. The median Tier 1 capital ratio is 15.5 percent in our sample. Starting from that value, a decline of 1.9 percentage points that solely results from an increase in RWAs would require RWAs to rise by about 14 percent.

Table 4: Capital Ratios

	Tier 1 / RWAs		Tier 1 / Tot. Assets	
	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	-1.874***		-0.449***	
	(0.285)		(0.107)	
$E_t^{\$,€}$		3.697***		1.025***
		(0.555)		(0.220)
n	1535	1535	1417	1417
N	99	99	99	99
T	23	23	23	23
KP F-stat.	43.7	17.2	27.1	8.3
SY 10%	11.5	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The dependent variable is the Tier 1 capital ratio, the ratio of Tier 1 capital to RWAs (1)-(2) and the Tier 1 leverage ratio, the ratio of Tier 1 capital to total assets (3)-(4), expressed in percent. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls are the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

5.3 Credit

What does the impact of the Federal Reserve's large-scale operations on banks' sovereign bond holdings and regulatory metrics imply for their lending activities in the euro area? To answer this question, we first draw on the same empirical approach as before and then extend it with an interaction term that is informative for the international bank capital channel.

Credit Provision in the Euro Area. We depart again from our baseline model where the dependent variable is now the amount of credit extended domestically, normalized by total assets. Domestic credit is defined as the total amount of lending by a bank in the country in which its headquarters are registered. For consistency with the regressions involving the regulatory capital ratios discussed above, we do not condition on other balance sheet items again. The estimation results are presented in the first two columns of Table 5. The total effect of the slope of the Treasury yield curve on domestic credit is positive, while the subcomponent of the effect working through the exchange rate is negative. Both are statistically significant at least at the 5-percent level. Compared with the analogous estimates for sovereign bond holdings and regulatory capital, the coefficients are of the opposite sign, pointing to the existence of channels beyond a response of credit to the worsening of capital ratios.

We isolate the role of regulatory capital by comparing banks that have ample capital with banks that are less-well capitalized. More specifically, we estimate

$$Credit_{i,j,t} = \alpha + \beta \cdot q_t^{LSAP} + \zeta \cdot q_t^{LSAP} \cdot \mathbb{1}_{LR_{i,j,t}<P33_t} + \eta \cdot \mathbb{1}_{LR_{i,j,t}<P33_t} + \boldsymbol{w}'_{j,t}\delta + u_i + \varepsilon_{i,j,t}\ , \tag{3}$$

where $Credit_{i,j,t}$ is the ratio of domestic credit to total assets of a bank and $\mathbb{1}_{LR_{i,j,t}<P33_t}$ is a binary variable indicating whether a bank's leverage ratio falls into the bottom tercile at a given time.[18] We now instrument the linear and the interaction term in q_t^{LSAP} with the orthogonalized LSAP shocks. The results are shown in the last two columns of Table 5. The coefficients on the slope of the yield curve and the exchange rate continue to be positive and negative, respectively. Banks in the bottom tercile of the leverage ratio distribution give significantly less credit relative to their total assets than banks with higher leverage ratios. Importantly, the coefficient on the interaction term is significant and has the opposite sign as the respective slope coefficient on the yield curve or the exchange rate in the two specifications—Belonging to the bottom tercile lowers the total effect of the slope of the yield curve on credit and increases the component of the total effect working through the exchange rate.

Discussion. Our results about the effects of LSAP shocks on the book-value and the market-value U.S. Treasury portfolio, regulatory capital ratios, and domestic credit provide a clear view on the mechanics of the international bank capital channel of unconventional monetary policy. In response to a policy-induced steepening of the Treasury yield curve, the value of long-term Treasury holdings of banks in the euro area declines and capital ratios worsen, which leads banks with comparatively little regulatory capital to contract their lending relative to banks with large capital buffers. The isolated effects stemming from the reaction of the exchange

[18] The choice of the cutoff value in the leverage-ratio distribution trades off sufficient separation between the low-capital and the high-capital groups with a sufficient size of each group and hence the precision of the estimates.

Table 5: Leverage and Credit

	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	1.817**		2.482**	
	(0.768)		(0.966)	
$E_t^{\$,€}$		-5.392***		-6.941***
		(1.428)		(1.579)
$Slope_t^{10y-1y} \times \mathbb{1}_{LR_{i,j,t}<P33_t}$			-1.615**	
			(0.630)	
$E_t^{\$,€} \times \mathbb{1}_{LR_{i,j,t}<P33_t}$				4.028***
				(1.139)
$\mathbb{1}_{LR_{i,j,t}<P33_t}$			-2.512***	-2.480***
			(0.757)	(0.733)
n	1217	1217	1217	1217
N	89	89	89	89
T	22	22	22	22
KP F-stat.	15.1	13.5	13.2	10.2
SY 10%	11.5	11.5	11.1	11.1
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equations (2) and (3). The dependent variable is credit extended domestically, normalized by total assets and expressed in percent. The second part of the table show the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls are the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

rate run in the opposite direction. The dollar appreciation increases the euro value of Treasury holdings, relaxes capital constraints or targets, and exerts upward pressure on the lending of worse-capitalized banks relative to better-capitalized banks. These findings show that the distance to capital constraints or targets affects the response to LSAP shocks even if generally banks in the euro area are well capitalized and regulatory constraints are not binding over the sample period. Falling to the supervisory limit is likely associated with sufficiently high costs for banks to maintain a buffer that influences their response to yield curve shocks away from but within some distance to the constraint. When the U.S. yield curve steepens and the value of their assets contracts, banks fall toward the regulatory limit. The banks in the lower tail of the distribution therefore contract their lending relative to banks in the remainder of the distribution to avoid approaching the constraint too closely.

The significance of the coefficients attached to the linear yield curve and exchange rate terms are indicative of additional channels that have previously been described in the literature. The profitability of maturity transformation increases with the slope of the yield curve.[19] Since positive shocks to the Treasury yield curve tend to result in a steeper yield curve also in the euro area, the positive total effect can be explained by an expansion of lending in response to a bigger spread between the lending and the funding rates of banks. Conversely, a depreciation of the euro against the dollar causes the funding costs of banks in the euro area to increase, because a significant part of bank funding is contracted in dollars.[20] Thus, the negative coefficient on the exchange rate is consistent with a contractionary effect resulting from currency mismatch.

6 Robustness

We perform a large number of robustness checks and derive additional results to fill in details on some of our findings.

Identification and Timing. Our results may depend on the identifying assumptions imposed by Swanson (2021) to extract the LSAP shocks from high-frequency surprises in asset prices. To inspect the role of the identifying assumptions, we repeat our analysis using as instruments a series of LSAP shocks taken from Jarociński (2024) that we orthogonalize to prior data releases and autocorrelation precisely as laid out in Section 3.1. A benefit of this series is that its identification from high-frequency surprises merely relies on the assumption of non-Gaussianity of the structural shocks.[21] The tables C.3 to C.5 in the Appendix contain the estimates for the impact on Treasury holdings, capital ratios, and credit. Overall, the results are little changed by the modification of the instrument. We find that the coefficients tend to be slightly smaller in absolute value though, likely as a result of attenuation bias.

[19] See English et al. (2018) for a discussion.

[20] In the second quarter of 2024, 17 percent of the funding of banks in the euro area was denominated in dollars according to the ECB's Financial Stability Review from November 2024

[21] Identification based on non-Gaussianity has been exploited in several instances. See, for example, Bonhomme and Robin (2009) and Gouriéroux et al. (2017, 2020).

The timing of the empirical model, described in Section 4.2, may also affect our findings. By matching the bank-level data on a given reference date with the slope of the yield curve and the exchange rate aggregated over the month that precedes it, we may focus too narrowly on revaluations and rebalancing that occur close to the reference dates. To assess this possibility, we assign quarterly rather than monthly values of the yield curve slope or the exchange rate to each reference date. We treat the LSAP shock series accordingly by aggregating it to quarterly frequency and using the contemporaneous value and the first four lags of the quarterly series as instruments. Table C.6 in the Appendix shows the results, concentrating on the estimates for credit for conciseness. The estimates are very similar to our baseline set of results. In particular, the total effect of the slope of the yield curve and the interaction term with the indicator for the bottom tercile of the leverage-ratio distribution are nearly unchanged.

Treasury Holdings, Capital, and Credit. By including the slope of the Treasury yield curve and the exchange rate separately in our models, we aim to draw conclusions about the total effect of LSAP shocks and the partial effect working through the exchange rate, respectively. In a robustness exercise shown in Tables C.7 and C.8, we add both variables jointly to the regressions for banks' sovereign debt holdings. In this setup, the coefficient on the exchange rate becomes insignificant, suggesting that the coefficient on the yield curve slope indeed picks up the exchange-rate revaluation channel when the exchange rate is excluded from the equation.[22] We further confirm that the effect of LSAP shocks on the Tier 1 capital ratio and the leverage ratio are driven by bank capital rather than the respective denominator. The results from using the logarithm of Tier 1 capital, RWAs, and total assets separately as the dependent variable are shown in Table C.9. Finally, we revisit the results for domestic credit. Table C.10 contains estimates of equation (3), in which the low-capital indicator is replaced with a binary variable reflecting whether a bank's Treasury holdings in the market value portfolio with a maturity of 1 to 10 years relative to total assets are in the top tercile. The coefficient on the interaction term with the yield curve slope is negative but somewhat less significant than in Table 5. There may be two explanations for this finding, both consistent with the international bank capital channel. First, the capital of banks with the largest Treasury portfolios may be eroded the most by

[22] Note also that the Kleibergen-Paap F-statistic drops below the Stock-Yogo critical value in this setup.

revaluation effects, prompting them to reduce credit provision to stabilize their capital ratios. Second, the source of the effect may be compositional. The distribution of capital ratios is more concentrated and hence the distance to regulatory limits is lower for banks with the largest Treasury holdings, as can be seen from Figures 1 to 3. The estimated effect of large Treasury positions may therefore be a result of correlation with comparatively low regulatory capital.

7 Conclusion

LSAPs carried out in the U.S. are detectable in bank balance sheets in the euro area. Our main findings are threefold. First, LSAPs have a sizable impact on government bonds held outright by euro area banks. A steepening of the U.S. Treasury yield curve induced by LSAP shocks decreases the ratio of U.S. Treasuries to total assets. Further evidence strongly suggests that this relationship is largely a result of revaluation effects—The total effect on Treasury holdings is negative consistent with the decline in the prices of long-term Treasuries, the isolated effect of the exchange rate is positive in line with the appreciation of the dollar, the response is larger for the market value portfolio than for the book value portfolio, and only maturities that are directly targeted by LSAPs are affected. Second, banks allow these valuation effects to feed into their regulatory capital ratios. That is, banks do not hedge their interest rate risk or adjust their RWAs sufficiently to fully stabilize regulatory metrics. Third, the overall effect of a steeper U.S. yield curve on the amount of credit extended domestically is positive, consistent with spillovers on the domestic yield curve and higher profits from maturity transformation. Importantly, banks with a comparably low leverage ratio contract their lending relative to banks that have a bigger capital buffer, which prevents their capital from falling even closer to regulatory bounds.

In a globalized financial system, policies adopted to improve domestic outcomes may have sizable international spillovers and interact with policies implemented abroad. Our results show that the Federal Reserve's LSAPs are transmitted not only to emerging market but also to advanced economies. The spillovers that we describe are triggered by monetary policy in the U.S. and mediated by capital constraints set by micro- and macroprudential policy in the euro area, highlighting the international interconnectedness of different policy tools.

References

Abbassi, P. and Bräuning, F. (2023). Exchange rate risk, banks' currency mismatches, and credit supply. *Journal of International Economics*, 141:103725.

Adrian, T. and Shin, H. S. (2010). Financial Intermediaries and Monetary Economics. In Friedman, B. M. and Woodford, M., editors, *Handbook of Monetary Economics*, volume 3, pages 601–650. Elsevier.

Baskaya, Y. S., di Giovanni, J., Kalemli-Özcan, S., Peydró, J.-L., and Ulu, M. F. (2017). Capital flows and the international credit channel. *Journal of International Economics*, 108:S15–S22.

Bauer, M. and Chernov, M. (2024). Interest Rate Skewness and Biased Beliefs. *The Journal of Finance*, 79(1):173–217.

Bauer, M. D. and Swanson, E. T. (2023a). A Reassessment of Monetary Policy Surprises and High-Frequency Identification. *NBER Macroeconomics Annual*, 37:87–155.

Bauer, M. D. and Swanson, E. T. (2023b). An Alternative Explanation for the "Fed Information Effect". *American Economic Review*, 113(3):664–700.

Boehm, C. E. and Kroner, T. N. (2025). The U.S., Economic News, and the Global Financial Cycle. *The Review of Economic Studies*.

Bonhomme, S. and Robin, J.-M. (2009). Consistent noisy independent component analysis. *Journal of Econometrics*, 149(1):12–25.

Borio, C. and Zhu, H. (2012). Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism? *Journal of Financial Stability*, 8(4):236–251.

Bruno, V. and Shin, H. S. (2015). Capital flows and the risk-taking channel of monetary policy. *Journal of Monetary Economics*, 71:119–132.

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

Dedola, L., Rivolta, G., and Stracca, L. (2017). If the Fed sneezes, who catches a cold? *Journal of International Economics*, 108:S23–S41.

di Giovanni, J., Kalemli-Özcan, S., Ulu, M. F., and Baskaya, Y. S. (2022). International Spillovers and Local Credit Cycles. *The Review of Economic Studies*, 89(2):733–773.

English, W. B., Van den Heuvel, S. J., and Zakrajsek, E. (2018). Interest rate risk and bank equity valuations. *Journal of Monetary Economics*, 98:80–97.

Georgiadis, G. and Jarociński, M. (2025). Global spillovers from multi-dimensional US monetary policy. *Journal of International Economics*, 158:104169.

Gilchrist, S. and Zakrajšek, E. (2012). Credit Spreads and Business Cycle Fluctuations. *American Economic Review*, 102(4):1692–1720.

Gouriéroux, C., Monfort, A., and Renne, J.-P. (2017). Statistical inference for independent component analysis: Application to structural VAR models. *Journal of Econometrics*, 196(1):111–126.

Gouriéroux, C., Monfort, A., and Renne, J.-P. (2020). Identification and Estimation in Non-Fundamental Structural VARMA Models. *The Review of Economic Studies*, 87(4):1915–1953.

Gourinchas, P.-O., Rey, H., and Sauzet, M. (2019). The International Monetary and Financial System. *Annual Review of Economics*, 11:859–893.

Greenwald, D., Krainer, J., and Paul, P. (2024). Monetary Transmission Through Bank Securities Portfolios. NBER Working Papers 32449, National Bureau of Economic Research, Inc.

Greenwood, R., Hanson, S., Stein, J. C., and Sunderam, A. (2023). A Quantity-Driven Theory of Term Premia and Exchange Rates. *The Quarterly Journal of Economics*, 138(4):2327–2389.

Gürkaynak, R. S., Sack, B., and Swanson, E. T. (2005). Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking*, 1(1):55–93.

Holm, M. B., Paul, P., and Tischbirek, A. (2021). The Transmission of Monetary Policy under the Microscope. *Journal of Political Economy*, 129(10):2861–2904.

Jarociński, M. (2024). Estimating the Fed's unconventional policy shocks. *Journal of Monetary Economics*, 144:103548.

Jiménez, G., Ongena, S., Peydró, J.-L., and Saurina, J. (2012). Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications. *American Economic Review*, 102(5):2301â€"26.

Jiménez, G., Ongena, S., Peydró, J.-L., and Saurina, J. (2014). Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking? *Econometrica*, 82(2):463–505.

Jordà, O. (2005). Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*, 95(1):161–182.

Karnaukh, N. and Vokata, P. (2022). Growth forecasts and news about monetary policy. *Journal of Financial Economics*, 146(1):55–70.

Kashyap, A. K. and Stein, J. C. (2000). What Do a Million Observations on Banks Say about the Transmission of Monetary Policy? *American Economic Review*, 90(3):407–428.

Kleibergen, F. and Paap, R. (2006). Generalized reduced rank tests using the singular value decomposition. *Journal of Econometrics*, 133(1):97–126.

Maćkowiak, B. (2007). External shocks, U.S. monetary policy and macroeconomic fluctuations in emerging markets. *Journal of Monetary Economics*, 54(8):2512–2520.

Melosi, L. (2017). Signalling Effects of Monetary Policy. *The Review of Economic Studies*, 84(2):853–884.

Miranda-Agrippino, S. and Nenova, T. (2022). A tale of two global monetary policies. *Journal of International Economics*, 136:103606.

Miranda-Agrippino, S. and Rey, H. (2020a). The Global Financial Cycle after Lehman. *AEA Papers and Proceedings*, 110:523–28.

Miranda-Agrippino, S. and Rey, H. (2020b). U.S. Monetary Policy and the Global Financial Cycle. *The Review of Economic Studies*, 87(6):2754–2776.

Miranda-Agrippino, S. and Rey, H. (2022). The Global Financial Cycle. In Gopinath, G., Helpman, E., and Rogoff, K., editors, *Handbook of International Economics*, volume 6 of *Handbook of International Economics*, pages 1–43. Elsevier.

Miranda-Agrippino, S. and Ricco, G. (2021). The Transmission of Monetary Policy Shocks. *American Economic Journal: Macroeconomics*, 13(3):74–107.

Morais, B., Peydró, J.-L., Roldán-Peña, J., and Ruiz-Ortega, C. (2019). The International Bank Lending Channel of Monetary Policy Rates and QE: Credit Supply, Reach-for-Yield, and Real Effects. *The Journal of Finance*, 74(1):55–90.

Nakamura, E. and Steinsson, J. (2018). High-Frequency Identification of Monetary Non-Neutrality: The Information Effect. *The Quarterly Journal of Economics*, 133(3):1283–1330.

Newey, W. K. and West, K. D. (1987). A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica*, 55(3):703–708.

Orame, A., Ramcharan, R., and Robatto, R. (2025). Macroprudential Regulation, Quantitative Easing, and Bank Lending. *The Review of Financial Studies*, 38(5):1545–1593.

Ramey, V. A. (2016). Macroeconomic Shocks and Their Propagation. In Taylor, J. B. and Uhlig, H., editors, *Handbook of Macroeconomics*, volume 2, pages 71–162. Elsevier.

Rey, H. (2013). Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence. In *Proceedings - Economic Policy Symposium - Jackson Hole*, pages 285–333.

Romer, C. D. and Romer, D. H. (2000). Federal Reserve Information and the Behavior of Interest Rates. *American Economic Review*, 90(3):429–457.

Sastry, K. (2025). Disagreement About Monetary Policy. Unpublished manuscript.

Stock, J. H. and Watson, M. W. (2018). Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments. *The Economic Journal*, 128(610):917–948.

Stock, J. H. and Yogo, M. (2005). Testing for Weak Instruments in Linear IV Regression. In Andrews, D. W. K. and Stock, J. H., editors, *Identification and Inference for Econometric Models*, pages 80–108. Cambridge University Press, Cambridge.

Swanson, E. T. (2021). Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. *Journal of Monetary Economics*, 118:32–53.

van den Heuvel, S. J. (2002). Does bank capital matter for monetary transmission? *Economic Policy Review*, 8(May):259–265.

A Data

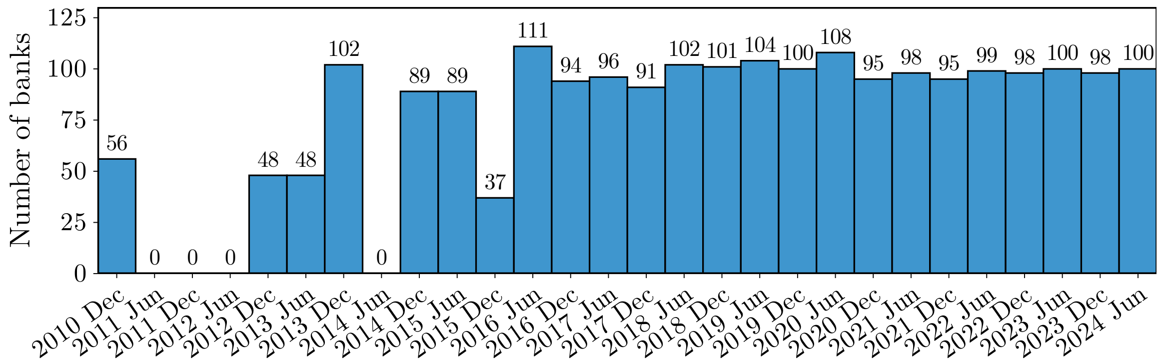

Figure A.1: Number of Banks Observed

Notes: The figure shows the number of banks contained in the sample in the semester ending in the month listed.

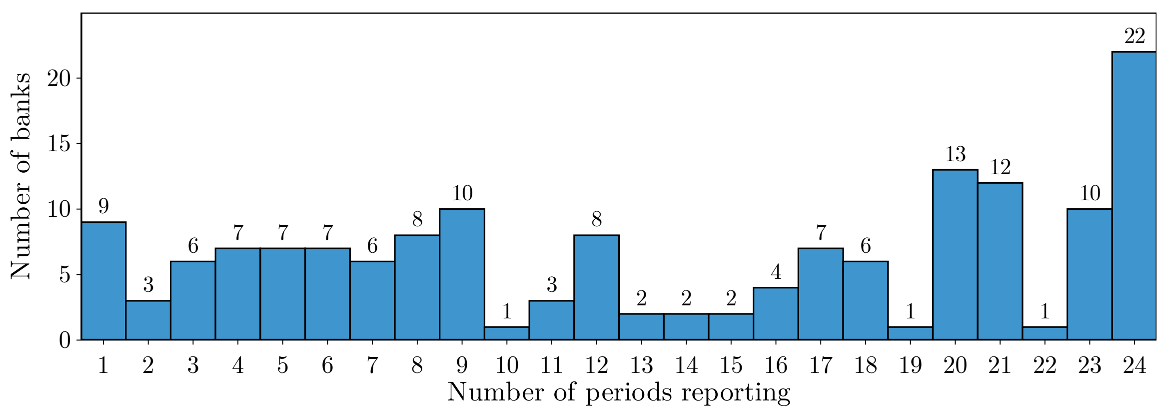

Figure A.2: Frequency of Bank Sampling

Notes: The figure reports the frequency at which individual banks are contained in the sample.

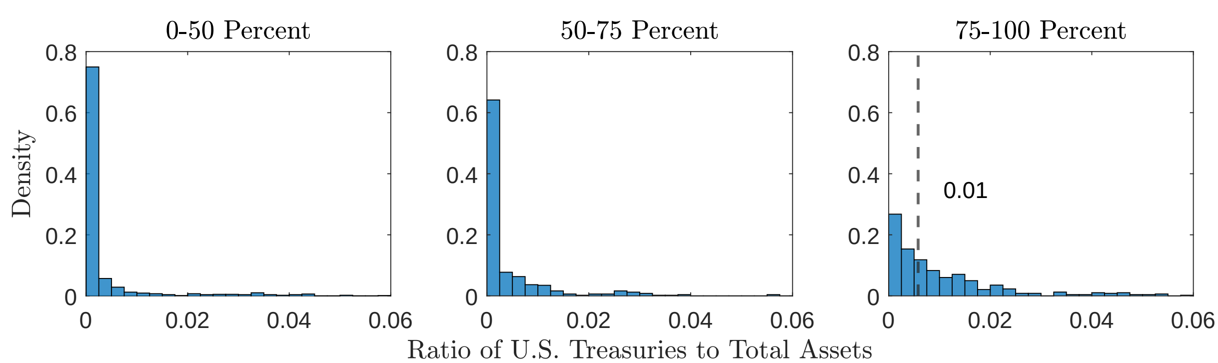

Figure A.3: U.S. Treasury Holdings Relative to Total Assets by Bank Size

Notes: Each panel of the figure shows the distribution of U.S. Treasury holdings relative to total assets for the segment of the total asset distribution given in the title. Treasury holdings include the market and the book value portfolio. The dashed vertical line in the right panel marks the group median.

B Monetary Policy Identification

Table B.1: LSAP Shock Orthogonalization

	(1)	(2)	(3)
Yield curve slope (3m change)	-0.22***	-0.21**	-0.21**
	(0.08)	(0.10)	(0.10)
Employment (expectational error)	0.06***	0.07*	0.08**
	(0.02)	(0.04)	(0.04)
Employment (1y growth)		0.01	0.01
		(0.03)	(0.03)
Commodity prices (3m growth)		-0.41	-0.39
		(0.35)	(0.38)
Stock prices (3m growth)			-0.31
			(0.69)
Treasury skewness (3m growth)			0.10
			(0.16)
T	360	360	360
R^2	0.03	0.03	0.04
F	7.0	3.6	2.4
(p-value)	(0.00)	(0.01)	(0.03)

Notes: The dependent variable is the series of LSAP shocks at FOMC meeting frequency from Swanson (2021), extended to range from February 1988 to December 2023. Shown in parentheses are heteroskedasticity-robust standard errors. All regressions include a constant. Asterisks indicate significance levels with $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

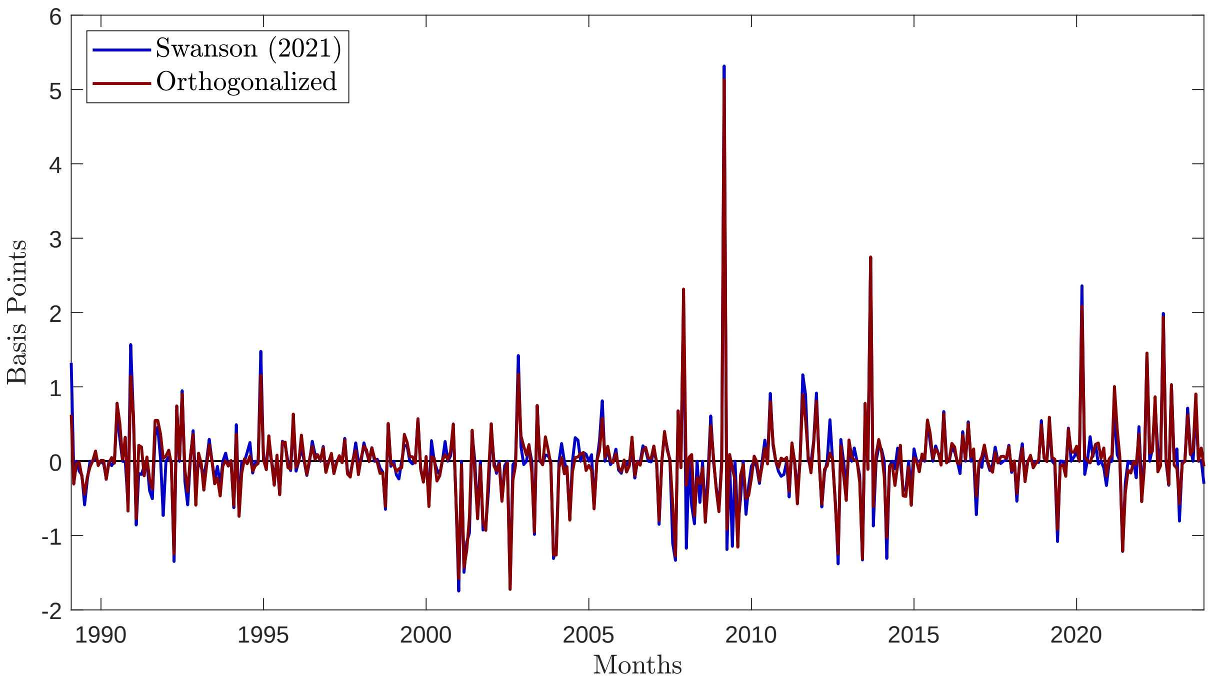

Figure B.1: LSAP Shocks Before and After Orthogonalization

Notes: The figure shows the extended LSAP shocks from Swanson (2021) and the same series after orthogonalization with respect to prior data releases and autocorrelation. Both series are shown at monthly frequency. A positive shock indicates larger than expected asset purchases.

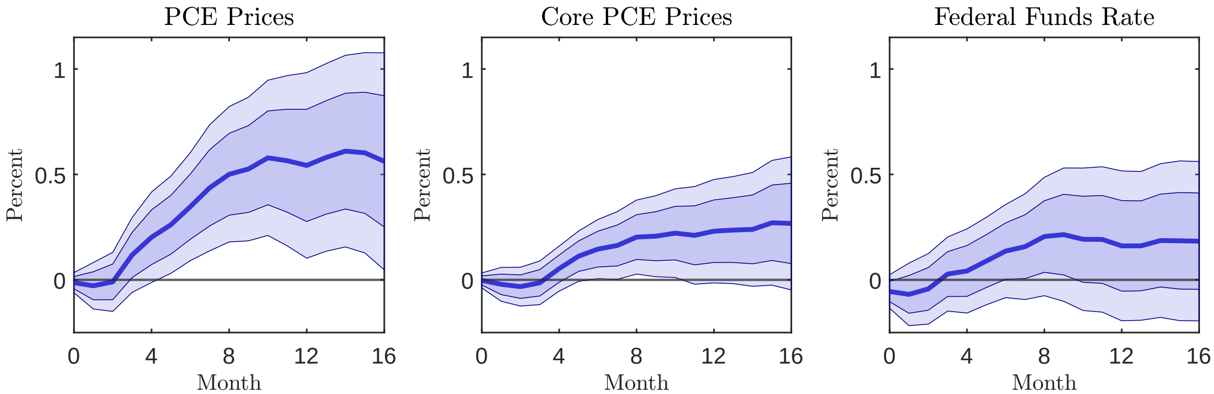

Figure B.2: Additional Impulse Responses

Notes: The figure shows impulse responses to an LSAP shock estimated based on equation (1) together with 68-percent and 90-percent confidence bands constructed based on Newey and West (1987) standard errors.

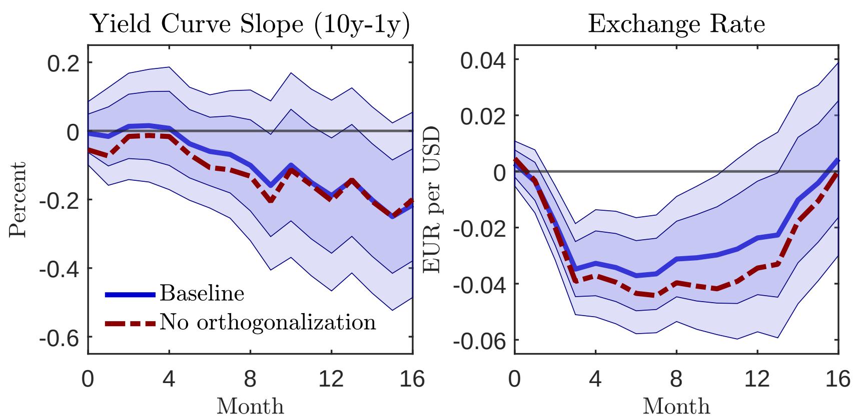

Figure B.3: No Shock Orthogonalization

Notes: The figure shows impulse responses estimated based on the orthogonalized shock series (Baseline) and the unorthogonalized shocks (No orthogonalization) together with 68-percent and 90-percent confidence bands constructed with Newey and West (1987) standard errors.

C Additional Estimation Results

Table C.1: First Stage (Slope of the Yield Curve)

	(1)	(2)	(3)
s_t^0	-0.0752	-0.0325	0.0219
	(0.233)	(0.141)	(0.143)
s_t^{-1}	-1.516	-0.863	-1.048
	(0.992)	(0.551)	(0.639)
s_t^{-2}	0.194	0.222	0.213
	(0.528)	(0.372)	(0.414)
s_t^{-3}	0.196	-0.116	-0.0575
	(0.166)	(0.150)	(0.148)
s_t^{-4}	2.017***	2.719***	2.906***
	(0.544)	(0.342)	(0.794)
s_t^{-5}	-0.227	1.063**	0.914*
	(0.693)	(0.537)	(0.524)
s_t^{-6}	-0.751***	-0.663***	-0.683***
	(0.199)	(0.135)	(0.131)
s_t^{-7}	-2.439***	-2.642***	-2.762***
	(0.838)	(0.808)	(0.880)
s_t^{-8}	0.287	1.948**	1.791**
	(0.562)	(0.819)	(0.761)
s_t^{-9}	-0.393**	-0.835***	-0.807***
	(0.163)	(0.170)	(0.166)
s_t^{-10}	1.787*	3.529***	3.559***
	(0.936)	(0.764)	(0.860)
s_t^{-11}	1.119	1.910***	2.066***
	(0.692)	(0.516)	(0.514)
n	1371	1371	1207
N	97	97	92
T	23	23	22
KP F-stat.	28.2	28.5	14.1
SY 10%	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes
Country controls	No	Yes	Yes
Bank controls	No	No	Yes

Notes: The dependent variable is $Slope_t^{10y-1y}$. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions include bank fixed effects. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.2: First Stage (Exchange Rate)

	(1)	(2)	(3)
s_t^0	0.234**	0.245***	0.318***
	(0.107)	(0.0884)	(0.0970)
s_t^{-1}	0.879*	0.643	0.199
	(0.474)	(0.479)	(0.461)
s_t^{-2}	0.335	0.433*	0.569***
	(0.240)	(0.224)	(0.216)
s_t^{-3}	-0.116	-0.0248	-0.0117
	(0.0808)	(0.106)	(0.0828)
s_t^{-4}	-0.718*	-0.833***	0.117
	(0.430)	(0.321)	(0.618)
s_t^{-5}	0.109	-0.106	-0.320
	(0.284)	(0.420)	(0.396)
s_t^{-6}	0.249***	0.235***	0.232***
	(0.0691)	(0.0575)	(0.0483)
s_t^{-7}	0.902	0.851	0.295
	(0.613)	(0.618)	(0.519)
s_t^{-8}	0.446	0.145	0.199
	(0.316)	(0.433)	(0.384)
s_t^{-9}	-0.0347	0.0365	-0.00471
	(0.0701)	(0.0870)	(0.0809)
s_t^{-10}	0.108	-0.420	0.0479
	(0.422)	(0.492)	(0.535)
s_t^{-11}	-0.830	-0.977**	-0.670
	(0.519)	(0.497)	(0.468)
n	1371	1371	1207
N	97	97	92
T	23	23	22
KP F-stat.	15.8	8.8	14.7
SY 10%	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes
Country controls	No	Yes	Yes
Bank controls	No	No	Yes

Notes: The dependent variable is $E_t^{\$,€}$. The second part of the table show the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions include bank fixed effects. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.3: U.S. Treasury Holdings with Jarociński (2024) Shocks

	Market Value		Book Value	
	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	-0.088**		-0.024	
	(0.038)		(0.016)	
$E_t^{\$,€}$		0.104		0.051*
		(0.067)		(0.031)
n	1186	1186	1207	1207
N	94	94	92	92
T	22	22	22	22
KP F-stat.	17.8	57.3	17.5	61.4
SY 10%	11.5	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The respective dependent variable is the market value portfolio (1)-(2) and the book value portfolio (3)-(4), all normalized by total assets and expressed in percent. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls include the bank-level and the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.4: Capital Ratios with Jarociński (2024) Shocks

	Tier 1 / RWA		Tier 1 / Tot. Assets	
	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	-1.745***		-0.414***	
	(0.321)		(0.110)	
$E_t^{\$,€}$		2.427***		0.575**
		(0.705)		(0.252)
n	1535	1535	1417	1417
N	99	99	99	99
T	23	23	23	23
KP F-stat.	85.1	47.2	37.9	32.7
SY 10%	11.5	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The dependent variable is the Tier 1 capital ratio, the ratio of Tier 1 capital to RWAs (1)-(2) and the Tier 1 leverage ratio, the ratio of Tier 1 capital to total assets (3)-(4), expressed in percent. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls are the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.5: Leverage and Credit with Jarociński (2024) Shocks

	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	1.867**		2.513**	
	(0.815)		(1.057)	
$E_t^{\$,€}$		-3.787***		-4.711***
		(1.354)		(1.752)
$Slope_t^{10y-1y} \times \mathbb{1}_{LR_{i,j,t}<P33_t}$			-1.544**	
			(0.707)	
$E_t^{\$,€} \times \mathbb{1}_{LR_{i,j,t}<P33_t}$				2.432*
				(1.325)
$\mathbb{1}_{LR_{i,j,t}<P33_t}$			-2.484***	-2.141***
			(0.780)	(0.705)
n	1217	1217	1217	1217
N	89	89	89	89
T	22	22	22	22
KP F-stat.	24.5	55.4	3.1	67.8
SY 10%	11.5	11.5	11.1	11.1
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equations (2) and (3). The dependent variable is credit extended domestically, normalized by total assets and expressed in percent. The second part of the table show the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls are the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.6: Leverage and Credit with Quarterly Instruments

	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	1.738**		2.355**	
	(0.785)		(0.969)	
$E_t^{\$,€}$		-4.091***		-5.206***
		(1.384)		(1.645)
$Slope_t^{10y-1y} \times \mathbb{1}_{Lev.ratio<p33_t}$			-1.519***	
			(0.576)	
$E_t^{\$,€} \times \mathbb{1}_{Lev.ratio<p33_t}$				2.867***
				(1.073)
$\mathbb{1}_{Lev.ratio<p33_t}$			-2.456***	-2.226***
			(0.722)	(0.687)
n	1217	1217	1217	1217
N	89	89	89	89
T	22	22	22	22
KP F-stat	20.6	10.4	11.4	5.2
SY 10%	10.8	10.8	10.6	10.6
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equations (2) and (3). The dependent variable is credit extended domestically, normalized by total assets and expressed in percent. The second part of the table show the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls are the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.7: U.S. Treasury Holdings ($Slope_t^{10y-1y}$ and $E_t^{\$,€}$)

	Market Value	Book Value
	(1)	(2)
$Slope_t^{10y-1y}$	-0.156***	-0.018
	(0.060)	(0.022)
$E_t^{\$,€}$	-0.079	0.050
	(0.132)	(0.058)
n	1186	1207
N	94	92
T	22	22
KP F-stat.	5.5	5.5
SY 10%	10.8	10.8
Bank FE	Yes	Yes
Controls	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The respective dependent variable is the market value portfolio (1) and the book value portfolio (2), all normalized by total assets and expressed in percent. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls include the bank-level and the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.8: Untargeted Sovereign Debt ($Slope_t^{10y-1y}$ and $E_t^{\$,€}$)

	U.S. Treasuries			
	mat. $\leq$ 1y	1y $<$ mat. $\leq$ 10y	mat. $>$ 10y	Non-U.S. govt. bonds
	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	-0.025	-0.110***	-0.015	-4.426**
	(0.016)	(0.029)	(0.019)	(2.105)
$E_t^{\$,€}$	-0.025	0.006	0.021	0.141
	(0.033)	(0.047)	(0.050)	(3.641)
n	1196	1194	1210	1211
N	93	93	94	94
T	22	22	22	22
KP F-stat	5.3	5.6	5.5	5.8
SY 10%	10.8	10.8	10.8	10.8
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The dependent variable is Treasury holdings with maturity below 1 year (1), Treasury holdings with maturity between 1 and 10 years (2), Treasury holdings with maturity above 10 years (3), and all non-U.S. sovereign debt (4), normalized by total assets and expressed in percent. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls include the bank-level and the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.9: Capital Ratios (Components)

	log(Tier 1)		log(RWA)		log(Tot. Assets)	
	(1)	(2)	(3)	(4)	(5)	(6)
$Slope_t^{10y-1y}$	-0.113***		0.022		-0.030	
	(0.022)		(0.020)		(0.020)	
$E_t^{\$,€}$		0.217***		-0.047		0.048
		(0.045)		(0.038)		(0.047)
n	1574	1574	1574	1574	1433	1433
N	99	99	99	99	99	99
T	23	23	23	23	23	23
KP F-stat.	43.9	16.8	43.9	16.8	28.3	8.4
SY 10%	11.5	11.5	11.5	11.5	11.5	11.5
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equation (2). The dependent variable is Tier 1 capital (1), RWAs (2), and total assets (3), all in logs. The second part of the table shows the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls are the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

Table C.10: U.S. Treasury Holdings and Credit

	(1)	(2)	(3)	(4)
$Slope_t^{10y-1y}$	1.817**		2.145**	
	(0.768)		(0.883)	
$E_t^{\$,€}$		-5.392***		-5.976***
		(1.428)		(1.516)
$Slope_t^{10y-1y} \times \mathbb{1}_{1y-10y\ US_{i,j,t} > P66_t}$			-1.085*	
			(0.568)	
$E_t^{\$,€} \times \mathbb{1}_{1y-10y\ US_{i,j,t} > P66_t}$				2.379**
				(1.086)
$\mathbb{1}_{1y-10y\ US_{i,j,t} > P66_t}$			-0.365	-0.369
			(0.462)	(0.402)
n	1217	1217	1217	1217
N	89	89	89	89
T	22	22	22	22
KP F-stat.	15.1	13.5	13.4	46.3
SY 10%	11.5	11.5	11.1	11.1
Bank FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table shows 2SLS estimates of equations (2) and (3). The dependent variable is credit extended domestically, normalized by total assets and expressed in percent. The second part of the table show the total number of observations (n), the total number of Banks (N), the number of semesters (T), the Kleibergen-Paap F-statistic (KP F-stat.), and the Stock-Yogo 10% bias-based critical value (SY 10%). All regressions apply bank fixed effects. The controls are the country-level variables. The standard errors (in parentheses) are two-way clustered at the bank and the semester level. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).