How Do Banks Adjust to Stricter Supervision?

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Abstract

We exploit a discontinuity in the assignment mechanism of the European Central Bank's Comprehensive Assessment in order to identify the effects of increased regulatory scrutiny on bank balance sheets. We find that banks adjust to stricter supervision by reducing leverage, and most of the adjustment stems from shrinking assets rather than from raising equity. We estimate a 7 percent reduction in leverage, two thirds of which are due to asset shrinkage. Securities are adjusted much more strongly than the loan book. On the liability side, banks mostly reduce their reliance on wholesale funding. Using data on syndicated loan issuance, we find that very weak banks also reduce the supply of credit. The evidence highlights banks' reluctance to adjust capital when target leverage changes and suggests that macroprudential considerations matter for stress-testing in practice.

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1 Introduction

> *Now what has been a restriction and we recognised that from the start, is that these exercises, of course, led the banks to be very careful in what they were doing with credit and with possible expansions of their balance sheet. They wanted to be as prepared as possible to pass this exam.* (Constâncio, 2014)

After the financial crisis of 2007/2008, bank supervision has become much tighter. But how do banks adjust their balance sheets when faced with increased regulatory scrutiny? For example, do they become safer by holding larger capital buffers? Does tougher regulation lead to a credit crunch, thereby harming the real economy? Or does regulation have little bite and banks' behavior remains mostly unchanged?

To answer these questions, we need a large-scale change in supervisory intensity and a way of establishing a credible counterfactual scenario. The introduction of the Eurozone's Single Supervisory Mechanism (SSM) and the associated Comprehensive Assessment provides us with both. First, the new regime centralized supervision for a sizable part of the banking system at the ECB and was designed to be "intrusive, tough, and fair".[1] Second, only banks with assets above a sharp cutoff were affected. Therefore, we can compare banks' behavior on either side of this cutoff to establish how banks would have behaved absent regulatory changes.

We find that banks reduced leverage in anticipation of the new regime. We provide a simple model of leverage adjustment in which banks may shrink assets if equity issuance is perceived as costly. By decomposing leverage adjustments in the data, we find that the majority of the leverage adjustment is indeed due to asset shrinkage, suggesting that banks are averse to raising equity in the short run.

The reactions that we find around the cutoff reflect the behavior of banks in the unrestricted sample, which includes observations far from the discontinuity. In the unrestricted sample, banks that were subject to the Comprehensive Assessment also reduced leverage. Moreover, asset shrinkage drives the reduction in leverage as before. This gives us confidence that we are documenting a behavior that applies more generally.

We also find some evidence for a credit crunch, but only for very weak banks. Given that balance sheet changes represent stocks—which might vary due to sales of legacy portfolios—we cannot immediately conclude from banks' asset shrinkage that they contracted the supply of credit. We address this concern with disaggregated data on syndicated loan issuance. Controlling for loan

[1] Daniele Nouy, Chair of the Supervisory Board of the SSM, in an interview with the Times of Malta (October 5th, 2014).

demand, we find evidence for a reduction in credit supply only for banks with very low capital ratios.

Our results underline a special role for securities on bank balance sheets. We find that for a given balance sheet contraction, banks disproportionately adjust their securities portfolios. As a consequence, large securities portfolios insulate loan books from asset shrinkage. However, this buffering feature of securities is much weaker when sovereign credit spreads are high: We find that the pass-through of balance sheet contractions to securities is lower for countries with impaired sovereign debt.

Our findings inform the debate around macroprudential financial policy. Hanson et al. (2011) define macroprudential financial policy as "an effort to control the social costs associated with excessive balance-sheet shrinkage on the part of multiple financial institutions hit with a common shock". The authors identify two externalities associated with asset shrinkage: fire sales and credit crunches. Poorly capitalized banks do not take those externalities into account when choosing between equity issuance and assets sales. Applying this logic to stress testing, regulators ought to focus on the level of capital in the financial system as a whole in addition to individual banks' capital ratios when assessing the banking sector (Greenlaw et al., 2012). While we do not conduct a thorough welfare analysis, our results highlight banks' reluctance to adjust equity at short notice. We speculate that the Comprehensive Assessment would have benefitted from additional measures to address banks' tendency to shrink assets in anticipation of the assessment.

The existing literature on bank stress-testing can be divided into three strands. First, there is a large theoretical body of work that deals with questions of optimal disclosure.[2] Second, a number of studies have conducted event studies of asset prices around the announcement of stress test results.[3] Third, and most closely related to our analysis, is the finding that undercapitalized banks appear to restrict lending when stress-tested (Mésonnier and Monks, 2015; Gropp et al., 2016). This paper adds to the literature by providing a clean identification strategy that allows us to isolate the effects of stricter supervision on bank balance sheets.

The fact that banks deleverage when faced with a tougher regulatory environment is consistent with evidence from very small banks in the United States. Agarwal et al. (2014) note that forced rotations of state and federal regulators lead to variation in regulatory intensity. In their setting, stricter regulation also leads banks to report higher capital ratios. However, the authors do not decompose changes in leverage into changes in assets and equity. The finding that such changes are mostly due to asset shrinkage is a central result of our paper. Moreover, their sample only

[2] See Goldstein (2014) for a survey.

[3] See, for example, Petrella and Resti (2013); Candelon and Sy (2015); Sahin and Haan (2015) and the references therein.

covers local banks with assets below $500 million in assets. By contrast, our sample covers the vast majority of Eurozone bank assets and includes systemic banks. Since both banks' business models and their regulatory environment vary by bank size, it is important to investigate the effects of tighter supervision for large banks as well.

The paper proceeds as follows: In section 2, we propose a simple theory of banks' balance sheet adjustments. Section 3 provides details on the institutional background around the ECB's Comprehensive Assessment and the new regulatory framework. In section 4, we discuss our data. We explain our identification strategy and the resulting estimates in section 5. The special role of securities in balance sheet adjustment is addressed in section 6. Loan-level regressions are presented in section 7. Finally, section 8 concludes.

2 Model

This section presents a dynamic, partial equilibrium model of bank deleveraging. The model features a deviation from the Modigliani-Miller benchmark: banks face adjustment costs in raising capital. The model elucidates under which conditions banks may react to stricter supervision by shrinking assets.

There are at least three reasons for banks to reduce leverage ahead of a tightening of supervision. First, in our setting the new regime featured recurring stress tests, which require banks to sustain minimum capital ratios under challenging macroeconomic scenarios. The required amount of capital to pass these tests may well exceed the amount that banks used to hold before. Second, the Comprehensive Assessment also included an Asset Quality Review, in which banks were forced to mark down assets that the new regulators deemed overvalued; this process further reduces the available capital in banks' books. Third, a major rationale for streamlining supervision at the ECB was that national regulators enforced similar rules in different ways. This applied, for example, to the eligibility of deferred tax assets as Tier 1 capital. Therefore, we model the tightening of supervision as a reduction in banks' desired leverage.

Banks can reduce leverage by selling assets or by raising equity. Both margins of adjustment involve costs: Selling illiquid assets may be associated with fire sales and, in addition, might imply suboptimal scale. On the other hand, raising equity may also be difficult in the short-run, for example due to informational frictions (Myers and Majluf, 1984) or debt overhang (Myers, 1977). In our model, we solve for banks' balance sheet choices as a function of these adjustment costs. We find that assets overshoot their long-run value if equity adjustment costs are relatively large. This is optimal from the banks' point of view since over-adjusting assets (relative to the long-run) allows the bank to under-adjust equity (relative to the long-run); this behavior economizes on adjustment costs, even though it leads to suboptimal scale during the transition.

2.1 Setup

We model the ECB's comprehensive assessment as an increase in the effective capital requirement. In the pre-period, weak regulatory oversight allowed banks to hold less capital E relative to assets A than is nominally required ($\tilde{\kappa}$). We use γ as a measure of regulatory lenience such that the effective capital requirement is

$$\frac{E}{A} \geq \tilde{\kappa}\,(1-\gamma)$$

We interpret the transfer of supervision to the ECB as a reduction in leniency γ. It is clear from the above formulation that this maps to an increase in the *effective* capital requirement. To economize on notation, we work directly with the effective capital requirement κ in what follows, which simplifies the constraint to

$$\frac{E}{A} \geq \kappa$$

The comparative static of interest is an increase in the effective capital requirement.

Cost of Capital

The weighted average cost of capital is given by

$$WACC\left(\frac{E}{A}\right) = \frac{E}{A}r_e + \left(1-\frac{E}{A}\right)r_d \tag{1}$$

where r_e and r_d are the required returns on equity and debt, respectively. We borrow from the literature on the cost of bank capital and introduce a deviation from Modigliani and Miller (1958)'s stylized environment. In the literature, at least four reasons have been proposed for why banks' cost of capital falls with leverage:

1. Tax-advantages of debt financing (Modigliani and Miller, 1958, 1963; Miller, 1977)
2. Managerial incentives of (short-term) debt (Diamond and Rajan, 2001)
3. A money premium on (short-term, safe) debt (Gorton, 2010; Stein, 2012; Krishnamurthy and Vissing-Jorgensen, 2012)

4. Low risk anomaly (Baker and Wurgler, 2015)

In this paper, we follow Kashyap et al. (2010) and introduce a catch-all term δ that reflects the additional cost of equity over and above what would be expected in a frictionless setup. We further assume that debt is risk-free and equity is priced according to the Capital Asset Pricing Model. Therefore, the required return on equity is given by $r_e - r_f = \beta_E \left(r_m - r_f\right)$. Note that the equity beta is given by $\beta_E = \frac{A}{E}\beta_A$ where β_A is the firm's asset beta. Substituting this into the WACC formula (1), banks' cost of capital is given by

$$WACC\left(\frac{E}{A}\right) = \left(r_f + \beta_A r_m\right) + \frac{E}{A}\delta \equiv \bar{r} + \frac{E}{A}\delta \tag{2}$$

The term $\bar{r} = r_f + \beta_A r_m$ captures the cost of capital in a frictionless benchmark case. Equation (2) is a crucial ingredient for our model, since it creates an incentive to minimize the share of equity capital on banks' balance sheets.

Adjustment Costs

Myers and Majluf (1984) propose a further cost of issuing equity that stems from asymmetric information between firms and investors. Their model endogenously generates a downward sloping demand curve for firms' stocks due to adverse selection. In order to capture the fact that accumulating equity slowly—for example through retained earnings—is easier than issuing a large amount, we introduce a convex cost of issuance:

$$c_E\left(E_t, E_{t-1}\right) = \frac{1}{2}c_e \times \left(E_t - E_{t-1}\right)^2 \tag{3}$$

Since bank assets tend to be illiquid, adjusting assets is not a frictionless process either. To account for adjustment costs in assets, we introduce a convex cost of asset sales:

$$c_E\left(A_t, A_{t-1}\right) = \frac{1}{2}c_a \times \left(A_t - A_{t-1}\right)^2 \tag{4}$$

Both adjustment costs should be interpreted as reduced-form versions of frictions generated by asymmetric information.

Payoffs

Investing A units yields a stochastic gross return of $f\left(A\right) + A\epsilon$ where $E\left[\epsilon\right] = 0$ and $Cov\left[\epsilon, r_m\right] = \beta_A Var\left[r_m\right]$. Hence, the expected return is $f\left(A\right)$ and its beta is β_A. We further assume a simple quadratic functional form for $f(.)$,

$$f(A) = \varphi_0 A - \frac{1}{2}\varphi A^2 \tag{5}$$

and let $\varphi_0 > 1 + \bar{r} + \delta$. Expected flow profits are

$$\pi(A_t, E_t; A_{t-1}, E_{t-1}) = f(A_t) - (1+\bar{r})A_t - E_t\delta - c_E(E_t, E_{t-1}) - c_A(A_t, A_{t-1}) \tag{6}$$

subject to $E_t \geq \kappa_t A_t$. The first term captures the expected gross return, the next two terms capture the cost of capital, and the last two terms capture the adjustment costs when raising additional equity and selling assets, respectively. Moreover, we assume that the bank was in steady-state before the exercise, i.e. E_0 and A_0 solve

$$\max_{A_0, E_0} f(A_0) - (1+\bar{r})A_0 - E_0\delta \text{ subject to } \frac{E_0}{A_0} \geq \kappa_0$$

which implies that

$$A_0 = \frac{1}{\varphi}(\varphi_0 - (1 + \bar{r} + \kappa_0\delta)),\ E_0 = \kappa_0 A_0 \tag{7}$$

Steady-state assets, A_0, depend on the capital requirement only if capital is "expensive" ($\delta > 0$) relative to a frictionless benchmark ($\delta = 0$). In steady-state, the bank equates expected marginal returns to the cost of capital. The existing literature on bank capital has concluded that the increase in banks' cost of capital due to an increase in capital requirements are likely to be modest. Kashyap et al. (2010), for example, estimate that a ten percentage point increase in capital requirements would lead to an increase in the weighted average cost of capital of at most 45 basis points. In our framework, this would correspond to a cost δ of 4.5%.

The timing is as follows: The initial capital requirement, κ_0, is in force before period 0. Between period 0 and period 1, the regulator unexpectedly announces a new effective capital requirement of κ, which has to be met from period 1 onwards.

Characterization of the Bank's Optimal Policy

We use standard techniques from dynamic optimization to describe the banks' optimal policy. From period 2 onwards, the problem is stationary and the Bellman equation is given by

$$V(A_{t-1}, E_{t-1}) = \max_{A_t, E_t} \pi(A_t, E_t; A_{t-1}, E_{t-1}) + \lambda_t(E_t - \kappa A_t) + \beta V(A_t, E_t)$$

The necessary conditions for an interior maximum are

$$f'\left(A_t^*\right) - (1+\bar{r}) - c_A'\left(A_t^*, A_{t-1}\right) - \kappa\lambda_t + \beta\frac{dV\left(A_t^*, E_t^*\right)}{dA_t} = 0 \tag{8}$$

$$-\delta - c_E'\left(E_t^*, E_{t-1}\right) + \lambda_t + \beta\frac{dV\left(A_t^*, E_t^*\right)}{dE_t} = 0 \tag{9}$$

$$\lambda_t\left(E_t^* - \kappa A_t^*\right) = 0 \tag{10}$$

Shrinking assets is associated with suboptimal scale and adjustment costs. However, it allows the bank to avoid raising equity (equation 8). The optimal choice of equity weighs the cost of issuing additional equity against the need to hit the capital requirement (equation 9). By the envelope theorem, we find that

$$\frac{d}{dA_t}V\left(A_t, E_t\right) = c_A'\left(A_{t+1}^*, A_t\right), \ \frac{d}{dE_t}V\left(A_t, E_t\right) = c_E'\left(E_{t+1}^*, E_t\right) \tag{11}$$

The problem simplifies to a univariate optimization problem if the constraint binds at all times. For an increase in capital requirements, this will be the case as long as the bank actually needs to raise capital to achieve the long-run optimum. Therefore, we need to rule out extreme scenarios in which the optimal level of equity *drops* after a rise in the capital requirement, which happens when optimal bank size shrinks so much that additional capital is not required.

Lemma 1. *(Sufficient condition for binding multipliers) The Lagrange Multipliers λ_t will be binding as long as the gross return function is sufficiently concave, i.e. $\varphi \geq \varphi^* \Rightarrow \lambda_t > 0 \ \forall t$ where φ^* is derived in the appendix.*

Proof. (see appendix) □

we assume that this condition is satisfied throughout the paper. Using lemma 1, the problem is straightforward to solve since $E_t = \kappa A_t$ for all t. Combining equations 3, 4, 5, 8, 9, and 11 leads to the following result:

Lemma 2. *(Path of Assets) The optimal path of assets for $t \geq 2$ is given by*

$$A_t = \tilde{A} + \left(A_1 - \tilde{A}\right) r^{t-1}$$

where $\tilde{A} = \frac{1}{\varphi}\left(\varphi_0 - (1 + \bar{r} + \kappa\delta)\right)$ is the long-run value of A_t and r determines the speed of convergence. The value of r is derived in the appendix.

Proof. (see appendix) □

Corollary 3. *(Long-run Assets) In the long-run, bank assets shrink if and only if equity capital is costly, i.e.* $\tilde{A} < A_0 \iff \delta > 0$ *.*

Proof. $A_0 - \tilde{A} = (\kappa - \kappa_0)\,\delta > 0 \iff \delta > 0$ using the fact that $\kappa > \kappa_0$. □

To find A_1, note that the above value function $V(.,.)$ is valid from $t = 2$ onwards. Therefore, at $t = 1$ the problem is to solve

$$V_1(A_0, E_0) = \max_{A_1, E_1} \pi(A_1, E_1; A_0, E_0) + \beta V(A_1, E_1) \quad \text{s.t. } E_1 = \kappa A_1$$

Applying a similar logic as before yields lemma 4:

Lemma 4. *(Asset choice upon impact) Assets in period 1 are given by*

$$A_1 = w_0 \left(\frac{\psi_0}{\psi} A_0 \right) + (1 - w_0)\,\tilde{A} \tag{12}$$

where $\psi_0 = \frac{1}{\varphi}(c_a + \kappa_0 \kappa c_e)$ *and* $\psi = \frac{1}{\varphi}\left(c_a + \kappa^2 c_e\right)$ *are measures of adjustment costs and the weight on the initial period is given by* $w_0 = \frac{\psi}{1+\psi+(1-r)\beta\psi}$ *.*

It might be natural to interpret expression 12 as a weighted average of initial assets A_0 and long-run assets $\tilde{A}$, where the weights are determined by the adjustment costs. Note, however, that it is not the case that A_1 is necessarily between A_0 and $\tilde{A}$. In fact, under many parameterizations, assets overshoot their long-run value (i.e. $A_1 < \tilde{A} < A_0$), which motivates proposition 5.

Proposition 5. *(Overshooting) After an increase in capital requirements, assets adjust more in the short-run than in the long-run if raising equity is costly relative to shrinking assets. Formally, the condition*

$$\frac{c_a + \kappa_0 \kappa c_e}{c_a + \kappa^2 c_e} < \frac{\varphi_0 - (1 + \bar{r} + \kappa\delta)}{\varphi_0 - (1 + \bar{r} + \kappa_0 \delta)} \tag{13}$$

implies that $A_1 < \tilde{A}$.

Proof. Consider an increase from κ_0 to $\kappa > \kappa_0$. It follows that $\tilde{A} < A_0$ and $A_0 - A_1 > A_0 - \tilde{A} \iff A_1 - \tilde{A} > 0$. From 12, $A_1 - \tilde{A} \propto \frac{\psi_0}{\psi} A_0 - \tilde{A}$. Plugging in for ψ_0, ψ, A_0, and $\tilde{A}$ yields 13. □

The overshooting result might seem surprising at first. The intuition is conveyed most easily in a stylized case without adjustment costs in assets ($c_a = 0$) and no change in the long-run value of assets ($\delta = 0$). Condition 13 then simplifies to $\kappa_0/\kappa < 1$, which is satisfied for any increase

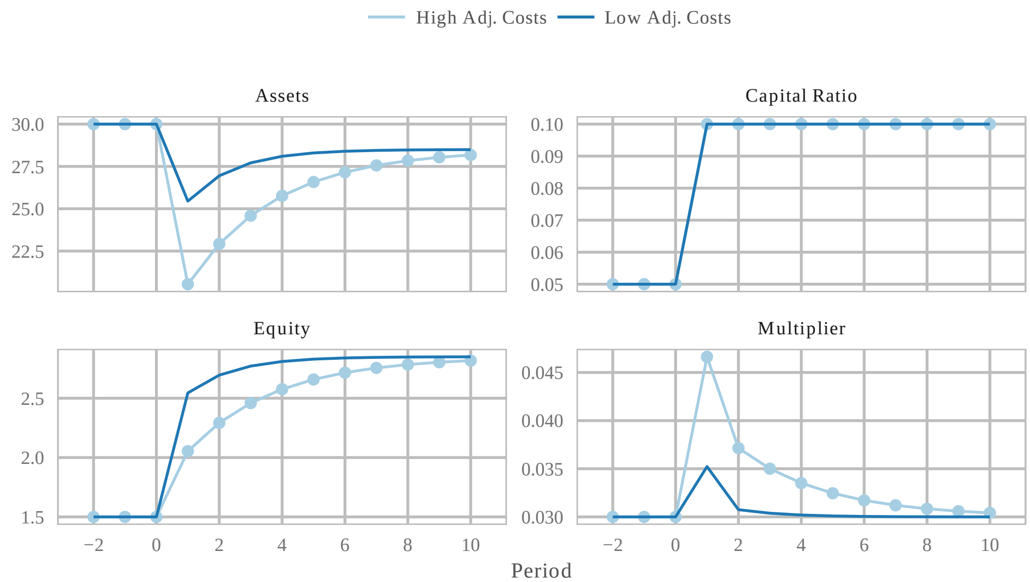


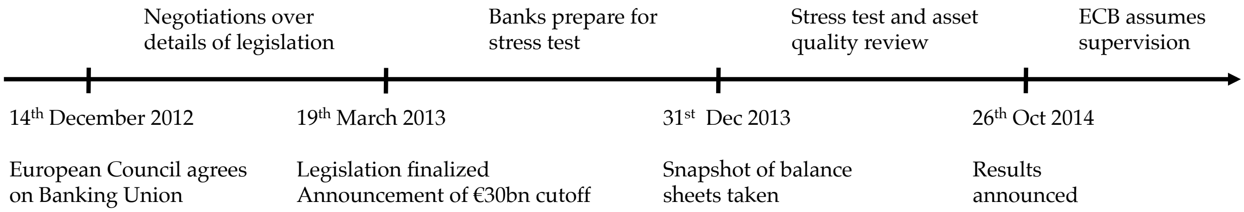
Figure 1: *Overshooting of Assets in the Short Run*

in capital requirements. Proposition 5 suggests that assets will fall below their initial value and gradually return. Consider a flat path of assets instead. Then, equity needs to jump when the higher capital requirement is introduced. But increasing equity is associated with convex adjustment costs. Therefore, reducing assets by one unit upon impact allows the bank to raise κ units less equity in the same period. This avoids a first-order adjustment cost and is associated with a second order cost due to suboptimal scale. As a result, the bank will contract assets upon impact in order to smooth out the equity adjustment.

In figure 1, we plot the paths of assets, equity, the capital ratio, and the Lagrange multiplier for an increase in the effective capital requirement at $t = 1$ for low and high equity adjustment costs. The harder it is to increase equity (e.g. by retaining earnings or issuing new stock), the more assets have to shrank to meet the increase in capital requirements.

The model guides our empirical analysis in what follows: Did the transfer of supervision to the ECB have any bite at all? Do banks perceive equity adjustments as costly and shrink their balance sheets to reduce leverage in the transition? Or do they simply meet reduce leverage by substituting debt with equity, leaving assets unaffected? Before testing these hypothesis in the data, we discuss the institutional background around the introduction of the Single Supervisory Mechanism and the Comprehensive Assessment.

Figure 2: *Timeline of Events*



3 Institutional Background

In this section, we describe why and how European leaders decided to form a so-called Banking Union. One aspect of the Banking Union were sweeping changes to banking regulation. Those changes generate variation in the tightness of supervision across banks and time, which we analyze in the empirical section of this paper.

At the height of the European sovereign debt crisis, policymakers decided to form a Banking Union in order to break the link between distressed sovereigns and distressed banks (Rompuy, 2012). On December 14th, 2012, the European Council agreed on a three-pronged approach. First, the largest Eurozone banks would be subject to the Single Supervisory Mechanism (SSM), which implied a transfer of regulatory oversight from national regulators to the ECB. Second, the Council decided to establish the European Stability Mechanism (ESM) as a joint source of financing for bank bailouts. Third, the Council passed new legislation on the resolution of failed banks: the Bank Recovery and Resolution Directive (BRR) and the Single Resolution Mechanism (SRM). The apparent failure of existing bankruptcy procedures for large financial institutions with cross-border activities motivated this change (Véron and Wolff, 2013; Véron, 2013).

A crucial stepping stone on the way toward the Single Supervisory Mechanism was the Comprehensive Assessment. The Comprehensive Assessment was carried out before the ECB assumed its new supervisory role and comprised the a review of asset quality and a stress test. The process covered bank assets worth €22tn, corresponding to around 80% of the Eurozone banking system.

Figure 2 presents a timeline of events. The SSM was agreed on in December 2012 and snapshots of bank balance sheets were taken on December 31, 2013. Therefore, banks had about one year to adjust their balance sheets in preparation for the assessment. It is this adjustment period that we evaluate.

3.1 Assignment of Banks to the Comprehensive Assessment

In this section, we discuss the algorithm by which banks were assigned to the Comprehensive Assessment. One of the criteria was an asset cutoff. The sharp cutoff allows us to establish a plausible counterfactual for how banks would have behaved had they not been assigned to the new supervisory regime.

The criteria for inclusion in the Comprehensive Assessment reflect a trade-off between coverage and the cost of conducting the assessment (ECB, 2014). The following two criteria[4] were sufficient for inclusion and are relevant for our empirical strategy:

1. bank assets exceed €30bn (asset cutoff);[5]
2. the bank is among the three largest credit institutions of its home country (rank condition).

In figure 3, we visualize the assignment based on size and country ranks. The vertical dashed line corresponds to the asset cutoff. Banks to the right of this line are assigned to the Comprehensive Assessment by virtue of having assets above $30bn. The horizontal dotted line corresponds to the rank condition. Banks below this line are assigned to the Comprehensive Assessment by virtue of being one of the three largest banks in their home country.

We construct our counterfactual by comparing banks to the left and to the right of the €30bn asset cutoff within the same country. In order to implement this comparison, we need to restrict the sample to countries that had banks on either side of the cutoff. This is true as long as there is at least one bank with more than €30bn in assets in this country, which applies to Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain.

3.2 Case Studies

Before proceeding to the empirical analysis, we present two case studies of banks that adjusted their balance sheets ahead of the Comprehensive Assessment, one from a regional lender and one from a large universal bank. The examples suggest that both large and small banks significantly

[4] A third criterion was whether the ratio of bank assets to GDP exceeds 20%, provided bank assets also exceed €5bn. The assets-to-GDP cutoff was binding only for a few smaller banks in Cyprus and Luxembourg. By definition, these do not exceed the €30bn cutoff and are excluded for the purpose of the regression discontinuity design.

[5] The ECB applied a 10% margin of error. Hence, the effective cutoff was €27bn, which we use for our empirical analysis.

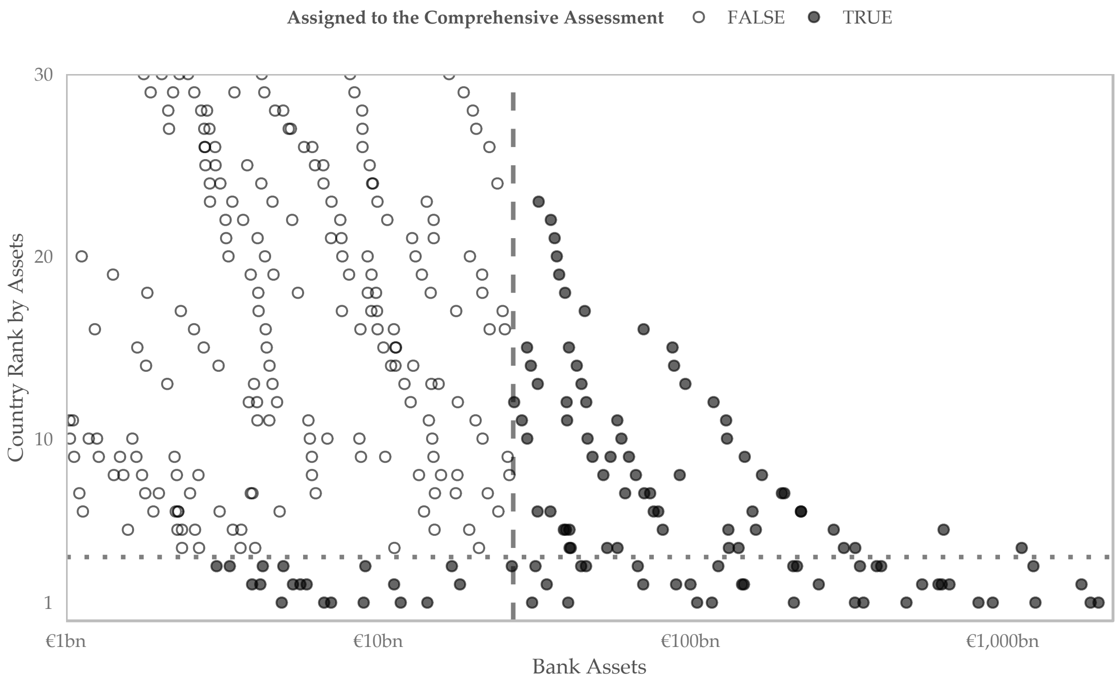


Figure 3: *Banks were assigned to the Comprehensive Assessment based on size and country rank*

changed their behavior in anticipation of the test. The anecdotal evidence complements our more formal estimates in the following sections.

UniCredit, Italy's biggest bank by assets, recorded an annual loss of €14bn in 2013. To put this number into perspective, UniCredit's annual revenues were €24bn and its assets amounted to €846bn in the same year.[6] The loss was mostly due to impairment of goodwill and additional loan loss provisions. The financial press interpreted management's decision to increase loan loss provisions as a preemptive move ahead of the stress test.[7]

Regional banks also adjusted their balance sheets in anticipation of the Comprehensive Assessment. ApoBank is a German bank that focuses on clients in the healthcare industry such as doctors and pharmacists. Its assets amounted to €35bn in 2013. Given that the bank's size exceeded the €30bn cutoff, it was included in the Comprehensive Assessment. In the year before the stress test, the bank reduced its assets by 8.4%, which was driven by reductions in the bank's securities portfolio. Even more strikingly, the bank trimmed its risk-weighted assets to €10.9bn, down from

[6]Unicredit, 2013 Consolidated Reports and Accounts (downloaded 11/9/2015)
[7]"UniCredit falls to record €14bn loss before stress tests", Financial Times, 03/1th/2014 (accessed 11/9/2015).

€17.1bn a year before.[8] In its 2013 annual report, the bank's management emphasizes that it was well-prepared for the stress test:

> The results of the Asset Quality Review and the stress test of the ECB are scheduled to be announced in the second half of 2014. Due to the developments in our risk profile and our current capital base described above, we do not expect to have to make any extensive additional risk provisions or take any major capitalisation measures. (apoBank, Annual Financial Report 2013)

In other words, the bank deems itself well-prepared for the new regulatory regime because it has sold securities and thereby increased its capital ratios. Anecdotal evidence therefore supports the hypothesis that both large and small banks changed their behavior ahead of the ECB's Comprehensive Assessment.

4 Data and Descriptive Statistics

In this subsection, we describe our data. We concentrate on banks' behavior in the year just before the Comprehensive Assessment and show that stress-tested banks are systematically different from non-tested banks, which motivates our empirical strategy in the following section.

4.1 Sample Construction

In this subsection, we discuss the sources and the construction of our data. We collect annual Eurozone bank balance sheets and add supervisory data from the ECB. Supervisory data includes both the assignment as well as the results of the Comprehensive Assessment, which allows us to link bank behavior to supervision.

We source a panel of bank balance sheets for the period 2012–2015 from SNL Financial.[9] We add 10-year government bond yields from the ECB's long-term interest rate statistics.[10] Since the bank data is annual, we take the average yield in a given year. We identify the banks that were subject

[8] apoBank, Annual Financial Report 2013 (downloaded 11/9/2015)

[9] Latvia and Lithuania joined the Eurozone during the sample period, but followed tight pegs before. We convert Latvian banks' balance sheets to Euros at the conversion rate of 0.7028 Lats per Euro (2011-2013). Lithuanian banks' balance sheets are converted at 3.4528 Litas per Euro (2011-2014).

[10] Estonia does not have any comparable bonds outstanding, so we omit the country when analyzing the relationship between balance sheet adjustments and yields.

to the Comprehensive Assessment based on the results published by the ECB after the stress test ECB (2014). We also add data on banks' capital ratios under the baseline and the adverse scenario. We lose one institution, LCH.Clearnet, since it is not part of the SNL database. We consolidate the balance sheets of Wüstenrot Bausparkasse (ID 4257337) and Wüstenrot Bank AG Pfandbriefbank (ID 4143295) since the company was assigned to the Comprehensive Assessment based on holding company assets (ECB, 2013), while SNL reports both subsidiaries separately.

A number of institutions are classified as banks by SNL but not treated as banks by the ECB. In particular, bad banks that are fully owned by governments were not part of the Comprehensive Assessment but are considered "banks" in the database. We therefore filter out all institutions in the dataset that were not assigned to the Comprehensive Assessment even though their assets exceeded €30bn. The set of deleted entities includes, for example, Portigon AG, Heta Asset Resolution AG, and BancoPosta.

We identify a sample of control observations in SNL's database of Eurozone financial institutions. First, we remove all banks that are subsidiaries of assessed banks as well as holding companies of assessed banks. For several banks, we manually add information on their corporate structure in order to avoid such double-counting. Then, we apply an economic filter to the data since SNL reports data for banks as well as non-bank financial institutions. We delete banks that are not classified as "bank" or "savings bank/thrift/mutual". We also delete very small banks with assets below €500m and banks whose fiscal year ends in months other than December. Finally, we require institutions to have a loans-to-assets ratio of at least 20% and a deposits-to-assets ratio of at least 20%. For consistency, we apply the same filter to the set of banks that were part of the Comprehensive Assessment. In order to avoid that our results are distorted by outliers, we winsorize all outcome variables at the 2.5% level. Manual checks suggest that many of these are reporting errors for smaller banks, for example due to changes in the level of consolidation.

Our preferred measure of banks' leverage is the ratio of total assets to tangible common equity. We prefer the leverage ratio as a measure of capital to regulatory capital for two reasons: First, there is little ambiguity in the accounting treatment of this measure. Tier 1 capital as well as total regulatory capital may include hybrid equity instruments, goodwill, and deferred tax assets, which have limited loss-absorbing ability and their treatment varies by country. Asset risk weights are zero for sovereign debt, which turned risky for several European sovereigns in the time period under consideration and risk weights may be subject to manipulation (Mariathasan and Merrouche, 2014; Behn et al., 2014). The total assets figure does not suffer from these shortcomings. Second, it is frequently argued that (unweighted) leverage provides a more useful basis for assessing bank solvency than regulatory capital ratios (e.g. Acharya et al., 2014; Steffen, 2014). Therefore, we focus on leverage defined as total assets over tangible common equity in subsequent analyses.

4.2 Descriptive Statistics

In this subsection, we present descriptive statistics for banks that were subject to the Comprehensive Assessment and for banks that were not. In addition to being larger, stress-tested banks tend to be more levered and more reliant on wholesale financing. These differences in bank characteristics imply that we cannot simply attribute all differences in behavior to the change in the supervisory regime—we need an identification strategy.

Summary statistics are reported in table 9 in the appendix. Our final dataset contains close to a hundred banks that were part of the Comprehensive Assessment and around a thousand control banks. For most of the analysis, we are interested in banks' balance sheet adjustments in 2013 and we use covariates as of December 31, 2012. We define bank size as the natural logarithm of total assets, where assets are denominated in millions of Euros. The average bank in our sample has a deposits-to-assets ratio of 66%, a loans-to-assets ratio of 60%, and a securities-to-assets ratio of 24%.

We cannot naively compare stress-tested banks to non-tested banks since the former group is significantly different on observable characteristics: In table 1, we compare the mean characteristics of the two groups. Banks that were part of the Comprehensive Assessment are significantly larger, rely more on wholesale financing, and are more leveraged.

In addition to observable differences between the two groups, we have to be wary of unobserved confounding factors that correlate with banks' assignment to the new supervisory regime. For instance, the phase-in of Basel III could account for some of the adjustments we observe on stress-tested banks' balance sheets, and Basel III likely affects stress-tested banks more than the control group due to their funding structure. The Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR), for example, penalize reliance on short-term wholesale funding. This might explain part of the reduction in banks' reliance on market funds in our data.

Given that stress-tested banks have significantly different characteristics and might be influenced by unobserved time-varying factors, we need a more elaborate empirical strategy to isolate the effect of tighter supervision. In the following section, we present our regression discontinuity design. Under weak conditions, these estimates have a causal interpretation as the average treatment effect on a bank at the discontinuity.

(Share of Assets, in %)	Stressed	Not Stressed	Difference	t-statistic	p-value	
Deposits	49.98	67.25	−17.27	−9.61	0.00	***
Wholesale Funding	44.27	24.56	19.71	10.28	0.00	***
Tangible Common Equity	4.72	8.05	−3.34	−7.85	0.00	***
Loans	58.18	60.07	−1.89	−1.16	0.25	
Securities	24.45	24.03	0.42	0.32	0.75	

Table 1: *On average, stress-tested banks are more levered and rely more on wholesale funding*

5 Regression Discontinuity Design

In this section, we present our main estimates. Banks whose assets exceed €30bn experienced a change in supervision whereas smaller banks did not. By comparing banks around this cutoff, we can identify the effect of tighter supervision on bank behavior.

5.1 Identification

In this subsection, we discuss how we identify the effect of tighter regulation. We use a regression discontinuity design (RDD), which is a well-established method in the treatment effects literature[11] that has also become popular in financial economics.[12] The strategy allows us to overcome confounding selection effects by focusing on comparable banks around the assignment cutoff.

Intuitively, the treatment effect is found by comparing banks just to the left of an assignment cutoff to banks just to the right of this cutoff. In the absence of treatment, the two groups would have plausibly behaved in similar ways. In our case, we allow for the fact that large banks might have adjusted to Basel III in different ways compared to small banks, for instance. We only require there to be no discrete jump in such omitted trends at the cutoff.

In the RDD subsample, the treatment indicator is defined as

$$\text{Stress-Tested}_i = \begin{cases} 1 & \text{if } A_i \geq 0 \\ 0 & \text{if } A_i < 0 \end{cases}$$

where A_i denotes the distance from the cutoff (often called the "running variable"). In our case, A_i is the difference between actual bank size (log assets) and the cutoff value. The object of interest is

$$\tau \equiv \lim_{a \downarrow 0} E\left[y_i | A_i = a\right] - \lim_{a \uparrow 0} E\left[y_i | A_i = a\right] \tag{14}$$

[11] Lee and Lemieux (2010) provide survey of regression discontinuity designs in economics.
[12] For examples, see Keys et al. (2010, 2012); Bubb and Kaufman (2014); Howell (2015).

We expect treatment effects to be heterogeneous in our application: Stricter regulation could be more challenging for weak banks or banks with poor risk-management. In this scenario, τ_i varies across banks and the estimand τ in equation (14) can be interpreted as the average treatment effect (ATE) on the subpopulation of banks at the cutoff (Hahn et al., 2001).

We follow the guidelines in Imbens and Lemieux (2008) and Lee and Lemieux (2010) when implementing our non-parametric approach. Define $m(a)$ as the conditional expectation of outcome Y_i for a bank with running variable a (normalized bank size),

$$m(a) = E[Y_i | A_i = a]$$

The function $m(\cdot)$ can be estimated with separate, locally linear regressions to the left ($\hat{\alpha}_-(a)$) and to the right ($\hat{\alpha}_+(a)$) of the cutoff:

$$\hat{m}_h(a) = \begin{cases} \hat{\alpha}_-(x) & \text{for } a < 0 \\ \hat{\alpha}_+(x) & \text{for } a \geq 0 \end{cases}$$

The local linear regression estimate at point a to the left of the cutoff is defined by

$$\left(\hat{\alpha}_-(a), \hat{\beta}_-(a)\right) = \arg\min_{\alpha,\beta} \sum_{i=1}^{N} \mathbf{1}\{A_i < 0\} \times (Y_i - \alpha - \beta(A_i - a))^2 \times K\left(\frac{A_i - a}{h}\right)$$

and similarly to the right of the cutoff. Here, $K(\cdot)$ denotes the chosen kernel and h denotes the chosen bandwidth. Finally, the estimated treatment effect is given by

$$\hat{\tau} = \hat{\alpha}_+(0) - \hat{\alpha}_-(0) \tag{15}$$

which is the empirical analogue to expression (14). In order to implement this approach, we need to choose a kernel $K(\cdot)$ and a bandwidth h. For our benchmark result, we use a a uniform kernel. This reduces to estimating

$$y_i = \beta \times \text{Stressed}_i + (\gamma_1 \times \text{Cutoff}_i + \gamma_2 \times \text{Cutoff}_i \times \text{Stressed}_i) + \epsilon_i, \quad |\text{Cutoff}_i| < h$$

by OLS, where h denotes the chosen bandwidth and Cutoff_i denotes the bank i's distance to the cutoff.

We add country fixed effects to this specification. Therefore, we estimate the treatment effect off the differential behavior of banks on either side of the cutoff within the same country. While such fixed effects are not strictly necessary for identification, they increase the precision of our estimates by absorbing macroeconomic effects that are common across all banks of a given country.

	Dependent Variable: Annual Change in %						
	Leverage	Assets	Equity	Wholesale	Deposits	Loans	Securities
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Stressed	-6.80^{*}	-4.30^{**}	2.50	-10.88^{***}	-0.31	-0.33	-12.44^{**}
	(3.97)	(1.95)	(3.45)	(4.06)	(2.57)	(1.88)	(6.28)
Cutoff	-0.40	-0.76^{*}	-0.37	0.27	-0.86^{*}	-0.63	-0.85
	(0.73)	(0.44)	(0.76)	(1.03)	(0.46)	(0.41)	(1.49)
Stressed x Cutoff	-2.31	-1.07	1.24	-1.13	0.02	-0.95	-2.58
	(2.35)	(1.14)	(1.96)	(2.39)	(1.52)	(1.25)	(3.34)
Country FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Bandwidth	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Observations	612	612	612	612	612	612	612
Adjusted R^2	0.35	0.17	0.34	0.18	0.30	0.19	0.23

Table 2: *Benchmark Regression Discontinuity Design*

Specifically, for bank i headquartered in country $j(i)$, we estimate

$$y_i = \beta \times \text{Stressed}_i + (\gamma_1 \times \text{Cutoff}_i + \gamma_2 \times \text{Cutoff}_i \times \text{Stressed}_i) + \theta_{j(i)} + \epsilon_i, \quad |\text{Cutoff}_i| < h \qquad (16)$$

where $\theta_{j(i)}$ denotes the country fixed effect. In table 2, we present benchmark estimates for a bandwidth of 3.0.[13] We estimate a 6.8% reduction in leverage, which is driven by a 4.3% reduction in assets. On the asset side, securities are most affected (-12.4%). On the liability side, the changes in scale are matched by a disproportionate reduction in wholesale financing (-10.9%). We find small and noisy estimates for equity, loans, and deposits.

5.2 Estimation on the Full Sample

In this subsection, we estimate the correlation between a stress-test indicator and bank behavior on the full sample. The estimates are very similar to the estimates in our regression discontinuity design in the preceding section. This suggests that the local effects from our RDD match the main patterns in the data even far from the discontinuity.

In theory, the regression discontinuity estimate in the preceding subsection only applies locally: It is the average treatment effect on a bank at the cutoff. Treatment effects may be different far away

[13] The automatic bandwidth selection algorithm of Imbens and Kalyanaraman (2012) selects bandwidths in a similar range (table 10), although for a triangular kernel. We provide estimates for a wide range of bandwidths in the appendix.

from the cutoff. For example, large banks may already have sophisticated risk-management in place, leading to smaller effects. Alternatively, large banks may be particularly weak due to their relationships with distressed sovereigns, so stress-testing them might lead to even more dramatic results. To gauge the external validity of our RDD results, we estimate the treatment effect using OLS on the whole sample, controlling for observable differences between treated and untreated banks.

In our baseline setup, we estimate the following specification across the entire sample of Eurozone banks:

$$y_i = \beta_1 \times \text{Stressed}_i + x_i'\gamma + \theta_{j(i)} + \epsilon_i$$

where y_i is an outcome variable for bank i, Stressed_i is an indicator for whether bank i was stress-tested, x_i is a vector of control variables, θ_j is a country fixed effect, and ϵ_i is an error term. The set of covariates comprises bank size, the wholesale ratio, the loan ratio, and the capital ratio. Bank size adjusts for the fact that many stress-tested banks are large relative to control banks. The wholesale ratio controls for differences in banks' liability structure (wholesale funding vs. deposits). The loan ratio controls for differences in banks' asset structure (loans vs. securities). Bank capitalization is measured as tangible common equity over assets and is known to correlate with banks' lending behavior even absent a stress-test (e.g. Peek and Rosengren, 1997).

We continue to find a strong effect on leverage (table 3). The point estimate suggests a 6.7% reduction in leverage for stress-tested banks, which is economically large and statistically significant at the 1% level. Looking at the components of leverage, we find that asset shrinkage accounts for most of the effect (-4.5%). Both effects are statistically significant at the 1% level. The point estimates for equity and deposit growth are small and imprecisely estimated. However, we do find a large reduction in wholesale funding (-8.0%), which is significant at the 1% level. On the asset side, we find that banks adjusted their holdings of securities disproportionately (-10.3%). In sum, the regression evidence paints a similar picture to the regression discontinuity design. Banks reacted to the prospect of tighter regulation by reducing leverage through asset sales. Asset sales primarily involved reducing securities holdings, and the proceeds were largely used to repay wholesale debt.

	Dependent Variable: Annual Change in %						
	Leverage	Assets	Equity	Wholesale	Deposits	Loans	Securities
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Stressed	-6.74^{***}	-4.53^{***}	2.20	-8.04^{***}	-1.83	-1.23	-10.31^{**}
	(2.53)	(1.20)	(2.44)	(2.97)	(1.52)	(1.22)	(4.46)
Bank Size	0.24	-0.56^{***}	-0.79^{**}	-0.11	-0.65^{**}	-0.55^{***}	-1.74^{**}
	(0.35)	(0.21)	(0.38)	(0.53)	(0.26)	(0.21)	(0.77)
Wholesale/Assets	-0.04	-0.11^{***}	-0.07^{**}	-0.12^{***}	0.04	-0.11^{***}	-0.09
	(0.03)	(0.02)	(0.03)	(0.05)	(0.03)	(0.02)	(0.07)
Equity/Assets	0.79^{***}	-0.004	-0.80^{***}	-0.15	0.13	-0.02	-0.59^{*}
	(0.18)	(0.11)	(0.15)	(0.24)	(0.12)	(0.11)	(0.31)
Loans/Assets	0.04^{*}	-0.01	-0.05^{**}	0.05	-0.01	-0.05^{***}	0.09^{*}
	(0.02)	(0.02)	(0.02)	(0.04)	(0.02)	(0.02)	(0.06)
Country FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	1,280	1,280	1,280	1,280	1,280	1,280	1,280
Adjusted R^2	0.38	0.26	0.41	0.15	0.34	0.28	0.28

Table 3: *Stress Tested Banks Reduced Leverage by Shrinking Assets*

5.3 Robustness and Falsification Tests

In this subsection, we assess the robustness of our regression discontinuity design and present falsification tests. We find that the estimates are not particularly sensitive to the chosen bandwidth and kernel, and the design passes a range of validity and falsification tests. This gives us confidence that our estimates are not spurious and do indeed constitute a reaction to the changes in the supervisory regime.

Bandwidth Choice

When choosing a bandwidth for locally linear regressions, researchers face a bias-variance tradeoff: On the one hand, choosing a small bandwidth reduces the estimator's bias; on the other hand, a smaller bandwidth increases the estimator's variance due to a smaller effective sample size. Imbens and Kalyanaraman (2012) derive a data-driven procedure to choose a bandwidth given this tradeoff. They derive the bandwidth that is optimal under an asymptotic mean squared error criterion at the cutoff.

In table 10, we implement the Imbens-Kalyanaraman approach analogous to our benchmark specification (16). We also report estimates for twice and half the bandwidth as is recommended. The results are very similar to our benchmark estimates in table 2: In anticipation of tighter regulation, there was a strong reduction in bank leverage (-7.4%), driven by a reduction in assets (-5.0%) and repayment in wholesale funding (-13.0%). We also confirm the now familiar pattern for the changes in asset composition: banks were more likely to reduce their holdings of securities (-13.5%) than the size of their loan books.

We also report estimates for our benchmark specification for a wide range of bandwidths in table 11. As we reduce the bandwidth, the sample size drops from over 1,200 observations to around 80 observations, with a corresponding loss of precision. Importantly, the point estimates for our main results are similar irrespective of the bandwidth we choose. The results indicate a strong reduction in leverage for those banks that were assigned to the Comprehensive Assessment. The balance sheet adjustments are tilted towards sales of securities and repayment of wholesale debt, rather than increases in equity.

Covariates are Balanced at the Discontinuity

The crucial assumption of the regression discontinuity design is the continuity of the conditional expectation function through the cutoff. The assumption implies that in the absence of treatment there should be no discontinuities at the cutoff value, neither for outcomes nor for other variables. This implication can be evaluated by running a placebo RDD on baseline covariates that were fixed at the time of treatment. In our setting, we use balance sheet ratios at the beginning of the year.

We jointly estimate the system

$$\begin{aligned} y_i^{(1)} &= \beta^{(1)} \times \text{Stressed}_i + \left(\gamma_1^{(1)} \times \text{Cutoff}_i + \gamma_2^{(1)} \times \text{Cutoff}_i \times \text{Stressed}_i\right) + \theta_{j(i)}^{(1)} + \epsilon_i^{(1)} \\ &\vdots \\ y_i^{(k)} &= \beta^{(k)} \times \text{Stressed}_i + \left(\gamma_1^{(k)} \times \text{Cutoff}_i + \gamma_2^{(k)} \times \text{Cutoff}_i \times \text{Stressed}_i\right) + \theta_{j(i)}^{(k)} + \epsilon_i^{(k)} \end{aligned} \tag{17}$$

where $\mathbf{y}_i = (y_i^{(1)}, \ldots, y_i^{(k)})$ is a k-dimensional covariate vector for bank i in country $j(i)$. We test whether the vector $\boldsymbol{\beta} = (\beta^{(1)}, \ldots, \beta^{(k)})$ is zero using a χ^2 test statistic (Imbens and Lemieux, 2008). The approach takes into account that we are testing multiple hypotheses and that the error terms $\boldsymbol{\epsilon}_i = (\epsilon_1^{(1)}, \ldots, \epsilon_i^{(k)})$ may be correlated. Moreover, we allow for heteroskedastic error terms as in the baseline specification. In practice, we use the following balance sheet ratios: the deposit ratio, the wholesale ratio, the (tangible common) equity ratio, the loan ratio, and the securities ratio.

Bandwidth	Obs	Treated Obs	χ^2	p-value
Inf	1223	80	24.14	0.00
3.50	884	73	16.02	0.01
3.00	612	67	6.25	0.28
2.50	397	62	3.27	0.66
2.00	248	54	1.13	0.95
1.50	143	41	7.32	0.20
1.00	74	34	5.03	0.41

Table 4: *Covariate Balance Around the Cutoff*

Table 4 shows that banks are indeed similar around the cutoff. While we find significant differences between stress-tested and untested banks when we estimate the system on the whole sample ($h = \infty$), these differences vanish as soon as we restrict the sample to banks of roughly similar size. The p-value associated with the null hypothesis that banks have the same balance sheets on either side of the cutoff ($\boldsymbol{\beta} = \mathbf{0}$) exceeds 20% for all bandwidths below 3.00.

Placebo test within untreated banks

If our identification strategy is valid, then we should not find any discontinuous effects at random points of the size distribution and only at the asset cutoff that was actually used to assign treatment. We exploit this logic to conduct a placebo test within the set of banks that were not assigned to the Comprehensive Assessment. To avoid any bleeding, we restrict the RDD sample to banks that were not treated. We arbitrarily define banks with assets above the median in this subsample as placebo-stressed and repeat our locally linear regression analysis from table 2. The results are presented in table 5. We estimate quantitatively small effects of our placebo stress test. All estimates are statistically indistinguishable from zero for all outcome variables.

	Dependent Variable: Annual Change in %						
	Leverage	Assets	Equity	Wholesale	Deposits	Loans	Securities
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Stressed	1.19	−0.17	−1.36	1.57	−1.04	−1.02	−0.43
	(1.00)	(0.70)	(1.09)	(1.78)	(0.88)	(0.74)	(2.24)
Cutoff	−0.68	−0.37	0.32	−1.53	0.92	0.31	−0.42
	(1.24)	(0.90)	(1.37)	(2.29)	(1.21)	(0.98)	(2.86)
Stressed x Cutoff	−0.22	−0.08	0.13	0.36	−0.98	−0.56	0.24
	(1.46)	(1.04)	(1.61)	(2.67)	(1.38)	(1.11)	(3.27)
Country FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Bandwidth	2	2	2	2	2	2	2
Observations	1,088	1,088	1,088	1,088	1,088	1,088	1,088
Adjusted R^2	0.37	0.21	0.44	0.14	0.36	0.25	0.31

Table 5: *Placebo Test with Untreated Banks*

Ex-Post Failure Correlates with Ex-Ante Shrinkage within the Treatment Sample

If it is indeed correct that banks shrank their balance sheets in anticipation of the stress tests, then we should also find heterogeneity within the sample of stress-tested banks. In particular, we expect strong banks to react very little to the prospect of tighter supervision, whereas weak banks are expected to adjust their balance sheets more. Since only a handful of banks actually failed, we calculate a continuous "buffer" measure for all banks. Banks could fail in two ways: by having a CET1 ratio below 8% in the baseline scenario or by having a CET1 ratio below 5.5% in the adverse scenario. We calculate bank i's buffer by

$$\text{buffer}_i = min\left\{\text{CET1 Ratio}_i^{baseline} - 8\%, \text{CET1 Ratio}_i^{adverse} - 5.5\%\right\}$$

Banks that passed the Comprehensive Assessment comfortably exhibit a high value for buffer_i , banks that passed narrowly exhibit a value close to zero, and banks that failed exhibit a negative value. We regress asset shrinkage (assets, loans, securities) on banks' buffer and the control variables from our benchmark specification. The specification is given by

$$y_i = \beta_0 + \beta_1 \times \text{buffer}_i + x_i'\gamma + \epsilon_i$$

We find that firms with a smaller buffer reduced assets, loans, and securities more than firms with higher buffers (table 6). A one percentage point decrease in firms' ex-post buffer is associated with a 0.6 percentage point reduction in asset growth, a 2.6 percentage point reduction in securities growth, and a 0.8 percentage point reduction in loan growth. All estimates are significant at the 1% level. These results hold even though we are (over-)controlling for initial capitalization, which stacks the cards against finding an additional effect of the ex-post buffer measure.

	Dependent Variable: Annual Change in %		
	Assets	Securities	Loans
	(1)	(2)	(3)
Buffer (%)	0.60***	2.55***	0.84***
	(0.21)	(0.90)	(0.23)
Bank Size	−1.77**	−6.13***	−1.46**
	(0.70)	(1.87)	(0.60)
Wholesale/Assets	−0.02	0.02	0.03
	(0.05)	(0.20)	(0.07)
Equity/Assets	−0.94**	−2.68***	−1.01**
	(0.40)	(1.04)	(0.40)
Loans/Assets	0.10	0.45**	0.02
	(0.08)	(0.21)	(0.08)
Country FE	*No*	*No*	*No*
Constant	*Yes*	*Yes*	*Yes*
Observations	97	97	97
Adjusted R^2	0.14	0.20	0.13

Table 6: *Ex-Post Buffer Predicts Ex-Ante Asset Shrinkage*

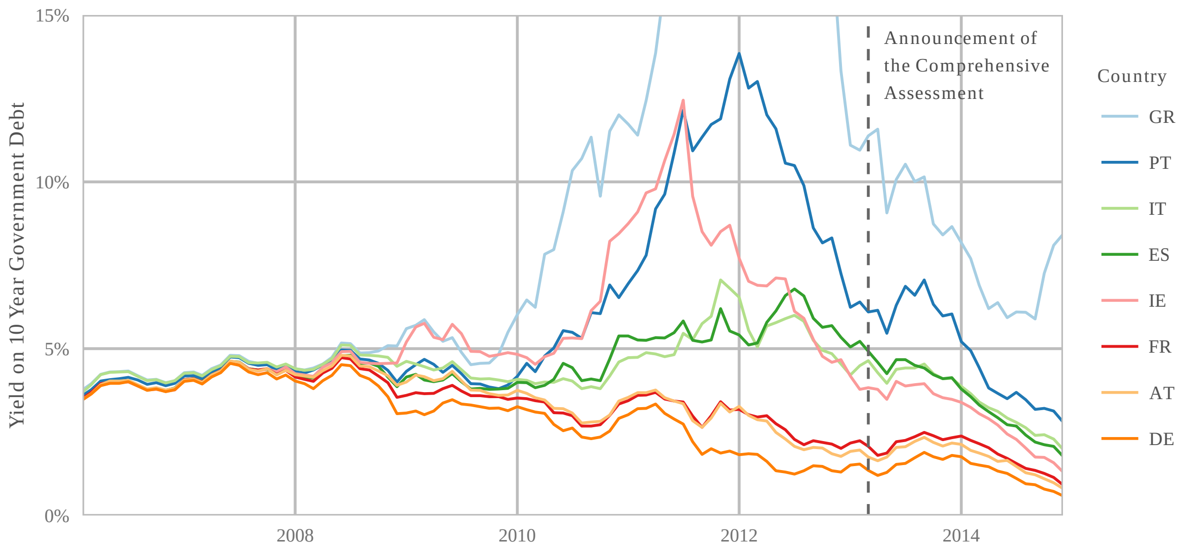


Figure 4: *Periphery Sovereign Debt was in Distress During the Adjustment Period*

6 Pass-Through and the Role of Securities

Our estimates in the preceding sections showed that banks disproportionately adjust the securities on their balance sheets, which motivates a closer look in this section. We find that large securities books insulate loan portfolios from asset shrinkage in normal times, but this relationship is weakened when sovereign spreads are high. The results suggest that sovereign distress affects how banks deleverage.

A salient feature of the banking crisis in Europe was the concurrent weakness of sovereigns in the Eurozone periphery (Greece, Ireland, Italy, Portugal, and Spain). Figure 4 exhibits yields on 10-year government bonds for selected Eurozone countries. When the Comprehensive Assessment was announced, spreads were still high and periphery sovereign debt was trading at substantial discounts, compared to pre-crisis levels.

High returns on securities can crowd out other activities by financial intermediaries, and this channel is particularly relevant for sovereign debt (Acharya and Steffen, 2015). Regulatory incentives and bank accounting rules further strengthen banks' tendency to retain or even increase their exposure to impaired sovereign debt. First, Eurozone sovereign debt carries a risk-weight of zero under Basel II (under some conditions). Second, reduced market values on hold-to-maturity assets affect banks' net income only when these securities are sold. As a consequence, both bank regulation and accounting rules strongly discourage sales of sovereign debt that trades below book

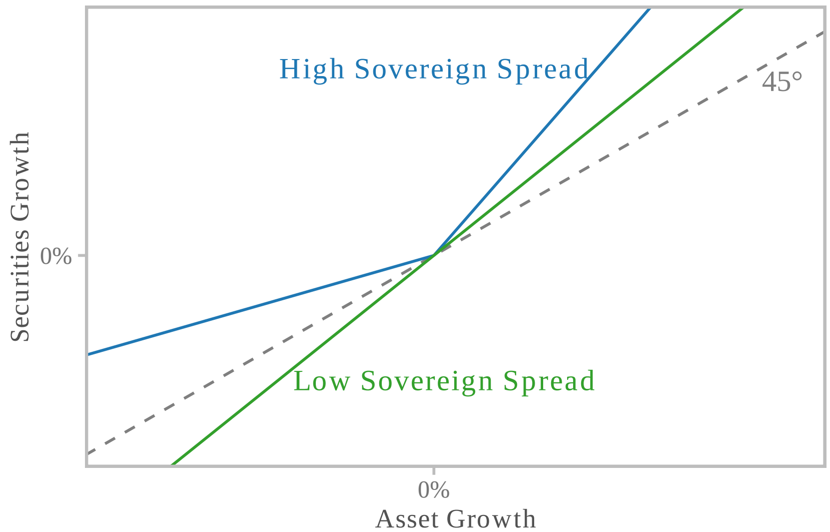


Figure 5: *Pass-Through Function from Assets to Securities: High vs. Low Yields*

value.

In this section, we investigate the pass-through from assets to securities for the banks in our data, pooling both treated and untreated banks. By definition, asset growth ($\Delta A/A$) is a weighted average of loan growth ($\Delta L/L$), securities growth ($\Delta S/S$), and the growth rate of other assets ($\Delta O/O$):

$$\frac{\Delta A}{A} = \frac{L}{A}\frac{\Delta L}{L} + \frac{S}{A}\frac{\Delta S}{L} + \frac{O}{A}\frac{\Delta O}{O} \approx w_l \frac{\Delta L}{L} + w_s \frac{\Delta S}{S} \tag{18}$$

where w_l is the share of loans in assets and w_s is the share of securities in assets. The influence of other assets tends to be small since their weight is low and they tend to be fairly stable. We start by estimating the pass-through from asset growth to securities growth by estimating a linear model:

$$\frac{\Delta S_i}{S_i} = \gamma_0 + \gamma \times \frac{\Delta A_i}{A_i} + \epsilon_i \tag{19}$$

If pass-through is completely neutral, then we would expect $\gamma_0 = 0$ and $\gamma_1 = 1$. Moreover, we hypothesize that bank and country characteristics determine how strongly banks adjust through securities. We group banks into four categories, depending on whether they are headquartered in a country with sovereign yields above the median or below, and whether they grow or shrink assets. We denote the yield in bank i's country of incorporation, $j(i)$, by $z_{j(i)}$ and the median yield by $\tilde{z}$. We therefore estimate the model

$$\frac{\Delta S_i}{S_i} = \begin{cases} \beta_1 \times \Delta A_i / A_i + \epsilon_i & \text{if } \Delta A_i \geq 0 \cap z_{j(i)} \geq \tilde{z} \ \rightarrow \text{Expansion, High Yield} \\ \beta_2 \times \Delta A_i / A_i + \epsilon_i & \text{if } \Delta A_i < 0 \cap z_{j(i)} \geq \tilde{z} \ \rightarrow \text{Contraction, High Yield} \\ \beta_3 \times \Delta A_i / A_i + \epsilon_i & \text{if } \Delta A_i \geq 0 \cap z_{j(i)} < \tilde{z} \ \rightarrow \text{Expansion, Low Yield} \\ \beta_4 \times \Delta A_i / A_i + \epsilon_i & \text{if } \Delta A_i < 0 \cap z_{j(i)} < \tilde{z} \ \rightarrow \text{Contraction, Low Yield} \end{cases} \tag{20}$$

Figure 5 illustrates the adjustment function. Intuitively, we allow for different coefficients depending on whether bank i grows or shrinks its balance sheet, and whether bank i is based in a high-yield country or a low-yield country. Using specifications 19 and 20, we test the following hypotheses:

- **Hypothesis 1 (High Pass-Through into Securities):** For a given amount of asset growth, securities are adjusted more, i.e. $\gamma > 1$.
- **Hypothesis 2 (Asymmetric Impact of Sovereign Yields):** High sovereign yields are attractive to banks that expand their balance sheets, but make banks reluctant to sell securities when they shrink their balance sheets, i.e. $\beta_1 > \beta_2$.

Table 7 presents the results of this exercise. First, we find a high pass-through of asset adjustments into securities (hypothesis 1). We estimate that a 1% adjustment in assets is matched by a 1.8% adjustment in securities ($\hat{\gamma} = 1.77$, column 1). Second, we find evidence for an asymmetric impact of sovereign yields. When banks operate in a high-yield environment, then asset expansions are passed through to securities even more strongly ($\hat{\beta}_1 = 2.47$, column 3). However, the opposite is true for asset contractions. We now find that a 1% contraction in assets is matched only by a 0.6% reduction in securities ($\hat{\beta}_2 = 0.63$, column 3). We do not find a similar asymmetry between balance sheet expansions and contractions for banks in low-yield countries and we cannot reject the null hypothesis that β_3 and β_4 are equal. The results are consistent with impaired sovereign debt being both an attractive asset to buy and an unattractive asset to sell. For completeness, we also report specifications that include a constant in columns (2) and (4), which does not affect our conclusions.

7 Loan-Level Analysis

By analyzing loan-level issuance data, we test whether the Comprehensive Assessment was associated with a reduction in the supply of credit. We focus on loans extended around the March 2013

	Securities Growth in %			
	(1)	(2)	(3)	(4)
γ: $\frac{\Delta A_i}{A_i}$	1.77^{***}	1.65^{***}		
	(0.14)	(0.14)		
β_1: $\frac{\Delta A_i}{A_i} \times (\Delta A_i \geq 0 \cap z_{j(i)} \geq \tilde{z})$			2.47^{***}	2.32^{***}
			(0.23)	(0.25)
β_2: $\frac{\Delta A_i}{A_i} \times (\Delta A_i < 0 \cap z_{j(i)} \geq \tilde{z})$			0.63^{***}	0.86^{***}
			(0.21)	(0.23)
β_3: $\frac{\Delta A_i}{A_i} \times (\Delta A_i \geq 0 \cap z_{j(i)} < \tilde{z})$			1.27^{***}	1.02^{***}
			(0.24)	(0.31)
β_4: $\frac{\Delta A_i}{A_i} \times (\Delta A_i < 0 \cap z_{j(i)} < \tilde{z})$			1.15^{***}	1.50^{***}
			(0.24)	(0.28)
$pr(\beta_1 = \beta_2)$	–	–	0.00	0.04
$pr(\beta_3 = \beta_4)$	–	–	0.72	0.32
Constant	*No*	*Yes*	*No*	*Yes*
Observations	1,278	1,278	1,278	1,278
Adjusted R^2	0.27	0.23	0.31	0.27

Table 7: *Asymmetric Pass-Through from Assets to Securities*

stress test announcement date and find a reduction in credit supply only for very banks. While we cannot rule out a credit crunch in other segments of the market, this suggests that the effects of banks' balance sheet clean-up on the real economy might have been limited.

We employ a granular dataset from the syndicated loan market, where large firms borrow from multiple banks. Syndicated loan flows exhibit strong co-movement with total loan flows (Gadanecz, 2004), despite the fact that the average syndicated loan is very large with an average size of $500 million. Syndicated loans represent a significant share of originating banks' loan portfolios. For example, they account for 26 percent of total C&I loans on the balance sheets of U.S. banks supervised by federal regulators, and for 36 percent of C&I loans on the balance sheets of foreign banks in the U.S. (Ivashina and Scharfstein, 2010). Moreover, syndicated loans represent almost one third of cross-border loan claims of internationally-active banking systems (Cerutti et al., 2015).

We employ a difference-in-differences strategy and control for loan demand in order to estimate the effect of tighter supervision on loan origination. We compare the lending behavior of large foreign banks in the Eurozone's syndicated loan market to the lending behavior of large domestic banks. We use large foreign banks because we do not have enough control observations headquartered within the Eurozone.[14] Therefore, the identification of a loan supply response hinges on the assumption that banks outside the Eurozone did not experience any events around March 2013 that led them to adjust Eurozone lending differentially compared to their Eurozone counterparts.

We construct our samples of stress-tested and non-tested banks by focusing on the largest 200 lead banks during 2010-2014 by loan volume. We match 82 stress-tested banks to the top 200 list. The control group comprises 66 lenders in the syndicated loan market, also from the top 200, that we are able to match to financial statement information in SNL Financial. Consistent with the approach of the ECB Comprehensive Assessment, lending data is aggregated at the highest level of consolidation and matched to consolidated balance sheets. During the 2010-2014 period we observe 66,826 loans, of which 95 percent were syndicated. The matched banks together accounted for 60 percent of the total deal volume in the market over the period that we analyze.

We compare the change in lending by treated and untreated banks to the same borrower following the methodology of Khwaja and Mian (2008). Therefore, we aggregate loan volumes at the bank-borrower level and analyze the change in lending before and after March 2013, when the list of banks that would be subject to the Comprehensive Assessment was announced. We provide estimates for windows of 6 months, 9 months, and 12 months around this date.[15] Our empirical model is given by:

$$\Delta y_{ij} = \beta_j + \beta_1 \text{Stressed}_i + \beta_2 \text{Stressed}_i \times \text{Capital}_i + \gamma' z_i + \epsilon_{ij} \tag{21}$$

where Δy_{ij} is the log-change in syndicated bank credit extended by bank i to borrower j and Stressed_i is an indicator for Eurozone banks that were subject to the stress test. We control for potential credit demand shifts using borrower fixed effects (β_j), which allow us to exploit multiple bank relationships of individual borrowers to isolate loan supply. We estimate the statistical significance of the regression coefficients with standard errors that are clustered at the bank level.

We also consider variants of equation (21) in which we control for bank characteristics (z_i), which include bank size, the equity ratio, the wholesale ratio, and the loan ratio. Moreover, we test for heterogeneity in banks' responses based on their financial health by adding an interaction term of the stress-test indicator with the initial capital ratio.

The results are reported in table 8. There are three variants of each specification: First, we include only the treatment indicator (Stressed_i), then we add control variables, and further we add the interaction with the capital ratio. The results indicate that on average Eurozone stress-tested banks

[14] The syndicated loan market is dominated by larger banks. The banks within the Eurozone but outside the SSM tend to be small and are usually not active in syndicated loans.

[15] All loans signed during the course of March 2013 are dropped from the analysis.

did not systematically reduce the supply of loans compared to non-tested banks outside the Eurozone. The coefficient on Stressed_i only become statistically significant if we condition on banks' level of capital. As seen in columns 3, 6, and 9, only stress-tested banks with very weak capital positions (that is, common equity ratios lower than about 3 percent, based on column 6) reduced the supply of loans compared to non-tested banks with similarly low capital ratios.

In sum, we find some evidence for a credit crunch, but only for weak banks. We cannot detect a widespread reduction in the supply of large corporate loans in anticipation of the 2014 Comprehensive Assessment and the associated changes in the supervisory regime. However, banks with ex-ante weak equity positions, did reduce the supply of loans. Our results should nonetheless be interpreted with caution because our data only captures lending to large firms and only through bank syndicates. We cannot rule out the possibility that a reduction in the supply of bank credit occurred in other segments of the credit market, especially those serving smaller firms.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Window (around March 2013)	6m	6m	6m	9m	9m	9m	12m	12m	12m
Stressed	0.047	-0.052	-0.327**	0.050	-0.006	-0.210**	0.014	0.014	-0.172**
	(0.049)	(0.063)	(0.126)	(0.045)	(0.047)	(0.095)	(0.030)	(0.035)	(0.071)
Stressed x Capital			0.093**			0.067*			0.061***
			(0.046)			(0.034)			(0.022)
Capital		0.009	0.001		0.009	0.003		0.003	-0.002
		(0.015)	(0.017)		(0.008)	(0.008)		(0.006)	(0.006)
Wholesale/Assets		0.003	0.000		0.004	0.002		0.001	-0.000
		(0.003)	(0.004)		(0.002)	(0.002)		(0.002)	(0.001)
Loans/Assets		0.001	-0.002		0.004	0.002		0.002	0.000
		(0.003)	(0.003)		(0.003)	(0.002)		(0.002)	(0.001)
Observations	1,664	846	846	3,765	2,045	2,045	6,399	3,535	3,535
R-squared	0.853	0.850	0.851	0.762	0.765	0.766	0.710	0.705	0.706
Borrower FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. banks	84	61	61	98	72	72	111	81	81
No. stress-tested banks	30	28	28	38	34	34	47	41	41

Table 8: *Loan-Level Results*

8 Conclusion and Policy Implications

In this paper, we examined changes in Eurozone banks' balances sheets in anticipation of a new regulatory regime—the move of banking supervision from national regulators to the ECB through its Single Supervisory Mechanism. Our goal was to determine how banks adjusted their balance sheets when they learned about the prospect of stricter supervision.

We exploited a stress-test eligibility rule based on bank size and compared balance sheet outcomes for banks just above and below the size cutoff to show that banks significantly reduced their leverage in anticipation of the ECB's Comprehensive Assessment. This decline in leverage was achieved mostly through a reduction in assets rather than an increase in equity. On the asset side, banks reduced securities the most. On the liability side, banks primarily reduced their reliance on wholesale funding.

A benign interpretation of the evidence is that banks "cleaned up" their balance sheets before supervisory changes. This is a positive finding since banks reduced leverage and became less reliant on potentially unstable wholesale funding. It is also possible, however, that reductions in bank assets were associated with fire sales and a reduction in credit supply, with implications for the real economy.

To determine if the supervisory changes "had a reciprocal effect on the economy" (Constâncio, 2014), we also examined developments in the market for large corporate loans. In particular, we analyzed loans granted to the same borrower by stress-tested Eurozone banks compared to banks outside the Eurozone. For the average Eurozone bank we found no evidence of a reduction in the supply of loans, but weakly capitalized banks did reduce loan volumes in anticipation of stricter supervision. However, our results should be interpreted with caution since the syndicated loan market is dominated by very large borrowers and might not perfectly reflect borrowing conditions in other markets.

Our results highlight a benefit of liquid securities holdings that is different from the usual arguments for liquidity regulation: In response to desired reductions in leverage, banks can sell securities holdings easily without resorting to adjustments in their loan portfolios. We found that for a given reduction of assets, banks reduce securities proportionately more than loans. However, the buffering function of securities is lost when sovereign debt is impaired: In the data, banks appear reluctant to sell securities when spreads are high.

Our finding that most of the adjustment took place on the asset side of the balance sheet—rather than through equity issuance or retained earnings—suggests a role for macroprudential regulation. Banks may not internalize the spillover effects of their individual balance sheet adjustments to the financial system and the broader economy. In particular, regulators may want to strengthen banks' incentives to raise equity rather than shed assets when phasing in new regulation. Such a mechanism would mitigate possible negative short-term effects such as asset sales and credit crunches. Our study does not evaluate the welfare implications of asset shrinkage in general equilibrium, which are necessary to assess the to characterize optimal policies. We consider the theoretical and empirical evaluation of such effects a challenging but fruitful avenue for future research.

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A Proofs

A.1 Proof of Lemma 1

In period 1, we have

$$\begin{aligned}
\lambda_1 &= \delta + c_e\left(E_1 - E_0\right) - \beta c_e\left(E_2 - E_1\right) \\
&= \delta + c_e\kappa\left(A_1 - \frac{\kappa_0}{\kappa}A_0\right) - \beta c_e\kappa\left(A_2 - A_1\right) \\
& \delta + \left[\left(1+\beta\left(1-r\right)\right)\left(c_e\kappa w_0\frac{\psi_0}{\psi}\right) - c_e\kappa_0\right]A_0 + \left[\left(1+\beta\left(1-r\right)\right)c_e\kappa\left(1-w_0\right) - \beta c_e\kappa\left(1-r\right)\right]\tilde{A}
\end{aligned}$$

This is greater than zero as long as

$$\begin{aligned}
\varphi &\geq \varphi_1^* \\
&\equiv \frac{\kappa c_e}{\delta}\left(\left[\frac{\kappa_0}{\kappa} - w_0\left(1+\beta\left(1-r\right)\right)\frac{\psi_0}{\psi}\right]\left(\varphi_0 - \left(1+\bar{r}+\kappa_0\delta\right)\right)\right. \\
&\quad \left. - \left[1 - w_0\left(1+\beta\left(1-r\right)\right)\right]\left(\varphi_0 - \left(1+\bar{r}+\kappa\delta\right)\right)\right)
\end{aligned}$$

In period $t \geq 2$, we have

$$\begin{aligned}
\lambda_t &= \delta + c_e\left(E_t - E_{t-1}\right) - \beta c_e\left(E_{t+1} - E_t\right) \\
&= \delta + \left(c_e\kappa\right)\left(\left(A_t - A_{t-1}\right) - \beta\left(A_{t+1} - A_t\right)\right) \\
&= \delta + r^{t-1}\left(1-\beta r\right)\left(1-r\right)\left(c_e\kappa\right)\left(\tilde{A} - A_1\right) \\
&= \delta + r^{t-1}\left(1-\beta r\right)\left(1-r\right)\left(c_e\kappa\right)w_0\left(\tilde{A} - \frac{\psi_0}{\psi}A_0\right)
\end{aligned}$$

If $\tilde{A} \geq \frac{\psi_0}{\psi}A_0$, this expression is always positive. Otherwise, we have

$$\begin{aligned}
\lambda_t &= \delta - r^{t-1}\left(1-\beta r\right)\left(1-r\right)w_0 c_e\kappa\left(\frac{\psi_0}{\psi}A_0 - \tilde{A}\right) \\
&\geq \delta - r\left(1-\beta r\right)\left(1-r\right)w_0 c_e\kappa\left(\frac{\psi_0}{\psi}A_0 - \tilde{A}\right)
\end{aligned}$$

which exceeds zero as long as

$$\varphi \geq \varphi_2^* \equiv \left(\frac{\kappa c_e}{\delta}\right)\left(1-\beta r\right)r\left(1-r\right)w_0\left(\frac{\psi_0}{\psi}\left(\varphi_0 - \left(1+\bar{r}+\kappa_0\delta\right)\right) - \left(\varphi_0 - \left(1+\bar{r}+\kappa\delta\right)\right)\right)$$

Define $\varphi^* = max\left\{\varphi_1^*, \varphi_2^*\right\}$. Then, $\varphi \geq \varphi^*$ is sufficient for non-negative Lagrange multipliers.

A.2 Proof of Lemma 2

Combining equations (3), (4), (8), (9), and (11) yields a second-order difference equation in A_t ,

$$A_t = \frac{\varphi_0 - (1 + \bar{r} + \kappa\delta)}{\varphi} + \frac{c_a + \kappa^2 c_e}{\varphi} (A_{t+1} - A_t) - \beta \frac{c_a + \kappa^2 c_e}{\varphi} (A_t - A_{t-1})$$

Defining $\tilde{A} = \frac{1}{\varphi} (\varphi_0 - (1 + \bar{r} + \kappa\delta))$ as the long-run value of A_t and $\psi = \frac{1}{\varphi} \left(c_a + \kappa^2 c_e\right)$ as a measure of adjustment costs, this can be re-written as

$$\beta\psi \left(A_{t+1} - \tilde{A}\right) - (1 + \psi + \beta\psi) \left(A_t - \tilde{A}\right) + \psi \left(A_{t-1} - \tilde{A}\right) = 0$$

After discarding the explosive root, we find that

$$\left(A_t - \tilde{A}\right) = \left(A_1 - \tilde{A}\right) r^{t-1} \text{ for } t \geq 1,\ 0 \leq r < 1$$

where

$$r = \frac{1}{2\beta\psi} \left((1 + \psi + \beta\psi) - \sqrt{(1 + \psi + \beta\psi)^2 - 4\beta\psi^2} \right)$$

A.3 Proof of Proposition 4

Using the envelope theorem again, the first-order conditions are

$$\begin{aligned}
f'(A_1) - (1 + \bar{r}) - c'_A (A_1 - A_0) - \kappa\lambda_t + \beta c'_A (A_2^* - A_1) &= 0 \\
-\delta - c'_E (E_1 - E_0) + \lambda_t + \beta c'_E (E_2^* - E_1) &= 0 \\
\lambda_t (E_t - \kappa A_t) &= 0
\end{aligned}$$

Plugging in functional form assumptions and the assumption that the multipliers bind,

$$\begin{aligned}
(\varphi_0 - \varphi A_1) - (1 + \bar{r}) A_1 - c_a (A_1 - A_0) - \kappa\lambda_1 + \beta c_a (A_2 - A_1) &= 0 \\
-\delta - c_e (\kappa A_1 - \kappa_0 A_0) + \lambda_1 + \beta\kappa c_e (A_2 - A_1) &= 0
\end{aligned}$$

Solve for A_1,

$$(1 + \psi + \beta\psi) A_1 = \tilde{A} + \left(\frac{c_a + \kappa_0\kappa c_e}{\varphi}\right) A_0 + \beta\psi A_2$$

Define $\psi_0 = \frac{1}{\varphi}\left(c_a + \kappa_0 \kappa c_e\right)$. Plug in $A_2 = \tilde{A} + \left(A_1 - \tilde{A}\right) r$. Then,

$$
\begin{aligned}
\left(1+\psi+\beta\psi\right) A_1 &= \tilde{A} + \left(\frac{c_a + \kappa_0 \kappa c_e}{\varphi}\right) A_0 + \beta\psi\left(\tilde{A} + \left(A_1 - \tilde{A}\right) r\right) \\
\left(1+\psi+\left(1-r\right)\beta\psi\right) A_1 &= \psi\left(\frac{\psi_0}{\psi} A_0\right) + \left(1+\left(1-r\right)\beta\psi\right)\tilde{A} \\
\iff A_1 &= w_0\left(\frac{\psi_0}{\psi} A_0\right) + \left(1-w_0\right)\tilde{A}
\end{aligned}
$$

where $w_0 = \frac{\psi}{1+\psi+(1-r)\beta\psi}$.

B Additional Tables

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
Leverage Growth	1,280	−5.95	11.32	−9.74	−4.79	−0.82
Assets Growth	1,280	1.98	7.41	−1.28	1.47	4.18
Equity Growth	1,280	7.93	11.42	2.77	6.04	10.17
Wholesale Funding Growth	1,280	−5.30	16.92	−15.04	−5.72	2.02
Deposits Growth	1,280	4.85	8.72	0.86	3.21	6.54
Loan Growth	1,280	2.16	7.80	−2.02	2.01	5.41
Securities Growth	1,280	6.84	25.59	−7.71	1.94	14.15
Deposit Ratio	1,280	65.94	15.87	56.71	70.88	77.55
Wholesale Funding Ratio	1,280	26.06	15.98	14.17	21.29	35.57
Equity Ratio	1,280	7.80	3.27	6.25	7.55	9.06
Loan Ratio	1,280	59.93	14.14	51.59	61.79	69.31
Securities Ratio	1,280	24.06	12.33	15.88	23.12	30.84
Bank Size (Log Assets)	1,280	7.64	1.39	6.67	7.26	8.10

Table 9: *Summary Statistics*

(% Change)	LATE	SE	BW	N	Half-BW	Double-BW	p	
Leverage	−7.36	3.36	4.11	1220	−7.62	−7.48	0.03	**
Assets	−5.03	1.70	4.16	1220	−3.53	−5.38	0.00	***
Equity	3.33	3.23	3.01	615	−1.57	2.18	0.30	
Wholesale	−12.99	3.82	2.83	542	−12.64	−12.62	0.00	***
Deposits	0.66	2.40	3.27	770	2.48	−0.60	0.78	
Loans	−0.32	1.74	3.36	808	2.13	−0.13	0.85	
Securities	−14.24	5.16	6.02	1223	−13.49	−14.20	0.01	***

Table 10: *Automatic Bandwidth Selection with a Triangular Kernel (Imbens and Kalyanaraman, 2012)*

Bandwidth	Annual Change in %	Leverage	Assets	Equity	Wholesale	Deposits	Loans	Securities
Inf	Estimate	-9.32	-5.47	3.85	-12.44	-0.77	0.14	-13.39
Inf	Standard Error	3.31	1.59	2.89	3.15	2.14	1.50	5.03
Inf	p-value	0.00	0.00	0.18	0.00	0.72	0.92	0.01
Inf	N	1223	1223	1223	1223	1223	1223	1223
-								
3	Estimate	-6.80	-4.30	2.50	-10.88	-0.31	-0.33	-12.44
3	Standard Error	3.74	1.82	3.26	3.73	2.41	1.73	5.91
3	p-value	0.07	0.02	0.44	0.00	0.90	0.85	0.04
3	N	612	612	612	612	612	612	612
-								
2.5	Estimate	-7.73	-3.59	4.14	-10.30	1.78	0.99	-13.52
2.5	Standard Error	4.04	2.00	3.63	3.98	2.52	1.84	6.50
2.5	p-value	0.06	0.07	0.26	0.01	0.48	0.59	0.04
2.5	N	397	397	397	397	397	397	397
-								
2	Estimate	-10.70	-3.59	7.10	-12.15	2.08	0.41	-12.06
2	Standard Error	4.22	2.35	3.86	4.29	2.98	2.20	7.26
2	p-value	0.01	0.13	0.07	0.00	0.48	0.85	0.10
2	N	248	248	248	248	248	248	248
-								
1.5	Estimate	-8.50	-3.47	5.04	-16.91	2.19	1.61	-7.76
1.5	Standard Error	4.70	2.80	4.28	5.30	3.28	2.72	8.78
1.5	p-value	0.07	0.22	0.24	0.00	0.51	0.56	0.38
1.5	N	148	148	148	148	148	148	148
-								
1	Estimate	-3.06	-0.74	2.32	-13.88	5.08	1.76	5.83
1	Standard Error	8.00	4.10	6.94	8.52	4.69	4.23	14.44
1	p-value	0.70	0.86	0.74	0.11	0.28	0.68	0.69
1	N	82	82	82	82	82	82	82

Table 11: *RDD Sensitivity to Bandwidth Choice*