Spillovers of LSAPs through Treasuries on foreign balance sheets*

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Abstract

We introduce and quantify a new financial channel for the international transmission of large scale asset purchase programmes (LSAP) by the Federal Reserve. European banks hold a significant amount of US Treasuries on their balance sheet, and quantiative easing (or tightening) policy in the US affects the value of their holdings via two opposing channels. It raises the price of long-term US Treasuries, resulting in a capital gain for banks (*price channel*). On the other hand, it depreciates the US dollar, resulting in a capital loss absent perfect hedging (exchange rate channel). The relative size of the two effects is not obvious *ex ante*, and we measure it, as well as the ramifications for credit provision, using granular data on European banks. The exchange rate channel dominates, and banks actively rebalance away from US Treasuries in response to QE. Bank net worth drops and lending contracts. QE in the US can then have *negative* spillovers to the real economy in Europe through banks' exposure to US Treasuries. The reaction of net worth and credit is more muted for large banks, suggesting that they can better cushion the impact of the shock.

Keywords: International spillovers, Quantitative easing, US Treasuries

JEL Codes: E44, E52, F41, G15

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1 Introduction

In the early months of 2023, the dramatic failure of Silicon Valley Bank due in large part to unrealized losses on their US Treasury portfolio showed that the world's safe asset of choice is not devoid of risk. The recent round of conventional policy tightening brought the severity of interest risk embedded in government bonds into sharp relief, and the ongoing process of reversing quantitative easing (QE) raises questions on the implications of valuation effects on government bonds for the financial sector and credit conditions both in the US and abroad.

European banks are also substantially exposed to US Treasuries, and they face an additional source of risk in the form of exchange rate fluctuations, provided that they do not perfectly hedge. By both, the raising of the price of U Treasuries in US dollars and causing a US dollar depreciation, QE policies by the Federal Reserve affect the value of US government bonds held by banks in Europe in two opposite directions. Through the lens of a financial accelerator framework in which banks are leverage-constraints (Bernanke et al., 1999), the resulting capital gains or losses cause bank lending to expand or contract. The relative size of these two effects is an open question, to which we provide an empirical answer.

Studies on the spillover of the Fed' LSAP abound, but they chiefly point to a *positive* effect on foreign economies, be it via a reduction of foreign yields (Neely, 2010; Bauer and Neely, 2014) and term premia (Alpanda and Kabaca, 2020), an increase in equity prices (Chen et al., 2012b), or a boost to local aggregate demand (Kolasa and Wesołowski, 2020). In this paper, we instead highlight the potential for QE policies to have *negative* spillovers to the real economy through the financial sector if the exchange rate effects dominates.

First, we provide evidence via local projections that QE shocks cause a drop in the yield of long-term US Treasury and a depreciation of the US dollar through a fall in the spread between long-term US and German government bonds. These results show that the price and exchange rate channels do indeed operate in the expected directions and thereby confirming the results of previous literature.

Then, we estimate the effect of QE shocks on the balance sheet of European banks. We exploit bank-level data provided by the European Banking Authority that allows us to observe the exposure of European banks to US Treasuries at a granular level of detail. We find that QE reduces the value of US Treasury holdings on European banks' balance sheets, consistent with the exchange rate channel dominating. A rebalancing away from US Treasuries is also apparent. We then trace out the ramifications to banks' net worth, finding that a QE shock raises net worth and lending through the price effect, and lowers them through the exchange rate effect. Our estimates of the net effect of QE show that net worth decreases as well as credit, conditional on macroeconomic and financial controls that account for other possible channels of QE spillovers. This finding indicates that the exchange rate effect on US Treasury dominates.

Overall, our results shed new light on the spillovers of the Fed's QE to credit conditions in Europe through the exposure of leverage-constrained banks to US Treasuries. Contrary to the positive spillovers highlighted by previous literature, our results demonstrate that the dollar depreciation of US Treasuries on banks' balance sheets in response to QE leads to a contraction in lending. Likewise, they suggest that the ongoing quantitative tightening policies might instead have a *positive* effect on the European economy through a US dollar appreciation

The rest of the paper is structured as follows. Section 2 introduces the granular dataset on European banks that we use in our empirical analysis. Section 3 reports evidence on the effect of the Fed's QE on the financial variables relevant for European bank's exposure to US Treasuries. Section 4 introduces a simple framework of banks' balance sheets under leverage constraints to guide the empirical analysis. Section 5 presents our estimates on the effect of QE on European banks' US Treasury holdings, net worth and lending using panel regressions.

2 Data

2.1 The EBA Transparency Exercise and Stress Test datasets

We use bank-level data from the European Banking Authority's (EBA) Transparency Exercise and Stress Test databases. They are based on regulatory reports filed by the largest banks domiciled in the European Economic Area, which includes European Union plus Iceland, Liechtenstein, and Norway.

The reports are semi-annual, available from December 2010 to June 2022 for a total of 20 semesters.[1] For the purpose of this study, we restrict our attention to banks operating in the euro area to simplify exchange rate effects to the EUR/USD currency pair only. This restriction leaves us with 152 out of 189 banks, not all of which are observed every semester. The resulting dataset is an unbalanced panel with 1671 observations.[2] Appendix B.3 details the number of banks by size quartile and country, showing that banks from Germany, Italy, Spain and France are the most

[1] The Transparency Excercise was first conducted in 2013, and did not take place in 2014. We supplement the data with information from the 2011 and 2014 Stress Tests, which contain data for December 2011 and December 2013. Therefore, we miss observations for the first semesters of 2012 and 2014.

[2] Some variables such as total assets and credit are not reported in every semester. Furthermore, the Jarocinski (2021) QE shock series is available only until June 2019. Therefore, the number of observations in regressions is lower. More specifically, we lose 595 observations which gives us a total of 1076 observations.

represented.

We can observe the exposure of individual banks to US government debt, broken down by maturity buckets and accounting portfolio.[3] The database also includes information on other balance sheet items such as *Total Assets, Tier 1 Capital ratios* and *Credit.* The variable *Total Assets* is interpolated with data from CapitalIQ.

The QE shock series utilized in our empirical analysis is identified by Jarocinski (2021) through a rigorous methodology. Jarocinski adopts a high-frequency identification approach, focusing on the 30-minute window surrounding the Federal Open Market Committee (FOMC) meetings. This approach allows him to isolate monetary policy shocks affecting both long-term and short-term interest rates in the USA. Notably, Jarocinski takes into consideration the non-Gaussian nature of market reactions, employing a Student-t distribution. This unique approach enables him to identify these shocks without imposing additional economic restrictions. To facilitate our analysis, we aggregate these shocks at the quarterly level. This aggregation involves summing the shocks that occurred within each quarter. On average, there are approximately four to five such shocks within each quarterly period.

2.1.1 Summary statistics

Table 1 reports summary statistics of the bank-level variables that we include in our analysis. Notwithstanding the restriction to banks subject to EBA reporting, our sample spans a wide range of sizes, with total assets ranging from €280 million to more than €2 trillion. In total, the dataset covers approximately 67% of the eurozone's banking sector by assets as of June 2022. [4]

Treasury holdings make up a relatively small percentage of banks' total assets on average, although some banks are heavily exposed. Holdings of US government bonds are small compared to total credit as well, on average less than €2 billion of exposure at market value versus €59.88 billion of credit, reflecting a sample of mostly commercial bank whose core business is lending. However, Figure 1 shows that Treasuries add up to a non-negligible share of capital for many banks, with an average total exposure of 10.25 of Tier 1 capital and several instances in which Treasury holdings

[3]Banks can report their balance sheet holdings of government bonds as either available for trading or held to maturity. In the former case, they report them at market value, while in the latter they report them at amortised historical cost. The EBA datasets record information on both types of holdings separately, which we refer to in the text as *Book Value Exposure* and *Market Value Exposure.* It also reports information on *Non-derivative Exposure*, which is the sum of market and book value exposure, and *Derivative exposure.* The sum of derivative and non-derivative exposure is reported as *Total Exposure.*

[4]Aggregate total assets of eurozone-domiciled banks in the EBA Transparency Exercise dataset divided by total assets of Monetary and Financial Institutions domiciled in the Eurozone as reported in the ECB's Balance Sheet Items dataset.

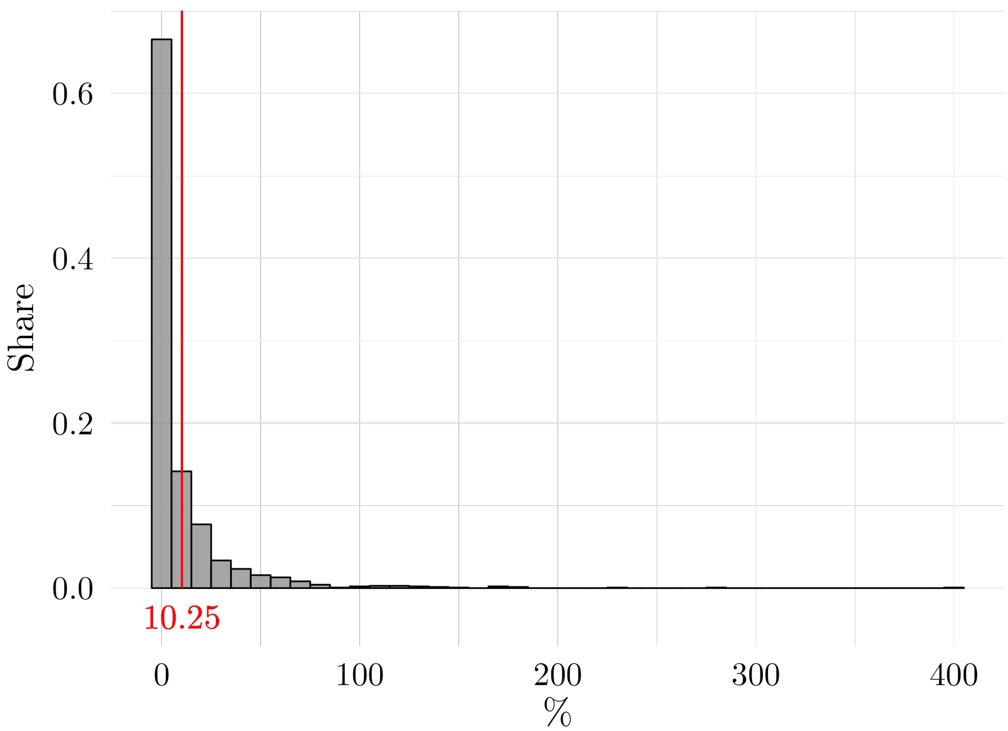
exceed the entire capital cushion. Therefore, fluctuations in the value of Treasuries through prices and exchange rates resulting from unconventional monetary policy can significantly affect bank capital. In turn, these fluctuations in net worth can impact credit provision and the real economy through leverage constraints.

Table 1: Summary statistics

Variable	Obs.	Mean	SD	Min	Median	Max
Total Assets (€ bln.)	749	247.85	400.13	0.28	75.32	2171.39
Tier 1 capital (€ bln.)	1019	13.05	18.73	0.08	5.35	91
T1 leverage ratio (pp)	749	6.95	5.96	1.15	5.81	76.65
Total Treas exp (€ bln.)	1076	2.14	6.75	0	0	58.76
Market-val. Treas exp.(€ bln.)	598	1.87	6.79	−0.16	0	78.83
Book-val. Treas exp.(€ bln.)	598	0.7	2.73	−0.08	0	34.26
Total credit (€ bln.)	1020	59.88	92.27	0.01	21.53	510.48

Notes: The table shows summary statistics for the estimation sample, which includes 152 European banks. All values except the *T1 leverage ratio* are in Euro billions. Negative amounts of market and book value exposure reflect short positions in US Treasuries, excluding positions on Treasuries reported among financial assets held for trading that are netted out with cash short position.

Figure 1: Treasury holdings as fraction of Tier 1 capital

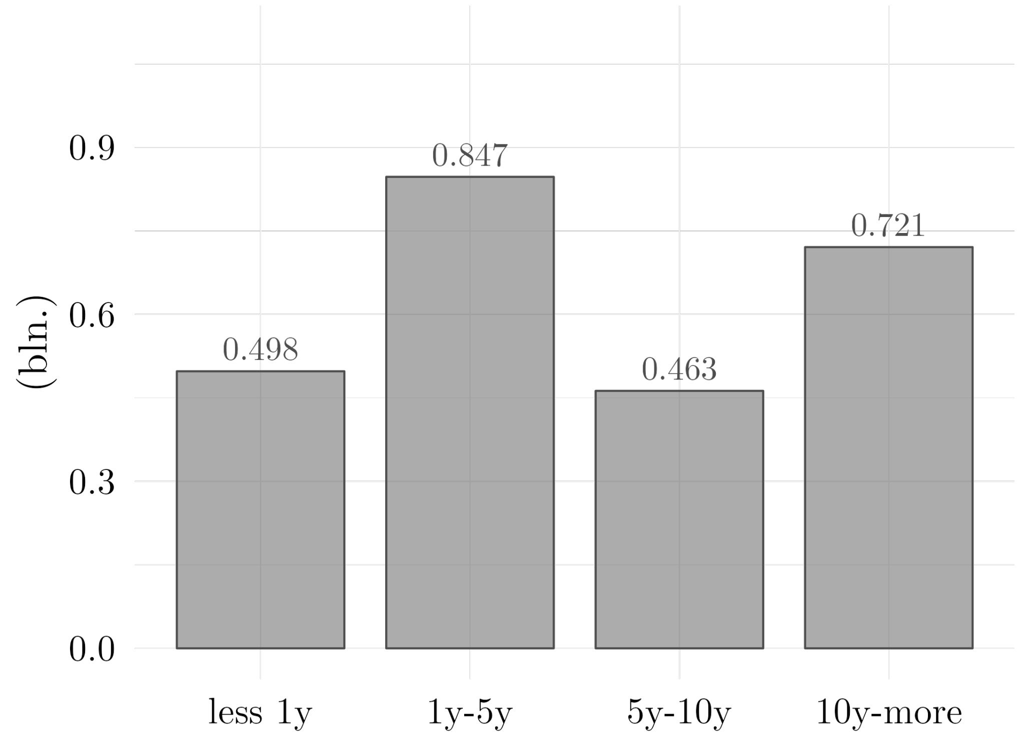


Notes: This figure shows the distribution of total exposure to US Treasuries as a percentage of the banks' Tier 1 capital.

2.2 Heterogeneity in Treasury holdings by bank size

The profile of banks' exposure to US Treasuries is varied in terms of both their importance on the balance sheet and their term structure. The most relevant determinant is bank size, so it is important to investigate the different sensitivity of large and small banks to QE shocks that affect the value of their Treasury holdings. European banks tend to hold US Treasuries mainly in the 1- to 5-year and 10-year or more maturity brackets, with average amounts of nearly €1 billion in either category (Figure 2).

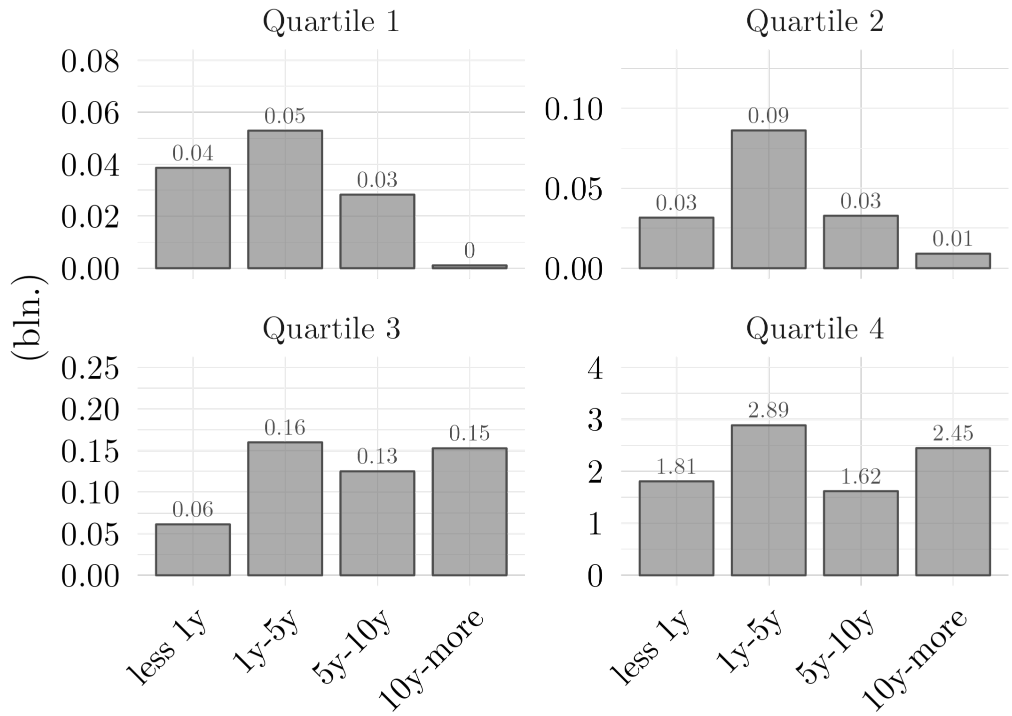
Figure 2: Term structure of Treasury holdings



Notes: European banks holdings of US Treasuries split up in different maturity buckets. US Treasuries with a maturity of less than 1 year are are called *Treasury Bills*, *Treasury Notes* have a maturity of 2-10 years, and *Treasury Bonds* of 10 or more years.

Drilling down to the difference in term structure across the bank size distribution, we can see how the pattern observed in the aggregate is driven by large banks. While banks in the first and second size quartile, on average, hardly hold any longer-term Treasuries, those in the upper two quartiles display a Treasury portfolio that is heavily tilted towards middle and longer maturties (Figure 3).

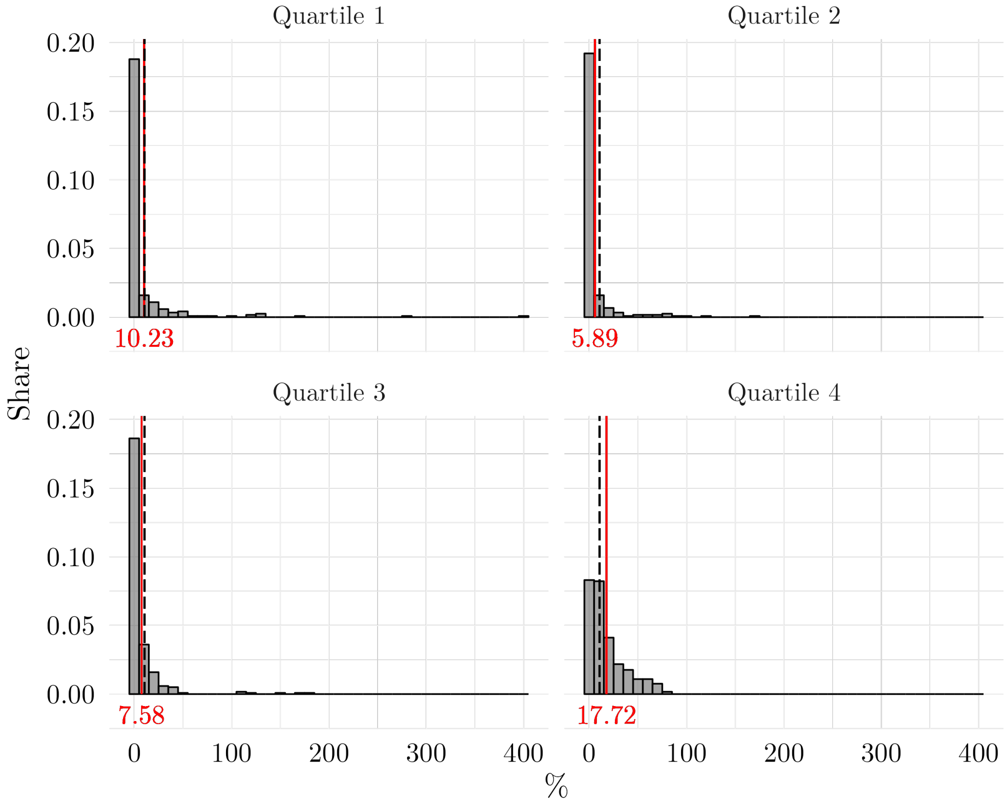
Figure 3: Term structure of Treasury holdings by bank size



Notes: US Treasury holdings split up by maturity and bank size quartile (where bank size is measured by total assets). *Quartile 1* contains the smallest banks, while the biggest banks are reported in *Quartile 4*.

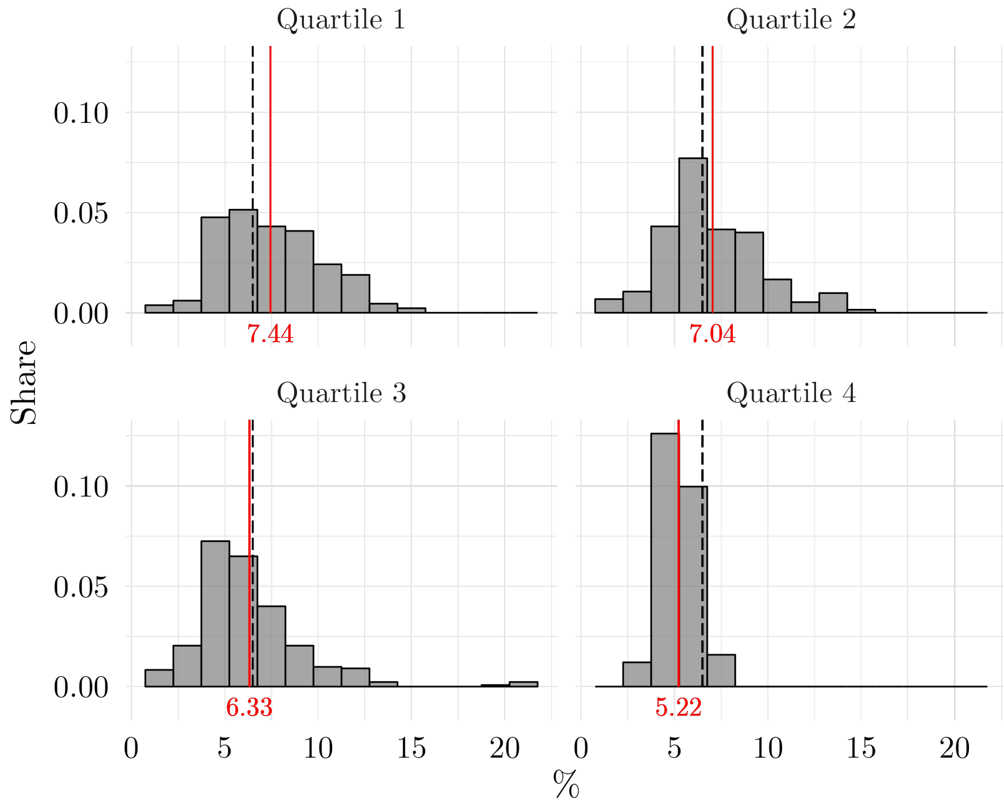
Likewise, larger banks are overall more exposed to Treasuries as a fraction of net worth. Figure 4 shows that banks in the third and fourth quartile by size have an average exposure of 17.5% of their Tier 1 capital, more than 6 percentage points higher than the average of 11% for banks in the first quartile. Large banks also display an altogether less right-skewed distribution characterised by many fewer zeros. Larger banks are also more leveraged, with an average ratio of Tier 1 capital to total asset of 5.23% in the fourth quartile, compared to 7.48% in the first (Figure 5). Therefore, the higher Treasury exposure and leverage might render lending by large banks *ceteris paribus* more sensitive to capital gains or losses incurred on their Treasury portfolio. On the other hand, large banks might be able to soften the impact of valuation changes of Treasuries through wider asset diversification, higher rates of foreign exchange and interest rate risk hedging, and better risk-bearing capacity.

Figure 4: Treasury holdings as fraction of Tier 1 capital by bank size



Notes: Total exposure to US Treasuries as a share of the banks' Tier 1 capital. The top-left panel (*Quartile 1*) shows the distribution of the smallest banks, while the bottom-right panel (*Quartile 4*) shows the distribution for the largest banks.

Figure 5: Leverage ratio by bank size



Notes: Tier 1 leverage ratio (defined as the Tier 1 capital divided by total assets) split up by bank size. The top-left panel (*Quartile 1*) shows the distribution of the smallest banks, while the bottom-right panel (*Quartile 4*) shows the distribution for the largest banks.

This heterogeneity suggests that the reaction of bank capital and credit to QE shocks is likely to vary significantly by bank size, and it is not obvious *a priori* whether large banks should react more or less strongly. We address this question in our econometric models by including bank size and interacting it with QE shocks.

3 Reaction of bond yields and exchange rates

The two main avenues through which QE affects the value of Treasuries on European banks' balance sheets are their price in US dollars, and the EUR/USD exchange rate. The existing empirical literature on the effects of QE has focused mainly on the former, finding that large-scale asset purchase programmes by the Fed lead to a drop in the yield of targeted assets (D'Amico and King, 2013; Krishnamurthy and Vissing-Jorgensen, 2011) and a compression in the term premium (Gagnon et al., 2011; Li and Wei, 2013), in accordance with with a portfolio balance channel through imperfect substitution between maturities (Vayanos and Vila, 2021; Greenwood and Vayanos, 2014)

. Evidence on the exchange rate effect is less abundant, but the general consensus is that QE leads to a dollar depreciation through a form of Uncovered Interest Parity (UIP), either standard (Dedola et al., 2021), or modified by preferred-habitat (Gourinchas et al., 2022) or convenience-yield (Jiang et al., 2021a) mechanisms.

In this section, we provide evidence of the joint response of Treasury yields, exchange rate and international spreads to the Fed's QE. The aim is to establish whether the QE shock series we use in the bank-level panel regressions has the expected effects on financial variables relevant for Treasuries. Together with the EUR/USD exchange rate, we consider the 10 year US Treasury yield, the 3-month US Treasury yield, the spread between the two, and the long-term international spread between yield of US Treasuries and German government bonds at the 3-month and 10-year maturities. [5]

The long-term US rate, here measured at the 10-year maturity, is directly targeted by QE, and which is also associated with a compressed term spread. The long-term spread between US and German bonds should then decrease, mediating a dollar depreciation on the exchange rate. However, the short-term US-German spread might move the exchange rate in the opposite direction if QE shifts the US yield curve downwards through signaling effects rather than flattening it Bauer and Rudebusch (2014).

We esimate monthly local projections of the variables listed above on the QE shock series identified by Jarocinski (2021) exploiting excess kurtosis in financial market responses. We choose this shock series as it reflects the state of the art in the identification of monetary policy surprises. Previous approaches distinguish between conventional and generic unconventional shocks (Gürkaynak et al., 2007), or more granularly between conventional, forward guidance, and QE shocks as in (Swanson, 2021). The Jarocinski (2021) can in addition distinguish QE from Delphic and Odyssean forward guidance.

The estimating equation, which follows the Jordà (2005) approach, is

$$y_{t+h} - y_{t-1} = \alpha^h + \beta^h \eta_t + \textstyle\sum_{i=1}^{p} \gamma_i^h \eta_{t-i} + \Gamma_i^h X_t + e_{t+h}, \tag{1}$$

where η is the QE shock in month t and β^h is the h-horizon component of the impulse response function. In addition, lags of the shock series are included ($p = 7$) and X_t is a vector of contemporaneous controls. We include the standard monetary policy shock, and the Delphic and Odyssean

[5] we use long- and short-term yields on the German goverment bonds because they are the safest in the eurozone and thus likely to be the relevant rate for UIP effects.

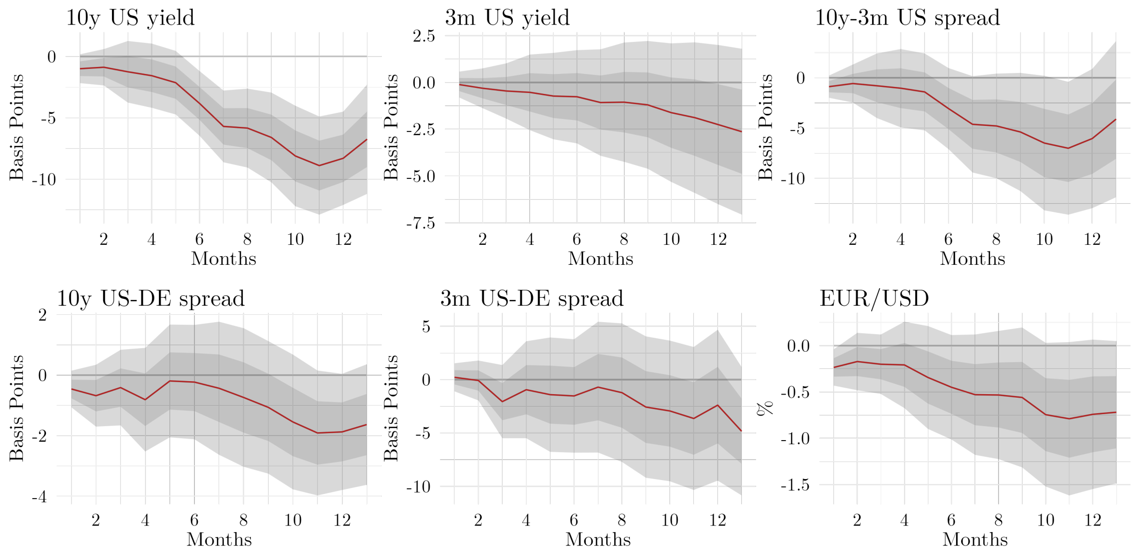
forward guidance surprises from which were identified by Jarocinski (2021), to account for possible residual contamination in the QE shock series.

Figure 6 depicts the impulse response functions to a one basis point QE shock. The 10 year yield on US Treasuries drops by one basis points on impact by constructions, and then declines persistently. On the contrary, the 3-month yield does not display a significant reaction. Combined, these two effects result in a compression of the US term premium, which decreases by approximately 1 basis points on impact and then persistently declines for up to one year.

The 10-year spread between US and German government bonds drops by less than 1 basis point on impact with an, while the 3-month counterparts does not display a statistically significant reaction at any horizon. Consistent with UIP, the EUR/USD exchange rate declines by around 0.25% on impact, which corresponds to a US dollar depreciation, and further decreases over the year.

The local projection results are overall consistent with the existing empirical evidence on the drop in US long rates and term premia through portfolio balance effects, rather than signaling effects. The estimated dollar depreciation, combined with the reduction in the 10-year US-Germany spread matches the theoretical prediction of (modified) UIP as well as empirical evidence. The lack of response of the 3-month international spread corroborates the findings on the signaling effects for US rates, and suggests that the 10-year international spread is a more relevant mediator of the exchange rate effect of QE.

Figure 6: Impulse response of financial variables



Notes: The figure shows the estimates of the response of various financial variables to the QE shock by Jarocinski (2021). The estimates are obtained from the local projection regression outlined in Equation (1). Shown in gray are the 68% and 95% confidence bands, using the Newey-West standard errors which correct for heteroscedasticity and autocorrelation.

4 Conceptual framework

4.1 A simple bank balance sheet

In order to fix ideas and guide our empirical analysis, we build a simple conceptual framework of the channels through which the Fed's QE can affect the balance sheet of European banks. Consider a simplified bank balance sheet, represented in Table 2.

Table 2: Simplified bank balance sheet

Assets		**Liabilities**	
S_t:	Credit	D_t:	Deposits
$E_t^{EUR/USD} B_{S,t}^{US}$:	US Treasuries LT	N_t:	Net Worth
$E_t^{EUR/USD} B_{L,t}^{US}$:	US Treasuries ST	$E_t^{EUR/USD} L_t$:	US Dollar liabilities

Notes: This table shows a hypothetical balance sheet of a European bank. *LT* and *ST* stand for long- and short-term, respectively.

On the asset side, the bank holds credit S_t denominated in euro, and US dollar-denominated

US Treasuries, either at long ($E_t^{EUR/USD} B_{L,t}^{US}$) or short ($E_t^{EUR/USD} B_{S,t}^{US}$) maturities. $E_t^{EUR/USD}$ is the EUR/USD exchange rate defined in euros per US dollar, such that an increase is a US dollar appreciation. On the liability side, banks fund themselves with euro-denominated deposits D_t, generic US dollar-denominated liabilities L_t, and net worth N_t. All quantities are in euro at market value.

Both assets and liabilities denominated in dollars are multiplied by $E_t^{EUR/USD}$ because we make the simplifying assumption of no hedging of exchange rate risk. The motivation is twofold. First, information on banks' hedging positions is notoriously opaque as they are not reported on balance sheets (Borio et al., 2017, 2022; Kloks et al., 2023). We cannot directly observe foreign exchange hedging in the EBA dataset, so we need to make an assumption on hedging behaviour. Second, the little evidence on foreign exchange risk exposure available in this dataset shows at the very least that banks tend to not hedge completely. The average exposure to foreign exchange risk across all currencies is € 446 millions with peaks of upwards of € 10 billions, on a similar order of magnitude as average Treasury exposure at market value. In our empirical analysis, we will only be able to infer whether the estimated responses to QE are consistent with imperfect hedging.

4.2 Transmission through leverage constraints

In the financial accelerator framework, bank net worth is a crucial determinant of credit provision because banks operate under a leverage constraint stemming from an agency problem between bank owners and managers (Bernanke et al., 1999; Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011).[6] As an optimality condition of the agency problem, the bank must maintain its leverage ratio ϕ_t under a threshold level such that

$$\phi_t \equiv \frac{S_t + E_t^{EUR/USD} B_{S,t}^{US} + E_t^{EUR/USD} B_{L,t}^{US}}{N_t} \leq \bar{\phi} \tag{2}$$

The maximum leverage $\bar{\phi}$ depends positively on the excess returns of asset prices, which in turn have a positive effect on net worth.

As shown by previous studies and confirmed by our own estimation in Section 3, a QE shock has a significant effect on the excess returns of long-term US Treasuries, in terms of both their US dollar yield and the EUR/USD exchange rate. Therefore, the banks' positions in Treasuries expose them to two kinds of QE-induced valuation effects: price and exchange rate. Quantitiative easing by the

[6] Note that the Basel III banking supervision rules impose a regulatory limit to leverage, so the sensitivity of credit to capital gains and losses is an underlying institutional feature and not strictly dependent on the microfoundations used in the literature.

Fed pushes up the US dollar price of long-term government bonds (price effect), relaxing the leverage constraint and allowing banks to lend more, as discussed in Karadi and Nakov (2021). At the same time, the exchange rate effect lowers the price of Treasuries in euro through a contemporeanous US dollar depreciation (exchange rate effect). The overall effect of the US dollar depreciation induced by QE is a function of the net balance sheet exposure to US dollar-denominated assets and liabilities $M_t \equiv E_t^{EUR/USD}(B_{S,t}^{US} + B_{L,t}^{US} - L_t)$. If $M_t > 0$ the bank is net long US dollars and a depreciation of the US dollar will lead to a fall in net worth. If $M_t > 0$, the bank is net short US dollars and a US dollar depreciation will have a positive effect on net worth instead. The EBA dataset does not allow us to observe the amount of US dollar-denominated liabilities, but we attempt to distinguish the exchange rate impact on US Treasuries and on the overall balance sheet with an instrumental variable approach.

The relative size of these two effects is *a priori* not obvious. It depends not only on the relative sensitivity of long-term US Treasury yields and exchange rates to QE, but also on the duration of the bank's US Treasury portfolio. For movements of the same size in long-term US Treasury prices and the EUR/USD exchange rate, banks with a longer-duration portfolio should be more sensitive to the price effect, while we can expect the exchange rate effect to dominate for banks with a shorter-duration portfolio.

In turn, the relative size of the exchange rate and price valuation effects has important implications for transmission of QE to the real economy in Europe: if the former dominates, leverage-constrained banks reduce credit so that QE has a contractionary effect, while if the latter dominates the effect on credit will be expansionary.

In addition to valuation effects, portfolio rebalancing by banks in response to changes in relative asset returns can also influence the sensitivity to the Fed's QE. This mechanism has been documented empirically for European banks in response to unconventional monetary policy by the ECB (Koijen et al., 2017; Albertazzi et al., 2021), as well as for other investors in the context of QE programmes by the Federal Reserve (Carpenter et al., 2015; Fratzscher et al., 2018; Goldstein et al., 2018) and Bank of England (Joyce et al., 2014). Since all US dollar-denominated assets have the same sensitivity to the exchange rate channel, QE reduces the returns of long-maturity US Treasuries compared to shorter maturities through the price effect. Provided that short- and long-term US Treasuries are not perfect substitutes, banks will have an incentive to tilt their portfolio towards short-term US Treasuries (and potentially other assets) due to the higher relative returns, while still demanding positive quantities of both assets in equilibrium.[7]. Such portfolio rebalancing can

[7]Imperfect substitution can be modeled as preferred-habitat (Vayanos and Vila, 2021) different diversion rates in the bank's agency problem (Karadi and Nakov, 2021), or transaction costs in long-term bonds (Chen et al., 2012a)

then attenuate the sensitivity of credit to the price effect, hence making banks more vulnerable to the exchange rate effect.

In Section 5, we use panel regressions with bank-level EBA data to establish empirically whether price or exchange rate effects dominate. We also investigate the portfolio rebalancing channel by estimating the changes in exposure to both long- and short-term US Treasuries in response to QE. Most importantly, we trace out the effects of the Fed's QE to the real economy in Europe through banks' US Treasury exposure by estimating models of credit provision and net worth.

5 Effect of QE on banks' balance sheets

We adopt a panel regression approach to investigate the effect of QE shocks on the holdings of US Treasuries of European banks (Section 5.1) and its transmission to credit conditions in the real economy through leverage constraints (Section 5.2). The baseline model is the following:

$$y_{i,t}^{hy} = \alpha + \beta\eta_t^q + \gamma(\eta_t^q \cdot BS_{i,t}^{hy}) + \delta BS_{i,t}^{hy} + \Gamma_1 X_{t-1}^q + \Gamma_2 MM_t^q + FE_i + \varepsilon_{i,t}. \tag{3}$$

$y_{i,t}^{hy}$ is either holdings of US Treasuries, the leverage ratio or credit depending on the model, measured at the end of semester hy on bank i's balance sheet. η_t^q is the Jarocinski (2021) QE shock, summed up over the quarter q leading up to the end of semester hy. $BS_{i,t}^{hy}$ is the bank size, defined as total bank assets. X_{t-1}^q is a vector of one-quarter lagged macroeconomic control variables including *harmonized unemployment rate*, *real gross domestic product (GDP) growth rate*, and the year-on-year *CPI inflation rate*. W_t are financial control variables, including 3 months and 10 years interest rate surprises in the Euro area (identified by Kearns et al. (2018)) and the *CBOE Volatility Index (VIX)*.

QE can affect bank lending through a potentially large number of channels, including a reduction of yields (Neely, 2010; Bauer and Neely, 2014) and term premia (Alpanda and Kabaca, 2020) in Europe, an increase in equity prices (Chen et al., 2012b), and a boost to local aggregate demand (Kolasa and Wesołowski, 2020). Therefore, we also control for GDP growth rate, inflation and unemployment, a parsimonious set of macroeconomic variables that account for the aggregate demand channel of QE transmission. In the period since 2011 the ECB pursued unconventional monetary policy concurrently with the Federal Reserve, so we control for 3-month and 10-year monetary policy surprises from Kearns et al. (2018). As well as controlling for the direct effect of the ECB's monetary policy on credit conditions in the eurozone, these variables partial out the documented spillovers of the Fed's QE through changes in yields abroad. Finally, we control for the VIX, a proxy for risk appetite in financial markets that correlates with US monetary policy, asset demand by global investors and exchange rates (Miranda-Agrippino and Rey (2020), Bruno and Shin (2015)).

FE_i are bank fixed effects, which we add to account for unobserved time-invariant bank-level characteristics. However, since our main explanatory variable is common for all banks, fixed effects tend to absorb much of the bank-level variability in dependent variables and make estimates more noisy, so we also present results without fixed effects. For all regressions we use inverse hyperbolic sine transformation for the variables in levels, which approximates the natural logarithm of that variable but preserves zero-valued observations.[8]

We add total assets BS_{hy} as an explanatory variable and keep balance sheet amounts in levels. We adopt this approach instead of rescaling amounts by total assets because it allows us to control for the correlation between the size of the bank and amounts of the variables of interest, while avoiding the impact of potential outliers on ratios. In addition, we showed in Section 2 that the structure of banks' US Treasury holdings varies by bank size, so we interact QE shocks with BS_{hy} throughout all specifications to investigate hetereogenous response by bigger banks.

5.1 Effects on US Treasuries holdings

As outlined in Section 4, QE affects the value of US Treasuries on European bank's balance sheet through both prices and exchange rates, which move in opposite directions. Furthermore, banks' exposure to US Treasuries can change in response to QE due to active portfolio rebalancing. In this section, we estimate these effects to investigate whether their signs are consistent with our conceptual framework. It is also important to gauge their relative size to understand the net effect on banks' net worth and lending.

Disentangling the channels of QE

We exploit the requirements to report to the EBA the exposure to US goverment debt in both book-value and market-value portfolios, in order to disentangle valuation and portfolio rebalancing effects. Exposures at book value are recorded at amortised historical cost, so they do not vary with the market price of US Treasuries. Therefore, by modelling the response of book value amounts in euros we can partial out the price effect, while book value amounts in dollars are insensitive to exchange rates effects as well, providing us with a clean estimate of portfolio rebalancing effects. Note, however, that only government bonds that are held to maturity are eligible to be held at amortised costs. Estimated changes in book value exposures net of valuation effects can then only reflect purchases, or lack of purchases that would have happened under the counterfactual. Therefore,

[8] The *Inverse Hyperbolic Sine Transformation* for a variable x is defined as $\tilde{x} = arcsinh(x) = \log(x + \sqrt{x^2 + 1})$.

coefficients are likely to be biased upwards, providing a lower bound for portfolio rebalancing effects if they are negative, and an upper bound if they are positive.

We run models for market value exposure in *euros* to quantify the overall effect of the three channels and establish which one dominates. Likewise, models for market value exposure in *dollars* allow us to measure the relative size of the price and portfolio rebalancing effects. As a robustness check, we estimate models of market-value exposures in dollars controlling for the price index of US government bonds in quarter q, which controls for the price effect. Since dollar amounts are not sensitive to the exchange rate effect, this approach provides an alternative estimate of the portfolio rebalancing effect.

Results

Tables 3, 4 and 5 report results of the estimation of equation 3, where y_t equals the log holdings of US Treasuries by European banks at all maturities, either at market or book value, and in either euros or dollars. Panels on the left-hand side contain models with fixed effects, while those on the right-hand side do not.

Table 3 shows the results for models of exposures in dollars, which net out the exchange rate effect. Focusing on models without fixed effects, column (3) shows that a one basis point QE shock leads to a statistically significant decrease of 3 percentage points in book value exposure for the average bank. The interaction with bank size in column (4) reveals a more heterogeneous reaction, with banks at the 25th percentile of the size distribution displaying a rebalancing of -0.1 percentage points, while the median bank reduces its US Treasury exposure by 1.4 percentage points and a bank at the 75th percentile by 3.1 percentage points. Since book values partial out price effects as well, we can interpret this as evidence of a negative portfolio rebalancing effects for US Treasuries of *all* maturities.[9] Estimates for book value exposures broken down by maturity in Appendix C show that rebalancing happens at short and especially at medium maturities, consistently with a rebalancig away from the upper segment of the yield curve due to lower yields. The market-value results in dollars also display negative coefficients, although they are smaller for larger banks as shown in column (8). Since holdings measured in dollars do not react to exchange rate movements, this suggests that rebalancing effects alone are enough to more than offset price effects, which should *raise* the market value exposure all else being equal.

Table 4 displays the results for models in dollar that include US government bond price index as a control in market value regressions. The left-hand side panel is equivalent to that of Table 3 and is

[9] We calculate size effects including the size of the non-interacted coefficient, despite its lack of statistical significance. The estimated portfolio rebalancing effect would be even larger if we treated the non-significant coefficient as a 0.

repeated for ease of comparison. The last row shows that the coefficients on the bond price index are all positive and statistically significant, which reassures us that they are an appropriate control for the price effect of QE. The coefficients on QE shocks on the right-hand side panel then provide an alternative estimate of the portfolio rebalancing effect. They are negative and statistically significant at the 1% level for all models, and they are substantially larger than the book-value based ones, with an average rebalancing of -7 percentage points in response to a one basis point QE shock (column (7)). This is consistent with the interpretation of book-value based estimates as a lower bound for portfolio rebalancing effects. Differently from the estimate based on book value exposures, the effect appears *smaller* for larger banks, with a reaction of -8.3 percentage points for a bank at the 25th percentile, and of -7.2 percentage points at the 75th percentile.

Finally, Table 5 shows the results for models in euros, which include the exchange rate and portfolio rebalancing effect for book value, and all three channels in the case of market value. The book-value results confirm the negative impact of both the exchange rate and the portfolio rebalancing channels on US Treasury exposure. Based on column (4), the size of the joint exchange rate and portfolio rebalancing effects is of -1.1 percentage points for the median bank and -4.4 percentage points for a bank in the 75th percentile by size. The coefficients are suitably larger in absolute value than those in Table 3, at least for large banks, as one additional channel is included when exposures are measured in euros. Regressions for market values also display slightly larger coefficients in absolute values in euros compared to Table 3 and 4, but along the whole bank size distribution. A one basis point QE shocks leads to a reduction in US Treasury exposure by 8.6 percentage points for the median bank, and by 7.3 percentage points for a bank at the 75th percentile.

In conclusion, we find that QE reduces the value of US Treasury holdings on European banks' balance sheets. Disentangling the three theoretical channels show that valuation effects have an overall negative impact and that the portfolio rebalancing channel alone offsets the price channel. Jointly, these results imply that the exchange rate channel is stronger. The exposure to US Treasuries falls in response to QE even when shutting down both the price and the exchange rate channels, indicating a rebalancing away from US Treasuries. Larger banks rebalance their portfolio away from US Treasury particularly strongly, and especially so for shorter maturities. The market value results in euros, where all three channels are at play, show that the negative impact of the portfolio rebalancing and exchange rate channel dominate and result in a large drop in the value of US Treasuries on European banks' balance sheets. In turn, the associated capital losses open the door to a potentially sizeable decline in credit provision by banks. In the next section, we turn to estimating directly the effects of QE on bank leverage and lending, providing evidence for spillovers to the real economy through a financial accelerator mechanism.

Table 3: Reaction of US Treasury exposure in USD

	Book value				Market value			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE shock$_t^q$	-0.023	0.083^{*}	-0.036^{*}	0.065	-0.058^{***}	-0.121^{***}	-0.070^{***}	-0.151^{***}
	(0.018)	(0.043)	(0.019)	(0.046)	(0.016)	(0.033)	(0.019)	(0.043)
QE shock$_t^q$ $\times$ log(Tot. assets)$_{i,t}$		-0.017^{***}		-0.016^{***}		0.010^{**}		0.013^{**}
		(0.005)		(0.006)		(0.004)		(0.005)
log(Tot. assets)$_t^{hy}$	-0.010	-0.020	0.149^{***}	0.138^{***}	-0.036	-0.030	0.250^{***}	0.259^{***}
	(0.099)	(0.085)	(0.030)	(0.028)	(0.053)	(0.055)	(0.037)	(0.037)
Bank FE	Yes	Yes	No	No	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	536	536	536	536	536	536	536	536
N Clusters	124	124	124	124	124	124	124	124

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

Table 4: Reaction of US Treasury exposure in USD - including a price index

	Book value				Market value			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE shock$_t^q$	-0.023	0.083^{*}	-0.036^{*}	0.065	-0.073^{***}	-0.104^{***}	-0.070^{***}	-0.133^{***}
	(0.018)	(0.043)	(0.019)	(0.046)	(0.019)	(0.029)	(0.019)	(0.041)
QE shock$_t^q$ $\times$ log(Tot. assets)$_{i,t}$		-0.017^{***}		-0.016^{***}		0.005		0.010^{*}
		(0.005)		(0.006)		(0.004)		(0.005)
log(Tot. assets)$_t^{hy}$	-0.010	-0.020	0.149^{***}	0.138^{***}	-0.014	-0.012	0.251^{***}	0.258^{***}
	(0.099)	(0.085)	(0.030)	(0.028)	(0.056)	(0.058)	(0.037)	(0.037)
Bond Price Index$_t^{US,q}$					0.089^{***}	0.084^{***}	0.054^{***}	0.046^{***}
					(0.021)	(0.020)	(0.017)	(0.016)
Bank FE	Yes	Yes	No	No	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	536	536	536	536	536	536	536	536
N Clusters	124	124	124	124	124	124	124	124

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

Table 5: Reaction of US Treasury exposure in EUR

	Book value				Market value			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE shock$_t^q$	-0.028	0.169^{**}	-0.050	0.143	-0.111^{***}	-0.192^{***}	-0.132^{***}	-0.238^{***}
	(0.031)	(0.084)	(0.033)	(0.090)	(0.031)	(0.061)	(0.033)	(0.079)
QE shock$_t^q$ $\times$ log(Tot. assets)$_{i,t}$		-0.031^{***}		-0.031^{**}		0.013		0.017
		(0.011)		(0.012)		(0.008)		(0.011)
log(Tot. assets)$_t^{hy}$	0.022	0.004	0.252^{***}	0.231^{***}	-0.064	-0.056	0.453^{***}	0.465^{***}
	(0.185)	(0.159)	(0.056)	(0.052)	(0.095)	(0.097)	(0.081)	(0.080)
Bank FE	Yes	Yes	No	No	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	536	536	536	536	536	536	536	536
N Clusters	124	124	124	124	124	124	124	124

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

5.2 Effects on net worth and lending

For the following estimations we use an instrumental variable (IV) approach, where we use the QE shocks as the instrument. We aim to isolate the direct effect of QE on lending through US Treasuries by instrumenting the relevant spreads for price and exchange rate valuation effects. For the price effect, we use changes in the 10-year US Treasury yield, which is targeted by QE and directly linked to the price of long-term US government bonds.

Quantifying the exchange rate effect on US Treasuries alone is more challenging, because a QE-induced dollar depreciation induces losses on all dollar-denominated assets on the bank's balance sheet equally, abstracting from hedging. We attempt to gauge the impact of exchange rate valuation effects on net worth and credit through US Treasuries by instrumenting changes in the international spread between US and German 10-year government bonds with QE shocks.[10] QE causes the spread to shrink through a reduction in the yield of long-term US Treasuries. In turn, the interest rate differential between US and German government bonds is linked to the exchange rate through the Uncovered Interest Parity condition, with a lower US rate associated to a depreciation.[11] We then estimate the overall impact of exchange rate valuation effects through any dollar denominated asset

[10] We choose German bond as the safest government debt issued by eurozone countries.

[11] Note that even in models where Uncovered Interest Parity Condition does not hold exactly because of wedges introduced by financial frictions or segmented markets, a decrease in the interest rate is still associated with a depreciation *ceteris paribus*. This is the case in much of the recent literature on exchange rate determination in financial markets, such as Gabaix and Maggiori (2015), Itskhoki and Mukhin (2021), Jiang et al. (2021a), and Jiang et al. (2021b).

and liability on banks' balance sheets by instrumenting changes in the exchange rate directly rather than the US-DE spread.

As seen in Figure 6, these channels react as follows. A QE shock decreases the US term spread (QE $\uparrow \implies$ -(US 10y - 3m)$_t^q \uparrow$), decreases the international spread (QE $\uparrow \implies$ -(US - DE 10y)$_t^q \uparrow$), and leads to a depreciation of the US dollar (QE $\uparrow \implies$ ΔEUR/USD $\downarrow$). For the IV estimation, we therefore replace the shock series η_t^q in Equation (3) with the fitted values from the first stage regression $\widehat{\eta_t^q}$.[12]

$$y_{i,t}^{hy} = \alpha + \beta\widehat{\eta_t^q} + \gamma\widehat{\eta_t^q} \cdot BS_{i,t}^{hy} + \delta BS_{i,t}^{hy} + \Gamma_1 X_{t-1}^q + \Gamma_2 MM_t^q + FE_i + \varepsilon_{i,t} \tag{4}$$

As the change in the 10-year US yield is directly targeted by Fed QE interventions, the price of long-term US Treasuries is positively affected. Therefore, we can expect a positive effect on net worth and credit through the price effect of US Treasuries. On the contrary, the exchange rate effect is expected to have a contrasting impact on banks, resulting in a negative effect on their net worth and credit. As previously discussed, QE leads to a decrease in the EUR/USD exchange rate, subsequently causing a depreciation of the US dollar. To analyse the overall net effect of a QE shock on the banks' balance sheet, we use the QE shock directly as an explanatory variable. This allows us to gauge the net impact of all channels at play. We expect a negative effect because Section 5.1 showed that the exchange rate effect dominates the price effect, engendering capital losses on US Treasuries. However, other effects of QE on the balance sheet of banks might offset valuation effects on the sovereign portfolio. By allowing all avenues to affect bank net worth and credit in this specification, we can better understand whether the US Treasury channel is quantitatively important.

5.2.1 Leverage

Tables 6, 7, and 8 show the results for banks' net worth, proxied by their leverage ratio. The leverage ratio (Tier 1 capital/assets) is used because it is consistent with the theoretical framework of a financial accelerator model where banks operate under a leverage constraint. Therefore, any capital gains through their portfolio of sovereign holdings should result in an expansion in lending, while losses should lead to a contraction. In Appendix G.1, we run a robustness check, where we proxy net worth as the regulatory Tier 1 capital ratio.

Table 6 shows that a QE induced decrease in the 10-year US yield, i.e. a higher US dollar price of US Treasuries, has indeed a positive effect on banks' net worth. On average the banks net worth

[12] Table A5 in Appendix D shows the first-stage regression results.

increases by 7 percentage points (column (3)). Banks at the 25th percentile react slightly stronger (9 percentage points increase) while bigger banks at the 75th percentile have a weaker reaction of 5 percentage points.

A decrease in the spread between US and German 10-year government bonds, is associated with a contemporaneous dollar depreciation through Uncovered Interest Parity. Table 7 shows that this results in a drop in net worth (column (3)).

Consistent with the two channels, particularly the stronger negative impact associated with the international spread and the exchange rate, we can observe in Table 8 that the overall effect of the Federal Reserve's QE policy results in a decline in the net worth of European banks. This decline is in line with the notion of capital losses on their US Treasury holdings, primarily attributable to the depreciation of the US dollar.

In conclusion, the separate estimates of the price and exchange rate effects on banks' net worth are consistent with expectations, the former being positive and the latter negative. Overall, the Federal Reserve's QE has a negative effect on European banks' net worth that is consistent with the valuation effect on US Treasuries on their balance sheet due to dollar depreciation. Appendix E.1 shows that the reaction of net worth does not appear to depend on the bank's exposure to US Treasuries in the previous semester.

Table 6: Reaction of net worth through US 10-year rate

	(1)	(2)	(3)	(4)
$-(\Delta \text{US 10y})_t^q$	0.020	0.033	0.079^{*}	0.175^{**}
	(0.012)	(0.030)	(0.042)	(0.075)
$-(\Delta \text{US 10y})_t^q \times \log(\text{Tot. assets})_{i,t}$		-0.003		-0.020^{**}
		(0.005)		(0.009)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	749	749	749	749
N Clusters	128	128	128	128

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

Table 7: Reaction of net worth through US-DE 10-year spread

	(1)	(2)	(3)	(4)
-(ΔUS-DE 10y)$_t^q$	-0.036	0.133	-0.248	1.193^{***}
	(0.024)	(0.095)	(0.161)	(0.374)
-(ΔUS-DE 10y)$_t^q$ $\times$ log(Tot. assets)$_{i,t}$		-0.031		-0.282^{***}
		(0.020)		(0.095)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	749	749	749	749
N Clusters	128	128	128	128

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Table 8: Overall effect of QE on net worth

	(1)	(2)	(3)	(4)
QE shock$_t^q$	-0.079	-0.364	-0.319^{*}	-1.667^{**}
	(0.048)	(0.271)	(0.174)	(0.743)
QE shock$_t^q$ $\times$ log(Tot. assets)$_{i,t}$		0.055		0.257^{**}
		(0.045)		(0.113)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	749	749	749	749
N Clusters	128	128	128	128

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

5.2.2 Lending

Our final dependent variable centers on the credit provision by European banks. Our goal is to investigate the transmission of QE through US Treasuries on European banks' balance sheets to the real economy. A significant effect would show that US monetary policy, propelled by the holdings of US Treasuries, extends its impact on European households. As discussed above, based on the theoretical framework of a financial accelerator model, we would expect that credit reacts in the same direction as net worth. Tables 9, 10, and 11 present the findings from our estimations of spread changes, which are instrumented by a QE shock.

In line with what we observed in Table 6, we find that upon a price increase in long-term US Treasuries (decrease in the 10-year US Treasury yield) caused by QE, leads to an increase of 1.5 percentage points (Table 9 column (3)).

Table 10 shows the effect of QE shocks on credit through the exchange rate channel as mediated by the US-DE 10 year spread. The effect seems to be negative and slightly stronger for big banks, where banks at the 75th percentile react with a 2 percentage point decrease of credit provision, whereas the median reaction is estimated to be at -0.7 percentage points. Again this is in line with the effect on banks net worth. The aggregate effect of QE is shown in Table 11. Supporting the theoretical framework, the effect is negative. Thus, upon a US QE shock that decreases European banks net worth, these banks credit provision decreases, consistent with the exchange rate effect dominating.

The higher US dollar prices of US Treasuries caused by a Fed QE shock leads to European banks extending more credit *ceteris paribus*. However, when estimating a model that uses QE shocks directly as an explanatory variable, the overall effect on total credit is negative. This is consistent with a large exchange rate effect, potentially due to the total balance sheet exposure to the USD/EUR rate, that more than offsets the positive effect of higher US Treasury prices. These results are consistent with the drop in net worth documented in the previous section, as banks face a leverage constraint. Larger banks seem to display a muted response of credit to QE shock, as we found for net worth in the previous section. Likewise, we show in Appendix E.2 that lagged exposure to US Treasuries is not associated with a particularly strong or weak reaction of credit either. In Appendix F, we estimate separate models for credit extended domestically and in the US, finding that the overall response is driven by domestic credit.

Table 9: Reaction of credit through US 10-year rate

	(1)	(2)	(3)	(4)
$-(\Delta\text{US 10y})_t^q$	0.021^{***}	0.001	0.015^{***}	0.007
	(0.005)	(0.005)	(0.005)	(0.006)
$-(\Delta\text{US 10y})_t^q \times \log(\text{Tot. assets})_{i,t}$		0.004^{**}		0.002
		(0.002)		(0.002)
$\log(\text{Tot. assets})_t^{hy}$	0.725^{***}	0.727^{***}	0.931^{***}	0.936^{***}
	(0.103)	(0.107)	(0.026)	(0.026)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	946	946	946	946
N Clusters	129	129	129	129

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

Table 10: Reaction of credit through US-DE 10-year spread

	(1)	(2)	(3)	(4)
$-(\Delta\text{US-DE 10y})_t^q$	-0.011^{***}	0.049^{***}	-0.012^{***}	0.052^{**}
	(0.002)	(0.018)	(0.004)	(0.021)
$-(\Delta\text{US-DE 10y})_t^q \times \log(\text{Tot. assets})_{i,t}$		-0.011^{***}		-0.012^{***}
		(0.003)		(0.004)
$\log(\text{Tot. assets})_t^{hy}$	0.682^{***}	0.626^{***}	0.931^{***}	0.819^{***}
	(0.117)	(0.107)	(0.025)	(0.035)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	946	946	946	946
N Clusters	129	129	129	129

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

Table 11: Overall effect of QE on credit

	(1)	(2)	(3)	(4)
QE shock_t^q	-0.033^{***}	-0.101^{***}	-0.029^{***}	-0.110^{***}
	(0.006)	(0.018)	(0.009)	(0.027)
QE $\text{shock}_t^q \times \log(\text{Tot. assets})_{i,t}$		0.012^{***}		0.015^{***}
		(0.003)		(0.004)
$\log(\text{Tot. assets})_t^{hy}$	0.644^{***}	0.669^{***}	0.933^{***}	0.941^{***}
	(0.104)	(0.108)	(0.025)	(0.026)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	946	946	946	946
N Clusters	129	129	129	129

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

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A Sources of data

B Further descriptive analysis

B.1 Summary statistics for additional bank-level variables

Variable	Obs.	Mean	SD	Min	Median	Max
T1 capital / RWA (pp)	1019	17.27	11.04	0.56	14.5	120.87
Treas exp ($\leq$ 1y)(€ bln.)	720	0.4	1.58	0	0	18.17
Treas exp (2-10y)(€ bln.)	776	1.1	3.47	0	0	33.44
Treas exp (¿ 10y)(€ bln.)	776	0.59	2.54	0	0	31.97
US credit (€ bln.)	548	7.34	13.49	0	1.93	66.46
Domestic credit (€ bln.)	928	31.76	44.9	0	16.14	343.41

Notes: The table shows summary statistics for the estimation sample. *T1 capital* stands for Tier 1 capital, and *RWA* stands for risk-weighted assets. The abbreviation *Treas exp* stands for US Treasuries exposure.

B.2 Descriptive statistics of financial variables

Variable	Obs.	Mean	SD	Min	Median	Max
10y US yield	1076	2.36	0.39	1.64	2.36	2.91
3m US yield	1076	0.86	0.92	0.01	0.27	2.4
10y US-DE spread	1076	1.7	0.73	-0.03	1.65	2.58
EUR/USD	1076	1.19	0.09	1.05	1.14	1.37
Jarocinski (2021): QE shock	1076	0.4	1.3	-1.73	0.71	3.12

Notes: The table shows descriptive statistics for the financial market variables over the sample period.

B.3 Banks by country

Appendix Table A1: Bank statistics according to size and country

Country	Q1	Q2	Q3	Q4	Total
Germany	3	12	6	6	27
Italy	5	5	7	2	19
Spain	1	2	7	4	14
France	2	3	2	6	13
Austria	6	3	0	0	9
Ireland	3	2	3	0	8
Netherlands	1	1	2	4	8
Belgium	3	2	1	1	7
Portugal	3	2	2	0	7
Luxembourg	5	0	1	0	6
Cyprus	4	0	0	0	4
Finland	2	1	0	1	4
Greece	0	1	3	0	4
Malta	4	0	0	0	4
Slovenia	4	0	0	0	4
Estonia	2	0	0	0	2
Latvia	2	0	0	0	2
Lithuania	1	0	0	0	1
Total	51	34	34	24	143

(a) Number of banks per country and quartile.

Country	Q1	Q2	Q3	Q4	Total
Germany	34	84	55	87	260
Italy	25	39	55	30	149
Spain	11	18	64	51	144
France	19	27	9	87	142
Netherlands	3	15	25	45	88
Austria	56	29	0	0	85
Belgium	38	25	2	15	80
Ireland	11	30	23	0	64
Portugal	15	28	12	0	55
Luxembourg	40	0	11	0	51
Greece	0	12	36	0	48
Finland	16	15	0	8	39
Cyprus	37	0	0	0	37
Malta	36	0	0	0	36
Slovenia	34	0	0	0	34
Estonia	13	0	0	0	13
Latvia	11	0	0	0	11
Lithuania	8	0	0	0	8
Total	407	322	292	323	1344

(b) Number of obs. per country and quartile

Notes: These tables summarize the number of banks in each quartile and for each country (panel (a)) and the number of observations in each quartile and each country (panel (b)). The total number (143) in panel (a) does not add up to 152, since not all banks reported their total assets. In addition, the bank size can change over time, implying that banks can change their quartile.

C Portfolio rebalancing across maturities

- Results for different maturity buckets
  - Book value: rebalancing seems concentrated in shorter maturities with significant heterogeneity by bank sizes: rebalancing *towards* US Treasuries for smaller banks, away from them for larger banks.

– Market value: exchange rate effect stronger for short- and medium-term Treasury holdings. This is consistent with the price effect of QE acting mainly on long-term debt.

Appendix Table A3: Reaction of Treasury exposure across maturities - Book value

	Short		Medium		Long	
	(1)	(2)	(3)	(4)	(5)	(6)
QE shock$_t^q$	0.081	0.063	0.178**	0.172**	0.028	0.032
	(0.057)	(0.059)	(0.079)	(0.081)	(0.058)	(0.059)
QE shock$_t^q$ × log(Tot. assets)$_{i,t}$	-0.015^{*}	-0.014	-0.030^{***}	-0.032^{***}	-0.007	-0.008
	(0.009)	(0.009)	(0.010)	(0.011)	(0.006)	(0.007)
log(Tot. assets)$_t^{hy}$	0.071	0.064***	-0.007	0.147***	0.070	0.127***
	(0.087)	(0.019)	(0.100)	(0.038)	(0.133)	(0.037)
Bank FE	Yes	No	Yes	No	Yes	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	489	489	534	534	534	534
N Clusters	124	124	124	124	124	124

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A4: Reaction of Treasury exposure across maturities - Market value

	Short		Medium		Long	
	(1)	(2)	(3)	(4)	(5)	(6)
QE shock$_t^q$	-0.128^{**}	-0.156^{***}	-0.151^{***}	-0.163^{**}	-0.100^{*}	-0.102
	(0.053)	(0.045)	(0.053)	(0.062)	(0.056)	(0.070)
QE shock$_t^q$ × log(Tot. assets)$_{i,t}$	0.009	0.011**	0.011*	0.013	0.006	0.005
	(0.006)	(0.005)	(0.007)	(0.008)	(0.008)	(0.009)
log(Tot. assets)$_t^{hy}$	-0.019	0.224***	-0.051	0.327***	-0.027	0.257***
	(0.093)	(0.060)	(0.079)	(0.068)	(0.064)	(0.062)
Bank FE	Yes	No	Yes	No	Yes	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	489	489	534	534	534	534
N Clusters	124	124	124	124	124	124

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

D First stage analysis for IV regressions

Appendix Table A5: First-stage regression results

	Net Worth			Total credit		
-(ΔUS10y)	-4.06			-1.94		
	(0.47)			(0.28)		
-(ΔUS-DE 10y)		1.29			2.39	
		(0.31)			(0.17)	
ΔEURUSD			1.17			0.6
			(0.04)			(0.04)
F-stat	220.38	342.09	283.81	233.75	488.01	283.29
Num. obs.	749	749	749	946	946	946

Notes: This table shows the first stage estimation of the Jarocinski (2021) QE shocks on the three instrumented variables that we use in the the regressions. The bottom row shows the first-stage F-statistic. The results differ for net worth and total credit, as the sample for which these variables are observed is not exactly the same.

E Effects on net worth and credit: interaction with Treasury exposure

E.1 Net worth

Appendix Table A6: Reaction of net worth through EUR/USD exchange rate

	(1)	(2)	(3)	(4)
ΔEURUSD_t^q	-0.062	-1.031	-0.272^{*}	-3.350^{*}
	(0.038)	(0.929)	(0.151)	(1.776)
$\Delta\text{EURUSD}_t^q \times \log(\text{Tot. assets})_{i,t}$		0.186		0.608^{*}
		(0.172)		(0.324)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	749	749	749	749
N Clusters	128	128	128	128

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A7: Reaction of net worth through US 10-year rate - Treasury exposure interaction

	(1)	(2)	(3)	(4)
-$(\Delta\text{US10y})_t^q$	0.020	0.025^{**}	0.079^{*}	0.090^{**}
	(0.012)	(0.010)	(0.042)	(0.040)
-$(\Delta\text{US10y})_t^q$ × Exp./assets$_{i,t-1}$		-0.001		-0.003
		(0.003)		(0.004)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	749	564	749	564
N Clusters	128	125	128	125

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A8: Reaction of net worth through US-DE 10-year spread - Treasury exposure interaction

	(1)	(2)	(3)	(4)
-$(\Delta\text{US-DE 10y})_t^q$	-0.036	0.067^{***}	-0.248	0.218^{**}
	(0.024)	(0.025)	(0.161)	(0.096)
-$(\Delta\text{US-DE 10y})_t^q$ × Exp./assets$_{i,t-1}$		-0.001		-0.008
		(0.009)		(0.015)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	749	564	749	564
N Clusters	128	125	128	125

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A9: Overall effect of QE on net worth - Treasury exposure interaction

	(1)	(2)	(3)	(4)
QE shock$_t^q$	-0.079	-0.150^{**}	-0.319^{*}	-0.670^{**}
	(0.048)	(0.061)	(0.174)	(0.306)
QE shock$_t^q$ $\times$ Exp./assets$_{i,t-1}$		0.012		0.030
		(0.034)		(0.044)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	749	564	749	564
N Clusters	128	125	128	125

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

E.2 Credit

Appendix Table A10: Reaction of credit through EUR/USD exchange rate

	(1)	(2)	(3)	(4)
ΔEURUSD_t^q	-0.046^{***}	0.749^{*}	-0.048^{***}	0.414^{**}
	(0.010)	(0.410)	(0.015)	(0.186)
$\Delta \text{EURUSD}_t^q \times \log(\text{Tot. assets})_{i,t}$		-0.149^{*}		-0.089^{**}
		(0.077)		(0.035)
$\log(\text{Tot. assets})_t^{hy}$	0.729^{***}	1.055^{***}	0.935^{***}	0.850^{***}
	(0.119)	(0.226)	(0.025)	(0.032)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	946	946	946	946
N Clusters	129	129	129	129

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A11: Reaction of credit through US 10-year rate - Treasury exposure interaction

	(1)	(2)	(3)	(4)
$-(\Delta \text{US10y})_t^q$	0.021^{***}	0.003^{*}	0.015^{***}	0.000
	(0.005)	(0.002)	(0.005)	(0.003)
$-(\Delta \text{US10y})_t^q \times \text{Exp./assets}_{i,t-1}$		0.000		-0.001
		(0.000)		(0.000)
$\log(\text{Tot. assets})_t^{hy}$	0.725^{***}	0.698^{***}	0.931^{***}	0.947^{***}
	(0.103)	(0.139)	(0.026)	(0.029)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	946	608	946	608
N Clusters	129	125	129	125

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A12: Reaction of credit through US-DE 10-year spread - Treasury exposure interaction

	(1)	(2)	(3)	(4)
-(ΔUS-DE 10y)$_t^q$	-0.011^{***}	0.009^{*}	-0.012^{***}	0.001
	(0.002)	(0.005)	(0.004)	(0.007)
-(ΔUS-DE 10y)$_t^q$ $\times$ Exp./assets$_{i,t-1}$		0.000		-0.003
		(0.001)		(0.002)
log(Tot. assets)$_t^{hy}$	0.682^{***}	0.673^{***}	0.931^{***}	0.945^{***}
	(0.117)	(0.152)	(0.025)	(0.029)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	946	608	946	608
N Clusters	129	125	129	125

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A13: Overall effect of QE on credit - Treasury exposure interaction

	(1)	(2)	(3)	(4)
QE shock$_t^q$	-0.033^{***}	-0.015^{*}	-0.029^{***}	-0.005
	(0.006)	(0.008)	(0.009)	(0.017)
QE shock$_t^q$ × Exp./assets$_{i,t-1}$		-0.001		0.008^{*}
		(0.003)		(0.004)
log(Tot. assets)$_t^{hy}$	0.644^{***}	0.720^{***}	0.933^{***}	0.947^{***}
	(0.104)	(0.126)	(0.025)	(0.029)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	946	608	946	608
N Clusters	129	125	129	125

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

F Effects on domestic and US credit

Appendix Table A14: Reaction of domestic and US credit through US 10-year rate

	Domestic				US			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
-(ΔUS 10y)$_t^q$	0.031^{***}	-0.003	0.025^{***}	0.016	-0.009	0.010	0.004	-0.005
	(0.009)	(0.008)	(0.008)	(0.011)	(0.020)	(0.009)	(0.022)	(0.013)
-(ΔUS 10y)$_t^q$ × log(Tot. assets)$_{i,t}$		0.007^{**}		0.002		-0.003		0.002
		(0.003)		(0.003)		(0.004)		(0.005)
log(Tot. assets)$_t^{hy}$	0.513^{**}	0.518^{***}	0.850^{***}	0.856^{***}	0.415^{**}	0.420^{**}	0.685^{***}	0.691^{***}
	(0.185)	(0.176)	(0.039)	(0.039)	(0.176)	(0.163)	(0.068)	(0.066)
Bank FE	Yes	Yes	No	No	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	854	854	854	854	515	515	515	515
N Clusters	123	123	123	123	69	69	69	69

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A15: Reaction of domestic and US credit through US-DE 10-year spread

	Domestic				US			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
-(ΔUS-DE 10y)$_t^q$	-0.014^{***}	0.066^{**}	-0.016^{***}	0.100^{***}	0.001	0.025	-0.001	-0.009
	(0.003)	(0.027)	(0.006)	(0.036)	(0.003)	(0.025)	(0.006)	(0.040)
-(ΔUS-DE 10y)$_t^q$ $\times$ log(Tot. assets)$_{i,t}$		-0.015^{***}		-0.022^{***}		-0.004		0.001
		(0.006)		(0.007)		(0.004)		(0.008)
log(Tot. assets)$_t^{hy}$	0.527^{***}	0.452^{***}	0.859^{***}	0.649^{***}	0.451^{***}	0.421^{**}	0.687^{***}	0.701^{***}
	(0.122)	(0.126)	(0.038)	(0.070)	(0.147)	(0.146)	(0.066)	(0.092)
Bank FE	Yes	Yes	No	No	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	854	854	854	854	515	515	515	515
N Clusters	123	123	123	123	69	69	69	69

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

Appendix Table A16: Overall effect of QE on domestic and US credit

	Domestic				US			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE shock$_t^q$	-0.043^{***}	-0.010	-0.039^{***}	-0.028	0.005	-0.028^{*}	-0.004	-0.025
	(0.009)	(0.018)	(0.013)	(0.025)	(0.010)	(0.015)	(0.018)	(0.034)
QE shock$_t^q$ $\times$ Exp./assets$_{i,t-1}$		0.010		0.037^{*}		0.001		0.030
		(0.005)		(0.015)		(0.002)		(0.016)
log(Tot. assets)$_t^{hy}$	0.474^{***}	0.680^{***}	0.859^{***}	0.886^{***}	0.457^{***}	0.219	0.687^{***}	0.684^{***}
	(0.122)	(0.189)	(0.038)	(0.043)	(0.148)	(0.119)	(0.066)	(0.070)
Bank FE	Yes	Yes	No	No	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	854	546	854	546	515	342	515	342
N Clusters	123	107	123	107	69	65	69	65

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$).

G Robustness checks

G.1 Tier 1 capital ratio as proxy for net worth

Appendix Table A17: Reaction of tier 1 capital ratio through US 10-year rate

	(1)	(2)	(3)	(4)
-$(\Delta \text{US 10y})_t^q$	-0.004	-0.074	-0.011	0.155
	(0.078)	(0.058)	(0.094)	(0.111)
-$(\Delta \text{US 10y})_t^q \times \log(\text{Tot. assets})_{i,t}$		0.021		-0.030
		(0.022)		(0.031)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	1019	946	1019	946
N Clusters	137	129	137	129

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A18: Reaction of tier 1 capital ratio through US-DE 10-year spread

	(1)	(2)	(3)	(4)
-(ΔUS-DE 10y)$_t^q$	0.001	−0.152	0.007	−2.088
	(0.032)	(0.170)	(0.063)	(3.593)
-(ΔUS-DE 10y)$_t^q$ × log(Tot. assets)$_{i,t}$		0.025		0.398
		(0.035)		(0.680)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	1019	946	1019	946
N Clusters	137	129	137	129

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).

Appendix Table A19: Overall effect of QE on tier 1 capital ratio

	(1)	(2)	(3)	(4)
QE shock$_t^q$	0.004	0.221	0.018	−0.644
	(0.095)	(0.297)	(0.154)	(0.480)
QE shock$_t^q$ × log(Tot. assets)$_{i,t}$		−0.048		0.112
		(0.044)		(0.078)
Bank FE	Yes	Yes	No	No
Macro Controls	Yes	Yes	Yes	Yes
Num. obs.	1019	946	1019	946
N Clusters	137	129	137	129

Notes: The left hand side of the table shows the regression results including bank fixed effects, whereas the right hand side does not include bank fixed effects. The *Macro Control* variables are the one-period lagged *harmonized unemployment rate*, *CBOE Volatility Index*, *real GDP growth rate*, and *inflation rate*. In addition, the *3 months* and *10 years interest rate surprises* in the Euro area are included (identified by Kearns et al. (2018)). Standard errors are clustered at the bank level and shown in parentheses below the estimated coefficient. Asterisks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$).